Final Report

Texas Emission Reduction Plan Assessment in the Dallas Fort-Worth Area

Prepared for

Houston Advanced Research Center
4800 Research Forest Dr.
The Woodlands, TX 77381

Prepared by

Lit-Mian Chan
Alison Pollack
Christian Lindhjem
Cuong Tran
Sandhya Rao
Priya Chandraker

ENVIRON International Corporation
101 Rowland Way, Suite 220
Novato, CA 94945

November 12, 2004

EXECUTIVE SUMMARY

The Dallas Fort-Worth (DFW) area was classified as a moderate ozone non-attainment area under the Federal Clean Air Act Amendment of 1990 (CAA), and was required to attain the 1-hour ozone standard by November15, 1996. The DFW non-attainment area, defined as Collin, Dallas, Denton, and Tarrant Counties, has been working to develop a demonstration of attainment in accordance with the CAA. However, the State Implementation Plan (SIP) submitted to EPA in 1994 failed to bring the DFW area into attainment by the November 1996 deadline. Subsequently, in March 1998, the EPA reclassified the DFW non-attainment area from moderate to serious, which required the state of Texas to submit a revised SIP by March 1999. The February 1999 SIP that was submitted to the EPA was found incomplete, and the EPA started the 18-month sanction clock effectively May 13, 1999.

Subsequently, in April 2000, the Texas Commission on Environmental Quality (TCEQ)[1] published a more complete SIP revision that was applicable to the DFW area. The April 2000 demonstration of attainment SIP for the DFW area (DFW SIP) included:

- Photochemical modeling of specific control strategies and future national and state rules for attainment of the 1-hour ozone standard by November 15, 2007;
- Modeling demonstration showing air quality in the DFW area is influenced at times by transport from the Houston Galveston Area (HGA);
- Transportation conformity motor vehicle emissions budgets (MVEB);
- Commitment to perform and submit a mid-course review by May 2004; and
- Various emissions control strategies, including the construction shift emissions reduction control strategy, and the accelerated purchase of Tier 2/Tier 3 equipment strategy.

In a further revision to the DFW SIP on May 23 2001, TCEQ committed to perform mobile source emissions modeling using MOBILE 6. In August 2001, additional revisions were made to the DFW SIP. Key revisions included repeals of the construction equipment operation restriction rule and the accelerated purchase of Tier 2/Tier 3 rule, and replacement of these rules by the Texas Emissions Reduction Plan (TERP) Program.

The 77th Texas Legislature established the TERP in 2001, through enactment of Senate Bill (SB) 5. The TERP includes a number of voluntary financial incentive programs, as well as other assistance programs, to help improve the air quality in Texas. The primary purpose of the TERP program is to reduce NOx emissions through voluntary incentive programs, mainly from heavy-duty on and off-road vehicles and equipment in the DFW and HGA ozone nonattainment areas. The emission reductions from the TERP are intended to replace reductions that would have been achieved through two mandatory measures that SB5 directed the TCEQ to remove from the SIP for the DFW and HGA ozone nonattainment areas. The two mandatory measures that were removed from the SIP were the Construction Equipment Restriction and the Accelerated Purchase of Tier 2/Tier 3 Diesel Equipment, in which the NOx reduction expected from these measures totaled 16.3 tons per day (tpd) for the DFW area[2]. The funding for the TERP is estimated to be about $130 million each year until fiscal year 2008.

[1] TCEQ was then named Texas Natural Resources Conservation Commission (TNRCC).
[2] In addition to the 16.3 tpd NOx emissions reduction in the DFW area, the TERP is intended to reduce NOx emissions by 32.9 to 38.9 tons per day in the HGA area.

In addition to the TERP, the DFW SIP also included emission reduction measures from the Voluntary Mobile Emission Reduction Programs (VMEP). The VMEP in the DFW area is funded by the Federal Congestion Mitigation and Air Quality (CMAQ) program, and is administrated by the North Central Texas Council of Governments (NCTCOG). One of the voluntary commitments under the VMEP in the DFW SIP is the Alternative Fuel Program, which provides funding to government and private entities to assist in their efforts to introduce low emission (clean) vehicles in their on-road fleets. Other VMEP programs that are applicable or relevant to the SIP include employee trip reduction, public education campaign, Tier II locomotive engines, vehicle retirement program, non-road ozone season reductions, off-road diesel engine retrofits, and sustainable development. The major restrictions of the VMEP program are that it funds only emission reduction projects for on-road vehicles, and it will not fund emission reduction projects related to clean fuels. The goal of the VMEP programs is to reduce NOx emissions in the DFW area by 5.0 tpd.

In addition to the current SIP and the mid-course review, the transition from the 1-hour average to the 8-hour average ozone and to the $PM_{2.5}$ standard could affect administration of the SIP, as well as the goals for these emission reduction programs. Technologies designed for the TERP and VMEP should therefore not create potential problems later on (i.e., technologies that reduce NOx emissions but have the potential of increasing PM emissions.)

Concerning the feasibility of achieving the NOx emission reductions in the DFW area with available funding, projects and NOx reduction technologies, as well as the need for the mid-course review, TCEQ and Houston Advanced Research Center (HARC), in January 2004, retained ENVIRON International (ENVIRON) to carry out HARC Project H20-2004 DFW entitled "Assessment of the Texas Emission Reduction Plan (TERP) for On-road and Off-road Mobile Sources in the Dallas-Fort Worth (DFW) Area." This project was a parallel project to an ENVIRON project for HARC entitled "Texas Emission Reduction Plan Assessment in the Houston-Galveston-Brazoria Region" (ENVIRON, 2004).

The objective of the project was to review the TERP in the DFW area and to develop an action plan to achieve appropriate emission reductions from on-road and off-road mobile sources in the DFW area. The DFW area for this study included the four non-attainment counties, Collin, Dallas, Denton and Tarrant Counties, and the surrounding eight near non-attainment counties, Ellis, Henderson, Hood, Hunt, Johnson, Kaufman, Parker and Rockwall. This Executive Summary presents some key discussions and conclusions of the project.

Emission Inventories - In order to achieve these objectives, ENVIRON first assessed the existing emission inventories for on-road and off-road mobile sources in the DFW area and revised these emission inventories for the TERP and NCTCOG program assessment. The emission inventory development and results for on-road vehicles and off-road diesel equipment in the DFW area are discussed in Section 2.

For on-road heavy-duty diesel vehicles (HDDVs), TCEQ provided the CY 2007 revised emissions inventory data broken down by vehicle class and model year. These on-road emissions inventory data were generated using the MOBILE6 model and had been corrected for the TxLED, and NOx temperature and humidity effects. Table ES-1 shows the comparison of the revised NOx emission estimate for HDDVs in the DFW, and that reported in the 2001 SIP.

Table ES-1. Comparison of CY 2007 NOx emission estimates for on-road heavy-duty diesel vehicles in the 12-county DFW area.

Description	NOx Emissions (tpd)
4/2000, DFW SIP (Source: NCTCOG)	84.0
TCEQ with TxLED, temperature/humidity and idling corrections	108.9

As shown in Table ES-1, the revised NOx emission estimate for on-road HDDVs increased from 84 tpd to 109 tpd or by about 30%, as compared to that reported in the 2000 DFW SIP. Similar to the TERP-HGA study (ENVIRON, 2004), the reasons for the dramatic increase in the estimates of heavy-duty diesel vehicle emissions from the 2000 SIP are mainly due to the increases in total VMT and percentage of VMT allocation to heavy-duty diesel vehicles, as well as the use of the MOBILE6 model instead of MOBILE5b. MOBILE6 estimates higher NOx emissions rates at about 9.3 g/mile compared to 7.9 g/mile in MOBILE5.

About 80% of the on-road HDDV NOx emissions are contributed by the Class 8 HDDV type (the largest truck class), with an estimated population of about 30,000 in the DFW area in 2007. Hence, reducing emissions from Class 8 HDDVs seems to be a viable option in the DFW area due to their overall emission contribution and ample vehicle availability.

For the off-road equipment, ENVIRON generated the CY 2007 emission estimates in the DFW area using the NONROAD2002 model with guidance from the TCEQ on the input files and assumptions used in generating the emissions estimates. The emission estimates were then corrected for the temperature and humidity effects. The NOx emission estimates for the non-road diesel equipment are presented in Table ES-2.

Table ES-2. CY 2007 NOx emissions from off-road diesel equipment (excluding locomotives) in the DFW area, generated by ENVIRON with and without corrections for NOx temperature and humidity effects.

Equipment Category	NOx Emissions Average Summer Day with NOx Temperature & Humidity Corrections (tons per day)	NOx Emissions Average Summer Day without NOx Temperature & Humidity Corrections (tons per day)
Agricultural	4.3	4.8
Commercial	4.2	4.7
Construction[1]	36.5[1]	40.7[1]
Industrial	4.9	5.4
Lawn and garden (Res & Comm)	1.4	1.5
Logging	0.05	0.05
Oil Field	1.9	2.1
Railroad maintenance	0.14	0.16
Recreational marine	0.07	0.07
Recreational equipment	0.04	0.05
Total	**53.5**	**59.5**

[1] The category "Diesel Cranes" was run with all NONROAD default values.

As shown in Table ES-2, construction equipment is the highest contributor (more than 65%) to the NOx emission inventory for the non-road diesel equipment in the DFW area. Therefore, it is the single most important category for TERP emission projects. Among the diesel construction equipment types, major emission contributors include excavators, crawler tractors/dozers, rubber

tire loaders, rollers, tractors/loaders/backhoes, surfacing equipment, graders, and bore/drill rigs, with an estimated population of about 25,000 units in the DFW area, emitting almost two-thirds of the total NOx emissions of 36.5 tpd from the diesel construction equipment. Hence, these emission sources provide very viable options for reducing NOx emissions in the DFW area due to their overall emission contribution and ample equipment availability.

Emission Control Strategies & Scenarios - ENVIRON reviewed the current and near-term emission reduction technologies for on-road HDDVs and for non-road diesel equipment. The potential emission reduction per vehicle/equipment, cost, cost effectiveness and availability of several verified and near-term unverified technologies for on-road HDDVs and off-road equipment were assessed and documented in Section 3. ENVIRON also developed potential emission reduction scenarios for reducing NOx emissions from on-road H-HDDVs and several major non-road construction equipment types (Section 7) based on these control technologies.

A summary of the general findings in terms of emission reduction technologies, potential emission reduction per vehicle/equipment and cost effectiveness for diesel engines with different model year and equipment types is presented in Table ES-3. As shown in this table, potential emission reduction and cost-effectiveness values vary substantially for different technologies. In general, it is more cost effective to apply emission reduction technologies to older, higher-emitting vehicles and equipment with higher usage.

Table ES-3. Summary of the cost-effectiveness and potential emission reduction values for some verified and near term, unverified emission reduction technologies.

Project and Equipment Type	Potential Emission Reduction per Unit (tpy)	Lifetime Cost Effectiveness[1] ($/ton of NOx reduced)	One-Year Cost Effectiveness[2] ($/ton of NOx reduced)
Emulsified Diesel Fuels			
On-road Vehicles	0.07 - 0.29	7,000 - 31,000	27,000 - 120,000
Off-road Equipment	0.05 - 0.40	11,000 - 31,000	40,000 - 120,000
Engine/Vehicle\Equipment Replacement			
On-road Vehicles	0.17 – 1.25	6,000 – 40,000	36,000 – 240,000
Off-road Equipment	0.05 – 1.65	6,000 – 42,000	38,000 – 260,000
Natural Gas/Dual Fuel Technologies			
On-road Vehicles	0.04 – 1.27	3,000 – 100,000	23,000 – 900,000
Off-road Equipment	NA	NA	NA
Injection Timing Retard with DPF/ODC Retrofit Systems			
On-road Vehicles	0.09 – 0.40	6,000 – 25,000	50,000 – 210,000
Off-road Equipment	0.03 – 0.78	9,000 – 50,000	73,000 – 430,000
Lean NOx Catalyst Retrofit Systems			
On-road Vehicles	0.11 – 0.48	6,000 – 22,000	41,000 – 190,000
Off-road Equipment	0.04 – 1.24	5,000 – 31,000	46,000 – 270,000
Exhaust Gas Recirculation (EGR) with DPF System Retrofits			
On-road Vehicles	0.11 – 0.48	6,000 – 24,000	48,000 – 210,000
Off-road Equipment	0.03 – 0.93	8,000 – 48,000	70,000 – 410,000
Selective Catalyst Reduction System Retrofits			
On-road Vehicles	0.27 – 1.21	3,000 – 12,000	23,000 – 100,000
Off-road Equipment	0.08 – 2.33	4,000 – 23,000	34,000 – 190,000

[1] TERP calculates an annualized (over the project life) cost divided by annual emission reduction

[2] One-year cost effectiveness is defined as total project cost divided by annual emission reduction. This figure is useful for determining the amount of money needed to fund a given emission reduction goal.

There are infinite possible NOx emission reduction scenarios that can be implemented in the TERP to potentially achieve the TERP NOx emission reduction goals in the DFW area by 2007 within the expected TERP fund for the DFW area, estimated to be approximately $270 million.

As presented in Section 7, a potential scenario for on-road HDDVs focuses on the Class 8 HDDV type (the largest truck class) as it contributes most of the HDDV NOx emissions in the DFW. This scenario shows that it would reduce about 5.5 tpd of NOx emissions totaling approximately $120 million, involving about 5,500 Class 8 HDDVs or about 20% of the total available fleet using various control technologies, which is a viable turnover rate over a 4-year period. This possible scenario is conservative in the sense that it assumes a 15% vehicle penetration rate for all technologies that have a cost-effective value of less than $6,000 per ton of NOx reduced, and 10% penetration rate for all other technologies that meet the $13,000 cost-effectiveness limit, instead of focusing on those most cost-effective technologies such as the EGR+DPF and SCR systems, or if the penetration rate is higher than the 10 to 15% for each of the technologies reviewed.

Also presented in Section 7 is a potential scenario for major emission sources from the non-road construction equipment with verified and near-term, unverified technologies. This potential scenario would reduce about 8.1 tpd of NOx emissions for about $190 million, involving 6,700 units of equipment or slightly more than 25% of the total available units for these equipment types, which is a viable turnover rate over a 4-year period. Similar to that for the on-road HDDV, this scenario is conservative in the sense that it assumes 10 to 20% equipment penetration rate for all technologies that meet the $13,000 cost-effectiveness limit, instead of focusing on those most cost-effective technologies such as the EGR+DPF and SCR systems or on higher penetration rates.

Carl Moyer and SECAT Programs - To draw from experience from other TERP-like programs, ENVIRON reviewed and documented the development, implementation and evolution California's Carl Moyer Program and the Sacramento Emergency Clean Air Transportation (SECAT) program. ENVIRON reviewed and reported the administration, emission reduction impacts, the key strategies used to reduce emissions, early mistakes and adjustments made throughout the development and implementation of these programs. Section 4 discusses these programs in detail.

Carl Moyer Program - The Carl Moyer Program was created by the California Assembly Bill 1571, which grants the California Air Resources Board (CARB) and California Energy Commission (CEC) with the authority to implement the voluntary, incentive-based program to reduce emissions from heavy-duty vehicles and off-road equipment. Similar to the TERP, the Carl Moyer Program provides funds on an incentive-basis for the incremental cost of cleaner HD vehicle and equipment, with emphasis on reducing NOx emissions, for both on-road and non-road road mobile sources.

The Carl Moyer Program is funded by California's fiscal budget, with matching funds from local air districts. The California Governor and the Legislature have appropriated a total of $140 million over the last five fiscal years, starting FY 1998/1999. Local air districts have provided more than $40 million in matching funds, mostly collected through vehicle registration fees.

While the Carl Moyer Program is mainly administrated by CARB, Air Quality Districts in California are responsible to outreach, solicit, approve, and issue Carl Moyer grants locally according to its guidelines, as well as monitor the implementation of these eligible projects.

The Carl Moyer Program is considered one of the most cost-effective emission reduction programs in the U.S. with an average cost-effectiveness of $5,000 per ton of NOx reduced. Table ES-4 summarizes the number of participating districts, funding available, estimated NOx reductions and cost-effectiveness values by fiscal year for the Carl Moyer Program. Table ES-5 shows the project types for the first three fiscal years. As shown in Table ES-5, agricultural irrigation pump projects provided the highest NOx reduction with a second most effectiveness value of about $2,400 per ton of NOx reduced. The second most NOx reduction for the Carl Moyer Program was from marine vessels.

Table ES-4. Program summary by fiscal year of the Carl Moyer Program.

Fiscal Year	Number of Participating Districts	Carl Moyer Funding ($ millions)	Matching Funds from Districts ($ millions)	NOx Reduction (tpd)	Cost Effectiveness Limit	Actual Average Cost-Effectiveness of All Projects Statewide
1998/99	16	24.5	12.25	4	$12,000.00	$3,000
1999/00	20	19	9.31	7	$12,000.00	Below $5,000
2000/01	21	45	12.00	14	$13,000.00	$4,000
2001/02	NA	16	~8	16	$13,600.00	NA
2002/03	NA	19.68	~9.8	NA	$13,600.00	NA

Table ES-5. Project summary for the first three fiscal years of the Carl Moyer Program.

Source Category/ Equipment Type	NOx (tpy)	Cost-Effectiveness ($/ton)	Number of Engines		Total Funds	
			Alt Fuel	Diesel	Alt Fuel	Diesel
On-Road						
Heavy-Duty Line Haul	41	$2,570	-	32	-	$788,661
Refuse Haulers	432	$6,563	511	62	$16,023,480	$735,077
Urban Transit Buses	413	$4,715	850	-	$11,323,140	-
School Buses	4	$10,039	20	-	$374,542	-
Other	116	$5,756	327	106	$5,025,363	$1,862,823
Off-Road						
Farm Equipment	36	$4,179	-	52	-	$535,492
Construction	54	$3,627	-	42	-	$1,066,286
Other	52	$3,587	18	42	$194,545	$375,603
Locomotives	22	$1,160	2	-	$820,000	-
Marine Vessels	698	$3,044	-	182	-	$14,162,390
Agricultural Irrigation Pumps	1767	$2,353	23	1878	$362,563	$20,414,223
Forklifts (electric)	163	$5,057	209	-	$2,083,527	-
TOTAL	**3798**		**1960**	**2396**	**$36,207,160**	**$39,940,555**

Some of the notable changes in the Carl Moyer program included the increase in the cost-effectiveness value from $12,000 to $13,600 per ton of NOx reduced to account for inflation, the inclusion of the PM emission reduction, funding for auxiliary power units (APUs), revised emission factors based on EMFAC2000 and OFFROAD emission models, and funding for incremental fuel cost on a case-by-case basis.

The funding for the Carl Moyer Program has been over-subscribed since its implementation in 1998 due to strong district response to their calls for project applications. Some of the key strategies for the success of the Carl Moyer Program include the following:

- Smooth initial implementation of the program;
- Quick response from CARB to accelerate the second year funding schedule to meet demand;
- Participation and assistance from the local level (air districts) to solicit, evaluate and implement projects;
- Inter-agency collaborations (e.g. CARB, CEC, California Department of Transportation, port authorities, California Department of Commerce etc.);
- Participation of the NGOs and local businesses (construction, agricultural, goods transportation industries etc.);
- Effective outreach programs via workshops and public meetings;
- Complement by the statewide Diesel Risk Reduction Program via mandatory regulations.

SECAT Program - The SECAT Program was created by California Assembly Bill 2511 to assist the Greater Sacramento Area to meet the 2005 SIP by reducing 3 tons per day of NOx from HD diesel vehicles by 2005. Similar to the Carl Moyer Program, the SECAT Program is an incentive based voluntary program. However, the SECAT Program is dedicated to reducing NOx emissions from on-road HD vehicles only.

The AB 2511 set aside $50 million of the California's 2000/2001 fiscal budget for the SECAT Program. In addition, local political leaders approved an additional $20 million from the CMAQ funds for the program. To date, the SECAT Program has funded $25 million on projects. The $45 million budget left in the program remains un-funded by California due to the California budget crisis, and the program is stalled at the moment due to this budget crisis.

Since its implementation in December 2000, the grant solicitations for the SECAT program have been successful and the program was over-subscribed. The program has allocated $25 million or 34% of its funds and met its 2005 goal of 3 tpd. The $25 million yielded a total of 154 contracts and resulted in a reduction of 0.54 tons per day of NOx in the Sacramento area with an average lifetime cost-effectiveness value of $18,200 per ton of NOx reduced. Funded projects included 176 repowered tractors, 107 Liquefied Natural Gas (LNG) garbage trucks, 131 Compressed Natural Gas (CNG) transit buses, and 13 propane utility trucks, as well as two LNG and three CNG fueling stations. The City of Sacramento also received funding for incremental fuel cost.

The major key control strategy for the SECAT program was the diesel power retrofit. Fifty nine percent (59%) of the NO_x reduction achieved by the SECAT program was from repowering trucks with remanufactured lower emissions diesel engines. Prior to the stalling of the funding, the SECAT program funded 140 projects to repower a total of 176 vehicles, with an average cost-effectiveness of $10,300 per lifetime ton NO_x reduced, and one-year cost-effectiveness of $44,600 per ton of NOx reduced.

The repower strategy was successful in the SECAT program because repowering older engines with newer engines is a common industry practice that provides significant benefits to the owners through reduction in maintenance and fuel costs. The success of the diesel repower strategy in the SECAT program was due largely to the active role of engine

distributors/dealerships in performing outreach to equipment owners, as well as in facilitating the application process. The outreach effort from engine distributors/dealerships was effective in terms of identifying older vehicles that would provide most emission reduction when repowered. In addition, the simple application and approval process in the SECAT program made it easy for fleet owners to submit grant applications. The other major key strategies to the success of the SECAT program are as follows:

- Formation of the technical and policy review groups;
- Development of the objective funding criteria based on technical supporting documentation and application assessment software;
- Effective outreach program/materials, including workshops, conferences, exhibits, public announcements, new releases, direct mail post cards, dealer flyers, vehicle decals, posters, truck stop pamphlets, brochures, promotional collateral, own SECAT website with emission calculator, marketing video, new coverage, radio campaign etc.;
- Air District's responsibilities and assistance - project solicitation, evaluation, implementation and tracking;
- MPO (i.e. Sacramento Area Council of Government or SACOG)'s responsibility and assistance;
- Cooperation from the federal, state & local governments, NGOs and local businesses and industries;
- Driven by the risk of losing highway funds – cooperation from SACOG and local construction and related businesses;
- Complement the statewide Carl Moyer Program and the Diesel Risk Reduction Program;
- Focused voluntary measure, targeting only on-road HD diesel trucks; and
- Strong cooperation with local truck/engine distributors/dealerships.

VMEP and TERP – In order to assess the VEMP and TERP programs, ENVIRON reviewed the emission reductions achieved to date of the TERP and NCTCOG VMEP's Clean Cities/Vehicles Program based on implemented or approved projects and program progress reports. Sections 5 and 6 discuss these programs, as well as present the results of the assessment for the programs.

VMEP – The EPA adopted a policy to allow credit in the SIP for voluntary mobile source reduction programs (VMEPs) in 1997. Currently EPA regulations have set a 3% limit on the amount of emission reduction allowed for VMEPs in a SIP. TCEQ estimated in the 2001 DFW SIP that 3% of the DFW area's projected NOx emissions was 5 tons per day.

TCEQ estimated in the April 2000 DFW SIP that 3% of the DFW area's projected NOx emissions was about 5 tons per day. The NCTCOG has taken the initiative to develop and implement VMEPs in the DFW area with the goal to achieve the 5 tpd of NOx emissions reduction.

One of the NCTCOG VMEPs is the Alternative Fuel Vehicle Program under the Clean Cities/Clean Vehicles Program, which is a voluntary, locally based government and industry partnership program that is designed to improve air quality, promote use of low emissions (clean) vehicles, reduce dependency on imported petroleum products, and stimulate public and private sector investment in clean vehicle technology and infrastructure. The NOx emission reduction goal for the Alternative Fuel Program was 0.18 tpd. Projects funded through FY2002 for the program are shown in Table ES-6. As shown in this table, NCTCOG has funded more

than $45 million alternative fuel vehicle projects for different vehicle classes and fuels, with an estimated total NOx reduction of 0.183 tpd - exceeding the SIP goal of 0.18 tpd for the Alternative Fuel Program. Projects approved by NCTCOG's Alternative Fuel Vehicle Program include mostly natural gas and propane alternative fuel vehicles, with a few electric and LPG vehicles. The average first-year cost-effectiveness value for NCTCOG funded projects was about $36,700 per ton of NOx reduction, and the project lifetime cost-effectiveness value was calculated to be about $6,000 per ton of NOx reduction. While the SIP goal has been achieved, NCTCOG's Alternative Fuel Vehicle Program continues to develop new partnerships and projects for FY2003 and FY 2004.

Table ES-6. Summary of NCTCOG alternative fuel projects for the DFW area (April 2000 DFW SIP).

Summary of NCTCOG Public Fleets Funded Projects Through FY 2000								
Vehicle Size	**Fuel**	**Quantity**	**Incremental Cost**	**NOx tons/yr**	**NOx tons/day**	**NOx $/tpy**	**NOx Lifetime (tons)**	**NOx $/ton**
LDV	CNG	529	$ 1,851,500	1.74	0.0067	$47,052	8.72	$ 9,410
	LNG	355	$ 1,242,500	1.17	0.0045	$47,052	5.85	$ 9,410
	Electric	2	$ 7,000	0.02	0.0001	$16,000	0.10	$ 3,200
	Propane	480	$ 1,680,000	2.74	0.0106	$27,113	13.72	$ 5,423
MDV	CNG	33	$ 115,500	0.18	0.0007	$28,555	0.90	$ 5,711
	Propane	104	$ 364,000	0.98	0.0038	$16,456	4.90	$ 3,291
HDV	CNG	131	$ 5,240,000	3.83	0.0147	$16,445	38.32	$ 6,057
	LNG	139	$ 5,560,000	4.07	0.0156	$16,445	40.66	$ 6,057
	Propane	347	$ 13,880,000	17.39	0.0669	$15,637	173.94	$ 3,535
Sub Total		**2120**	**$ 29,940,500**	**32.13**	**0.1236**	**$25,639**	**287.10**	**$5,788**
Summary of NCTCOG Private Fleets Funded Projects - FY 2000								
LDV	CNG	46	$ 161,000	0.17	0.00064	$ 47,493	0.83	$ 9,499
	Electric	13	$ 45,500	0.11	0.00044	$ 17,776	0.57	$ 3,555
	Propane	146	$ 511,000	4.25	0.01633	$ 13,595	21.23	$ 2,719
	LPG	2	$ 7,000	0.01	0.00004	$ 30,120	0.05	$ 6,024
HDV	Propane	1	$ 40,000	0.01	0.00005	$ 34,116	0.14	$ 3,412
Sub Total		**208**	**$ 764,500**	**4.55**	**0.01749**	**$ 28,620**	**22.81**	**$ 5,042**
Summary of NCTCOG TIP Call FY 2000-2002								
LDV	CNG	239	$ 856,250	2.76	0.0106	$ 11,691	13.79	$ 2,338
MDV	CNG	10	$ 40,000	0.05	0.0002	$ 32,635	0.27	$ 6,527
HDV	CNG	275	$ 14,054,000	8.07	0.0310	$ 123,254	80.69	$ 12,325
Sub Total		**524**	**$ 14,950,250**	**10.88**	**0.0419**	**$ 55,860**	**94.76**	**$ 7,064**
Grand Total		**2,852**	**$ 45,655,250**	**47.56**	**0.1829**	**$ 36,706**	**404.7**	**$ 5,965**

While no emissions benefits were quantified, two other VMEP measures in the DFW SIP involved non-road equipment and off-road heavy-duty diesel engines. While non-road projects are not eligible for CMAQ funding, NCTCOG has been effective in developing public outreach programs to educate and facilitate non-road projects using TERP funding. This includes the forming of the Clean Construction Campaign (C3) Air Quality Group to address immediate and long range efforts related to NOx emissions calculations and reductions from nonroad construction activities in the DFW region. One of the immediate goals of the C3-Air Quality is to provide the guidance and oversight needed to conduct a regional inventory of non-road diesel construction equipment, which was a critical component of the DFW SIP development process.

In addition, the C3-Air Quality Group also is developing regional guidance on implementing the TERP program.

TERP - The TERP, which is funded through revenue from fees and surcharges, was established to reduce emissions in the nonattainment and near nonattainment areas of Texas through voluntary incentive programs. The main program funded by the TERP with applicability for heavy-duty diesel engines for on-road and non-road applications is the Emissions Reduction Incentive Grants Program, which provides monetary grants to offset the incremental costs associated with reducing NOx emissions from high emitting internal combustion engines.

Since the establishment of the TERP, TCEQ has completed two grant application and selection processes for funding for FY 2002 and FY 2003. For FY 2004, TCEQ has also completed September 2003 and January 2004 grant solicitations. The January 2004 solicitation closed on March 12, 2004. Unlike the prior solicitations, TCEQ has conducted workshops in various counties, including the DFW area, to discuss the TERP as well as to explain application procedures, cost-effectiveness and emission reduction calculations. When ENVIRON was performing the data analyses and drafting the report starting in early February, TCEQ had only published the awards of the FY 2002 and FY 2003 grant applications, while it was still finalizing the award decision on the September 2003 solicitation and the January 2004 solicitation closed on March 12, 2004. Therefore, the data analysis and assessment results for the TERP discussed in this report were based on the FY2002 and FY 2003 data. TCEQ is in the process of revising the award results of the September 2003 January 2004 solicitations.

The TERP approved a total of 25 projects in the DFW area for a total funding of approximately $12 million for FY 2002 to FY 2003. The funded projects were far less than the projected available $75 million TERP fund for the DFW area, assuming a 50% split of the FY 2002 and FY 2003 expected fund of about $150 million (i.e. $20 million for FY 2002 and $130 million for FY 2003) between the HGA and DFW area.

As shown in Table ES-7, the estimated NOx reduction for these projects was about 1.0 tpd for a total cost to TERP of $12 million, with an average amortized cost-effectiveness value of $ 4,400 per ton of NOx reduced. This 1.0 tpd is only slightly over 6% of the 16.3 tpd NOx reduction goal for the TERP in the DFW area. Most of the emission reduction (about 70%) was from projects related to on-road heavy-duty diesel vehicles, while about 26% of the emission reduction was from the non-road equipment and 4% was from fuel related projects.

Table ES-7. Summary of the TERP approved projects for FY 2002 and FY 2003 in the DFW area.

Project type	Number of Projects	Number of Activities	Total Grant Amount	Estimated NOx Reduction (tpy)	Estimated NOx Reduction (tpd)	Estimated NOx reduction (total tons)	Projected Project C-E ($/ton)
Onroad	2	362	$7,605,680	237.1	0.65	1,873	$ 4,062
Nonroad	20	81	$3,213,772	90.7	0.25	712	$ 4,511
Fuel	3	362	$733,982	14.2	0.04	68	$ 10,764
Total	25	805	$11,553,435	341.9	0.94	2,653	$ 4,354

The technologies used in most of the on-road projects were retrofitting of EGR+DPF on DART's transit buses. Most of the technologies used in the non-road projects were new purchases of non-road construction equipment. For the fuel projects, most of the projects were the use of emulsified diesel fuel, TxLED or ULSD fuels, and funding for a LNG refueling infrastructure.

While there was no official announcement regarding award for the September 2003 TERP grant solicitation, TCEQ indicated that it has approved about $19 million projects while waiting for approval for another $35 million projects. As for the 2nd round of the FY 2004 solicitation, the number of grant applications was expected to increase substantially due mostly to the available of the formal TERP guidance documents, as well as workshops conducted by TCEQ to explain the application procedures, cost-effectiveness and emission reduction calculations for the TERP. A quick review on the draft award and projects received data in the September 2003 and January 2004 solicitations indicates that average cost-effectiveness value is lower, while the project participations increased as compared to FY 2002 and FY 2003 data.

Based on the $12 million to date to reduce 1.0 tpd of NOx, it would require an additional $200 million to achieve the 16.3 tpd of NOx reduction in the DFW area. TCEQ estimated that the total expected TERP fund from FY 2002 to FY 2008 would be about $671 million. If 40% of this TERP fund ($270 million) were allocated to the DFW area, the TERP would be able to achieve the 16.3 tpd of NOx reduction for the DFW area. In addition, a quick review on the award and projects received data in the September 2003 and January 2004 solicitations indicates that the required funding to achieve the NOx reduction goal is substantially lower than the $200 million estimated based only on FY2002/2003 data.

While the January 2004 solicitation resulted in a substantial increase in project participation, the challenge is to continue the outreach effort to maintain if not increase the activities/project participation, focusing on reducing emissions from major NOx sources such as the H-HDDVs in the on-road category, and the construction equipment in the non-road equipment category. Also, many of the cost-effective approved projects involved the use of unverified technologies, such as the EGR+DPF and SCR retrofit systems. Therefore, it is essential that the TERP continue funding these cost-effective projects while making sure that technology vendors for these systems are pursuing verification of their products with EPA or CARB, and providing funding under the New Technology Research and Development Program of TERP to assist these vendors in their quest for product verification.

List of Recommended Actions - Based on the review of the Carl Moyer and SECAT programs, and assessments of control strategies and the TERP and VMEP programs, the following actions are recommended to achieve the NOx emission reduction goals for the TERP and VMEP in the DFW area. Some of these actions were recommended in the TERP-HGA report (ENVIRON, 2004) as well.

1. **Change emission standards for on-road HD CI engines in TERP Guidelines**[3]

   The TERP guidelines use incorrect emission standards for MY 1989 and earlier engines. The guidelines should use a NOx emission standard of 10.7 g/bhp-hr for model years 1989 and earlier HD engines, instead of 10.0 g/bhp-hr for MY 1987 and 6.0 g/bhr-hr for MY 1988-

[3] TCEQ had since corrected these emission standards in its revised Technical Supplemental Document for On-road Vehicles (TCEQ-10430a) dated November 4, 2004.

1989 engines; while adopted for the MY 1988 and later engines, the 6.0 g/bhp-hr NOx emission standard was postponed by EPA until MY 1990 engines. These changes provide additional 7% NOx reduction for 1987 and earlier baseline engines, and more than 40% more NOx reduction for 1988 to 1989 baseline engines, which are found in an estimated 1,900 HD diesel vehicles in the DFW area. In addition, TERP should consider using MOBILE6-based emission factors, instead of emission standard based, to calculate the emission reduction and cost effectiveness because it would be consistent with the SIP emission inventory calculation.

2. **Provide funding to fuel projects through the year of 2007 in order to be eligible for the SIP emission reduction**[4]

In order to claim the SIP emission reduction in the year 2007, one of the criteria for the SIP emission reduction is "Permanent." If TERP funded, for instance clean fuels, projects with a project life of only 1 to 1.5 years prior to the year of 2006, the emission reductions from these projects would not be considered "Permanent" in the year of 2007 and therefore not creditable under the SIP. The TERP has funded some emulsified diesel fuel projects for only 1 to 1.5 years due to "funding restrictions."

3. **Focus on projects related to on-road Class 8 HDDVs**

There are about 30,000 on-road Class 8 HDDVs that contribute to about 86 tpd or 80% of the NOx emission inventory from HDDVs in the DFW area. Since NCTCOG Clean Cities/Clean Vehicles program under the VMEP cannot fund non-road projects nor the cost of clean fuels because of the limitations on the use of CMAQ funds, NCTCOG should be focusing on funding projects related to emission reductions from Class 8 HDDVs. TERP can then assist by funding clean fuels, such as alternative fuels (i.e. natural gas), TxLED or ULSD fuels, or provide matching funds for the Federal CMAQ dollars. While the NCTCOG Alternative Fuel program seems to be meeting the 0.18 tpd SIP goal for that measure, emissions benefits from continuing funding the alternative fuel vehicle program could be used to supplement any shortfall in the SIP, as well as for meeting the 8-hour ozone standard.

The TERP should also actively pursue projects related to emission reductions from on-road Class 8 HDDVs, as there are abundant numbers of available vehicles. Using the TERP's cost-effectiveness limit of $13,000 per ton of NOx reduced, a potential scenario (Table 7-3) shows that 5.6 tpd of NOx reduction could be achieved for a cost of about $120 million with a 10% penetration rate for different model years and various control strategies. Total number of vehicles involved in the potential scenario would be about 5,500 or only about 20% of the total available fleet. The potential emission reduction would be higher if the TERP's baseline emission levels (i.e. emission standards) for the 1989 and earlier CI engines are corrected as recommended above.

4. **Focus on projects related to non-road construction equipment**

Construction equipment contributes to more than 35 tpd or about 65% of the NOx emission inventory from the non-road diesel equipment (excluding locomotives) in the DFW area. Major contributors include excavators, crawler tractors/dozers, rubber tire loaders, rollers,

[4] TCEQ had since revised the emission reductions for these projects to zero based on the TERP project data provided by TCEQ to ENVIRON on November 02, 2004.

tractors/loaders/backhoes, surfacing equipment, graders, and bore/drill rigs, with an estimated population of about 25,000 units in the DFW area, emitting almost two-thirds of the total NOx emissions from the diesel construction equipment. The TERP should actively pursue projects related to emission reduction from these non-road sources, as there are abundant numbers of available equipment.

Using the TERP's cost-effectiveness limit of $13,000 per ton of NOx reduced, a potential scenario (Table 7.5) shows that 8.1 tpd of NOx reduction could be achieved for a cost of about $190 million with 10 to 20% penetration rates for different vehicle technologies (i.e. Tier 0, 1 or 2 baseline engines), horsepower ranges and equipment types with various control strategies. Total number of equipment involved in this potential scenario would be about 1,420 or 64%, 3,960 units or 40%, and 1,330 units or 17% of the equipment with Tier 0, Tier 1 and Tier 2 baseline engines, respectively.

5. Increase program staff members, especially at the local levels

At least 21 air districts in California are applying for funding from the Carl Moyer program with an average annual funding of $25 million for the past five years. Each district at least has one staff member involved in the Carl Moyer program, with some larger districts (i.e. South Coast, Bay Area, Sacramento) having several staff members. In addition, CARB has several staff members administrating the Carl Moyer program.

In contrast, the TERP, with a projected $130 million annual funding, consists of one section manager, one program coordinator, one technical staff, four grant managers, a project development coordinator, and an administrator for a total of 9 staff members. The potential understaffing in the TERP could be one of the reasons the TERP was under-subscribed at the beginning and requires longer time for project review and approval. The TERP, now heavily over-subscribed, should consider adding more staff members or outside assistance in the program, especially on-site staff members or outside assistance at the *local levels* (at least in the HGA and DFW area) to interact with the local MPO, industry, NGO etc. Adding staff members could increase program outreach (e.g. via workshops, conferences etc.), outside accessibility, and speed up review of grant applications.

6. Continue to work with engine distributors and other technology vendors and EPA/CARB to encourage and accelerate the verification process

The TERP has funded significant numbers of projects that use unverified technologies, namely EGR+DPF retrofit and SCR systems. While they are as yet unverified, these retrofit technologies are essential for the success of the TERP due to the higher potential NOx emission reductions from the use of these technologies, as well as limited available NOx reduction technologies.

In addition to the Dual-Fuel NG retrofit system, there are only two NOx technologies that have been verified by CARB or EPA: PuriNOx emulsified diesel fuel and Cleaire's Flash & Match system. One EGR+DPF vendor (STT EMTEC) indicated that applications have been filed with the CARB and EPA. One SCR vendor (Extengine) indicated that an application has been filed with the CARB.

In addition to these technologies, the TERP should fund demonstration projects for other promising near term NOx reduction technologies through its NTRDP, and/or laboratories (e.g. SwRI, University of Houston etc.), so that it would further validate these technologies as well as generate additional or initial field data that could be used for the EPA and/or CARB verification process.

It is encouraging to note as a result of the FY 2004 NTRDP solicitation, TCEQ has funded more than 10 projects to assist technology vendors to verify and deploy their emissions control technologies or products.

7. Other recommended actions

The TERP program staff should:

- Work closely with government (federal/state/local) fleets to encourage participation
- Actively promote the TERP to and through local engine distributors
- Encourage collaboration among affected agencies (TCEQ, TxDOT, etc.)
- Encourage MPO & NGO collaboration
- Consider incentive-based government contracts with industry
- Continue to develop and implement effective emission benefit and funding tracking software/programs
- Continue to conduct effective outreach programs to promote the TERP, including workshops, conferences, exhibits, public announcements, new releases, marketing materials (direct mail post cards, dealer flyer, vehicle decals, posters etc.), truck stop pamphlets, brochures, promotional collateral, TERP website, marketing video, and Radio campaign (Appendix E includes some examples of program outreach materials).