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REPORT VOLUME III – APPENDICES

PART 4 OF 4

APPENDICES 8-1 THROUGH 11-5

SOUTHERN CALIFORNIA ACCELERATED RAIL ELECTRIFICATION PROGRAM

PHOTO BY SPACESHOTS INC.

Prepared for

Southern California Regional Rail Authority

February 10, 1992

DRAFT

REPORT VOLUME III – APPENDICES

Part 4 of 4

Appendices 8-1 through 11-5

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DISCLAIMER

All participants in the Electrification Task Force identified on the previous page have contributed in some measure to the preparation of this Southern California Accelerated Rail Electrification Program report. However, not every participant is in agreement with the analysis and findings contained herein. Accordingly, identification of a participant does not indicate acceptance of, or agreement with, the entirety of the information provided in the report.

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South Coast Air Coast Quality Management District

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Southern California Regional Rail Authority

Southern Pacific Transportation Company

Union Pacific Railroad

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(Part 4 of 4)

APPENDIX 8-1

FEASIBILITY OF NATURAL GAS-POWERED COMMUTER TRAINS IN THE LA BASIN

Prepared as an Appendix to the:

Southern California Regional Rail Accelerated Electrification Program Report

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NATURAL GAS

Technology

This section discusses the technologies available for converting diesel locomotives to natural gas operation.

Design and Operating Characteristics

For the purposes of this report, it is important to understand that locomotives are designed very differently from highway trucks[1]. Thus, typical engine design and conversion systems used to convert diesel truck or bus engines to natural gas are not directly applicable to locomotive engines. A primary characteristic of locomotives is they have a very high power for their frontal area. One of the functions for locomotives is to provide as much tractive power as possible; however, the dimensions of a locomotive are generally constrained by those of the standard rail tunnel and clearances between trains. The job of the locomotive is to "push" as much power as possible through the clearance envelope while riding on the standard 4'81/2" gauge track.

Locomotives are designed with such features as very high output engines, long engine configurations (such as V-12, V-16, or even V-20) and very narrow "V" angles between banks to accomplish their tasks.

Locomotives also operate quite differently from trucks. Generally, most US locomotives operate on a "Notch" schedule. Locomotives operate in eight distinct speeds and loads called Notches. For example, Notch 8 provides full power, intermediate Notches are designated to provide adequate power with good fuel consumption. Thus, locomotives do not operate under transient conditions in the same way on-highway vehicles operate, but rather at eight discreet operating conditions (plus idle and dynamic braking modes).

Current railroad engines are optimized for economy not emissions. For example, the 1991 emissions specifications for on-highway trucks requires NO_X emissions be below approximately 5 gm/bhp-hr as measured on the Federal Test Procedure (FTP) transient test cycle. By comparison, today's railroad engines provide approximately 9.5 gm/bhp-hr of NO_X at full power. Locomotive engines are optimized for high fuel economy. Thermodynamically, high engine efficiency comes from providing high combustion temperatures. Unfortunately, these high temperatures produce high NO_X emissions.

Figure 1 provides a comparison of mechanical loading for automobile, truck, and locomotive engines. These three classes of engines are compared in terms of brake mean effective pressure (BMEP), an indication of the mechanical loading of the engine. As seen here, a typical automobile engine has less than 100 psi BMEP at rated power. This compares to just over 200 psi for most truck engines at rated power. Current line-haul locomotives

MECHANICAL LOADING COMPARISON

Brake Mean Effective Pressure (BMEP)

4-Stroke Engines, Rated Power

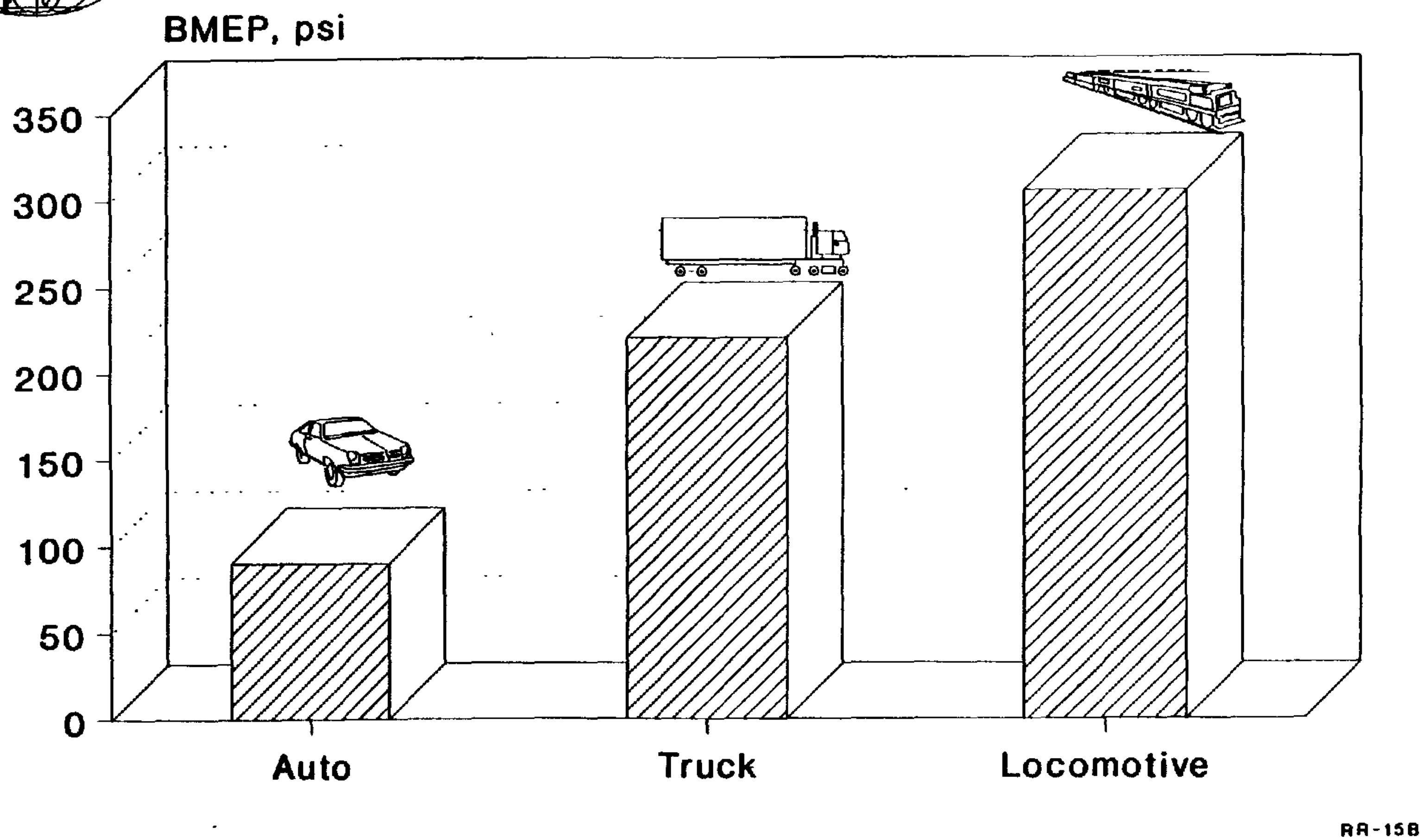

FIGURE 1

have BMEP in excess of 300 psi at rated power. In other words, locomotive engines are stressed nearly 50 percent higher than comparable diesel truck engines at rated conditions. As explained earlier, this increased output is required due to the combination of physical constraints of the rail system and railroad operating requirements. Locomotive engines also operate near their rated power more often than truck engines which further increases the typical loading factor for locomotive engines compared with truck engines.

This increased mechanical loading is not without cost. Locomotives engines are designed to provide high quantities of excess airflow through the cylinders. This excess scavenging flow helps cool components such as piston crowns, valve heads, and the cylinder head firedeck. Unfortunately, this high flow-through for cooling complicates introduction of natural gas. Normal intake fumigation systems used on automobile engines and many truck-type engines are not suitable for use with high flow-through locomotive-type engines. The locomotive engines have valve timing events with high valve opening duration and high overlap between intake and exhaust strokes. Up to one third of the fuel introduced by fumigation would pass directly out the exhaust pipe without a chance for combustion. This phenomenon exists for both two-stroke and four-stroke locomotive engines.

Locomotive Engines and Technology Options

Engines

Two manufacturers produce locomotives in the United States: Electro-Motive Division of General Motors and General Electric Transportation Company of General Electric. Both manufacturers build the entire locomotive, including the engine. The locomotive engines produced by these manufacturers generally have a displacement in excess of 10 liters per cylinder. Some of the characteristics of these engines are listed below:

TABLE 1. U. S. LOCOMOTIVE ENGINE CHARACTERISTICS

Manufacturers	EMD	GE
Cycle	2	4
CID/cylinder	567,645, 710	668
Hp/cylinder	200-270	same as EMD
Rated Speed (rpm)	900	1050
Configuration	V8, V12, V16	same as EMD
Cost (approx.)	$1-$2M	"
Life	500,000 to 1,000,000 miles	"

Recently, Caterpillar has been reconditioning locomotives used for local yard and switching operations and replacing the original prime movers with 3500 and 3600 series Caterpillar engines. The Caterpillar 3500 series engine is normally used for heavy off-road equipment and stationary applications. The 3500 series engine is designed to operate in the 200 psi BMEP range. It should be noted that both 3500 and 3600 series Caterpillar diesel engines are available in higher BMEP packages (up to 300 psi BMEP). However, the life expectancy of these engines is lower than the 500,000 to 1,000,000 mile target life for locomotive engines that operate under these high load levels.

The EMD locomotive engine is commercially available in diesel configuration only. No commercial natural gas-fueled EMD locomotives have been developed for railroad application. Burlington Northern, one of the four largest railroads in the United States, has recently developed a prototype EMD natural gas burning locomotive. This locomotive uses a small diesel pilot to initiate combustion and reportedly has a very high substitution rate with natural gas. Although no fuel economy or emissions data have been reported for this engine, Burlington Northern has demonstrated the feasibility of running natural gas in a locomotive. This technology will be discussed in the following section.

General Electric does not produce natural gas locomotives either. They recently announced that they are actively pursuing development of a natural gas locomotive and anticipate the first units being available for production within 12 to 24 months. No details on fuel economy or emissions levels have been released from GE at this time.

The Caterpillar 3500 and 3600 series locomotive engines have an advantage over EMD and GE with respect to natural gas operation. The 3500 series engine is currently available in natural gas configuration for a variety of applications. In fact, it has already been developed for low emissions using lean-burn technology. This lean-burn technology is currently being applied to the 3600 series engine at Caterpillar. Since the Caterpillar eight-cylinder 3608 is capable of developing 3,000 horsepower at 1,000 rpm on diesel fuel, it could hold great promise for natural gas railroad applications when available in a gas configuration.

One other engine must be included for the purposes of this report. The Detroit Diesel DDC 8V-149TI is planned for use as an auxiliary power generation engine on the EMD locomotives which will be delivered to the LA Basin in mid-1992. Emissions numbers were not readily available for this engine for the purposes of this report; therefore, emissions and fuel economy numbers from a similar engine being developed for low emissions at Southwest Research Institute (SwRI) were used for projecting fuel consumption and emissions generation from the DDC 8V-149TI engine. These emissions and fuel economy figures are listed below in Table 2.

TABLE 2. ESTIMATED PERFORMANCE AND EMISSIONS DATA FOR DDC 8V-149TI DIESEL ENGINE

Power Rating: 780 horsepower
Rated Speed: 1,800 rpm

Emissions (gm/hp-hr)	Load Factor (%)				
	0	25	50	75	100
NO_X*	11.0	10.4	9.5	9.0	9.4
CO*	10.2	2.1	0.7	0.6	0.8
HC*	3.2	0.9	0.6	0.5	0.4
PM*	0.4	0.2	0.1	0.1	0.2
BSFC* (lb_m/bhp-hr)	0.56	0.39	0.35	0.33	0.33

* Data not available for DDC 8V-149TI. SwRI used data for 15L, six-cylinder, TA model engine currently under development.

Technology Options

This portion of the report discusses natural gas engine technology options only. Clean diesel technology options are discussed later in this report. For the purposes of comparison, all emission reductions in this section and the following sections on clean diesel and aftertreatment options are based on the best level of emissions which have been achieved by EMD with the 12-710G3A engine to-date. This is the engine used in the F59PH locomotive. The baseline diesel data which are used throughout this chapter are shown in Table 3 below. These data were obtained from EMD and represent the best available emissions levels on today's production locomotives.

TABLE 3. BASELINE DIESEL EMISSIONS AND PERFORMANCE DATA

Engine Model: EMD 12-710G3A

			Emissions (gm/bhp-hr)				Fuel Consumption
Notch	RPM	Bhp	CO	NO_X	HC	PM	BSFC (lb_m/bhp-hr)
8	903	3196	1.23	9.51	0.11	0.23	0.35
7	823	2536	1.71	9.36	0.09	0.21	0.35
6	728	1696	0.83	10.71	0.11	0.25	0.36
5	650	1402	0.61	10.93	0.12	0.21	0.36
4	566	1053	0.29	12.01	0.13	0.23	0.36
3	489	717	0.26	13.88	0.17	0.3	0.37
2	342	372	0.34	15.04	0.22	0.31	0.38
1	342	209	0.54	15.94	0.40	0.17	.5
Idle	197	7.8	6.94	114.03	7.02	4	7
DB6	728	64.3	5.02	56.22	3.95	4	3
DB4	566	24.8	9.21	112.96	7.69	4	3
DB1	343	12.3	7.71	114.88	5.72	4	3

There are numerous technologies available for converting diesel truck engines to natural gas operation. Some of the results of these technologies have been reported by various researchers[2-15]. These results are not directly transferrable to locomotive engines due to the differences in engine design and operating conditions described in the previous section of this report.

Some data is available on the topic of running natural gas in locomotive engines[16]. Unfortunately, emissions were not a major concern for railroad engines at the time of this project, thus emissions measurements were not made.

Therefore, the projections for fuel economy and exhaust emissions contained in this report should be considered as preliminary estimates of the effect of converting diesel locomotives to natural gas operation. These estimates are based on published truck engine data and SwRI's appreciation of the difficulty in applying truck engine data directly to locomotive engines.

Five techniques are discussed that could be used to convert diesel locomotives to natural gas fuel.

1. Dual-fuel (with gas injection after valve or port closure)
2. 100 percent gas conversion (with spark ignition)
3. Medium pressure, early cycle injection of natural gas
4. High pressure, late cycle injection of natural gas
5. Re-engine the locomotive with a gas engine

Dual-Fuel

Conventional dual-fuel engines, when operating with pipeline quality natural gas, can provide approximately 80 percent of the full diesel power. The power is limited by detonation of the natural gas fuel. The Burlington Northern Railroad and Air Products, Inc. have stated that full diesel power has been achieved using 99 percent methane fuel.(17) No written reports are available that give details. This option will increase fuel consumption by approximately 10 percent. NO_x emissions will be approximately 80 percent of those achieved by diesel engines. (These values are SwRI estimates from previous research experience with these type engines.) Visible smoke can be reduced significantly with a well-designed dual-fuel system.

100 Percent Gas Conversion

The 100 percent gas option has the potential to reduce NO_x to only 20 percent of the current diesel version (i.e. from 12 g/bhp-hr NO_x to 2.5 g/bhp-hr). Fuel consumption will be increased a minimum of 20 percent due to the high flow-through characteristics described above. The main disadvantage is reduced power. Only 65 percent of current high-horsepower locomotive engine output can be produced with typical spark-ignited gas engines. While technology is expected to increase this amount in the future, the reduction in power may mean increased numbers of locomotives per train in the near term. This carries a negative impact on economic feasibility.

Medium Pressure, Early-cycle Injection

Injection of the gas after valve or port closure eliminates the possibility of flow-through of the fuel as described for the 100 percent gas conversion approach. However, early-cycle injection of the fuel leads to stratification of the fuel and air mixture. Stratification is difficult to control over the range of speeds and loads experienced by the locomotive. Therefore, a strong source of ignition is needed to initiate the combustion process.

This conversion is similar to the dual-fuel approach, except that a lower compression ratio is used and the diesel pilot is not used as a source of ignition. Instead of the diesel pilot, a spark-ignited, natural gas precombustion chamber is often used for ignition. By reducing the compression ratio and using a natural gas flame as the source of combustion, the NO_X emissions can be reduced by as much as 75 percent compared with the baseline diesel. A 25 percent power loss and 5 to 10 percent fuel economy penalty will likely be required to accomplish this reduction in NO_X.

Higher power levels can be produced with this approach, but a trade-off in NO_X emissions benefits will occur. Particulate matter and visible smoke emissions should be reduced at least 80 percent with this system, regardless of the power level.

This combustion system is used extensively for NO_X reduction in large stationary gas engines and SwRI has successfully applied this technology to urban bus and trucks for emission reductions.[2,15,18] Unfortunately, this technology has not been demonstrated in locomotives and is not directly transferrable to locomotive engines due to their higher BMEP levels. However, with the proper combustion development, this conversion could hold the greatest long term potential for NO_X reduction without an unacceptable increase in fuel consumption.

High Pressure, Late-Cycle Injection

The most promising near term technology for converting diesel locomotives is high-pressure, late-cycle injection of natural gas. This technology uses gas injection to "make gas burn like diesel fuel." A specially-designed injection system provides direct injection of the gas at approximately the same time diesel fuel would normally be injected. The engine is no longer limited in output by detonation (or knock), but rather by fuel mixing and smoke. Power equal to diesel is possible. The fuel consumption penalty will be minor, and will largely depend upon gas supply pressure. NO_X reductions of 40 percent of diesel have been reported. Reductions in compression ratio are necessary to achieve 40 percent NO_X reduction which does cause a slight penalty in fuel economy. A small ignition source, such as pilot diesel charge or glow plug, will probably be required. If properly designed, the engine can revert back to full power diesel operation for emergency back-up power.

SwRI pioneered late-cycle, high-pressure gas injection in locomotive engines under U.S. Department of Energy funding in 1986. Since that time, Wartsilla, Sulzer, and Mitsui have fielded large gas engines with late-cycle injection. The Gas Research Institute is currently funding research projects on this technology at Caterpillar and Detroit Diesel Corporation.

At this time, the high-pressure, late cycle injection technology holds the highest promise for near term gas substitution on railroad engines.

Re-Engine

To re-engine a locomotive to a gas engine is quite difficult since few engines will fit in the constraints of a locomotive frame. However, the option may exist to re-power with smaller dedicated natural gas engines from other applications, and use these locomotives strictly for yard switchers and local trains which require lower power. Since these engines are now fully developed for natural gas, the expected performance is similar to the 100 percent gas conversion.

Unfortunately, few natural gas engines can meet the physical requirements for retrofit into a locomotive. For example, let us examine two gas engines made by Caterpillar.

The Caterpillar 3516 diesel engine is offered by some remanufacturers for retrofit into smaller locomotives at rebuild. This 16-cylinder engine is offered at 2075 hp for locomotive use. Caterpillar also offers a natural gas version of this engine for stationary applications. This engine, however, is only offered at 1150 hp with natural gas fuel.

Caterpillar has also offered their larger 3600 series engines for locomotive operation. This large engine can barely fit within the confines of a locomotive. An 8-cylinder version, the 3608, is offered at 3300 hp at 1000 rpm. Caterpillar is also developing natural gas versions of this engine. A gas version of the 3608, if developed for locomotive applications, may be an option.

The other four options, dual-fuel, 100 percent gas conversion, medium pressure, early-cycle injection, and high pressure, late cycle injection each have trade-offs. Figure 2 quantifies these trade-offs of power, fuel consumption, and NO_x emissions relative to the diesel counterpart.

The following assumptions have been made for the purposes of calculating air quality benefits and cost-effectiveness of natural gas trains. First, the early-cycle injection, precombustion chamber gas engine was chosen for further comparison with the diesel locomotive since it represents the full potential for emissions reduction with natural gas. The relative differences in fuel economy and emissions of the gas locomotive compared with the diesel baseline are shown below:

TABLE 4. ASSUMPTIONS FOR GAS LOCOMOTIVE PERFORMANCE COMPARED WITH BASELINE DIESEL LOCOMOTIVE

Emissions	Reduction with Gas
NO_x	75 percent
PM	80 percent
Fuel Economy	(5 percent)*
* Increase in fuel economy for gas engine assumed to be 5 percent of diesel baseline.	

GAS LOCOMOTIVE TECHNOLOGIES

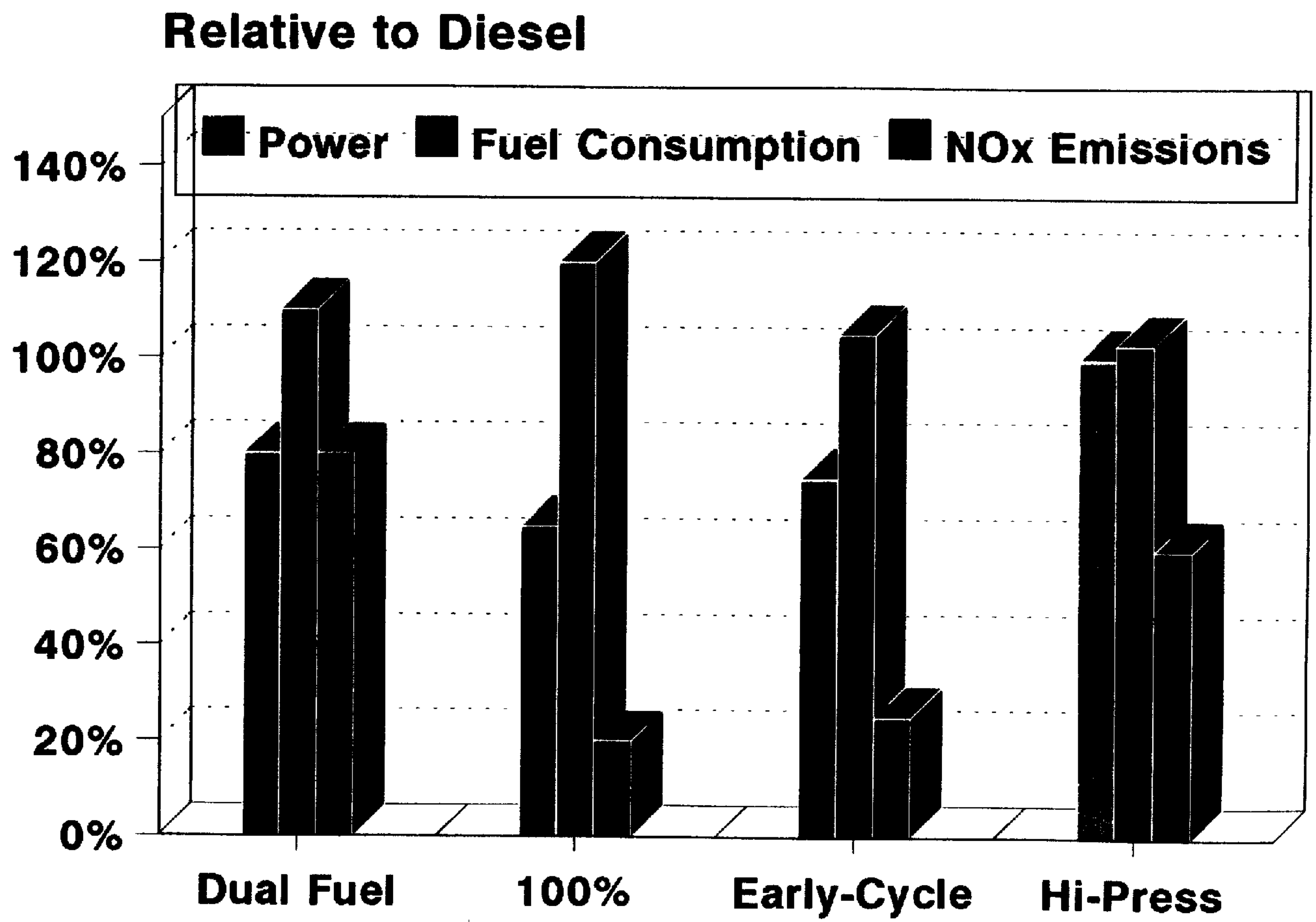

FIGURE 2

Power for the gas locomotive was assumed to be equal to the baseline diesel locomotive for the purposes of this study.

Second, the 100 percent gas conversion was chosen for comparison with the diesel DDC 8V-149TI since this engine does not have the same flow-through characteristics of the locomotive diesel engines. The relative differences in fuel economy and emissions of the gas auxiliary engine compared with the baseline diesel DDC 8V-149TI are shown below:

TABLE 5. ASSUMPTIONS FOR GAS AUXILIARY ENGINE COMPARED WITH BASELINE DIESEL DDC 8V-149TI ENGINE

Emissions	Reduction with Gas
NO_x	75 percent
PM	80 percent
Fuel Economy	(5 percent)*
* Increase in fuel economy for gas engine assumed to be 5 percent of diesel baseline.	

Power for the gas auxiliary engine was assumed to be equal to the baseline diesel for the purposes of this study.

Fueling Logistics

Five scenarios have been identified for refueling and storing natural gas fuel on commuter trains. Table 6 lists these scenarios.

TABLE 6. NATURAL GAS FUELING SCENARIOS

Fuel Type	Refueling - Storage
CNG	Cylinders on locomotive - two compressor stations
CNG	Cylinders on locomotive - one compressor station
LNG	Removable tank "cage" on locomotive
LNG	Tanks permanently mounted on locomotive
LNG	Fuel tender

The following describes these scenarios in regard to tankage, compressors, and LNG liquefaction.

The typical commuter locomotive carries 1500 gallons of diesel which provide an excess capacity for the daily round trip. Based on the fuel consumption for the EMD 3000-hp F59PH passenger locomotive, each commuter train operating according to a specific notch schedule will use between 60 and 500 gallons of diesel fuel for the daily round trip. Assuming a diesel fuel specific gravity of 0.875 and a lower heating value of 18,250 BTU per pound, this translates into an energy consumption of 8 to 67 million BTU per locomotive for the round trip.

Total diesel fuel consumption for all nine commuter routes is estimated at 4.3 million gallons/year after intermediate service is established for all routes. A fuel consumption breakdown for each route is given in Table 7.

TABLE 7. DIESEL FUEL CONSUMPTION FIGURES FOR EACH COMMUTER ROUTE

Route	Daily Fuel Consumption Per Locomotive (gallons/day)		Annual Fuel Consumption for Entire Route* (gallons/year)
	Start-up	Intermediate	
2	285	338	702,216
3	204	245	508,880
4	183	216	224,788
5	421	500	1,039,696
6	297	352	457,095
7	316	374	389,136
8	200	236	245,972
9	297	352	731,600
10	60	71	73,556
		Total	4,372,939

* Based on intermediate service with no electric or other alternative fuel operations

CNG & LNG Technologies

Compressed Natural Gas

One method for storing the fuel on the train is as a compressed gas.

Tank Requirements

Comdyne I, Inc. (located in West Liberty, Ohio) manufactures a CNG tank with a capacity of 2,800 standard cubic feet (SCF) of gas at 3,600 psi. This tank has a length of 8.5 feet and a diameter of 19 inches.

Figure 3 shows the relevant dimensions of an EMD F40PH locomotive[(19)] (which is smaller than the F59PH), and illustrates one possible tank arrangement which would allow 24 tanks to be installed on the locomotive. Detailed specifications on this locomotive are included in Appendix B. This arrangement would involve removing the existing 1,500 gallon diesel tank and relocating the air brake equipment and batteries. A new location for the air brake equipment and batteries will need to be determined. The space currently occupied by the fuel tank and batteries could be retrofitted with two nests of CNG tanks which hold 12 tanks each (see Figure 3). Using 140 SCF of natural gas per gallon diesel, this approach allows the locomotive to carry 480 gallons diesel equivalent of natural gas. This fuel capacity will allow all of the trains to make one round trip per day without refueling (except for Route 5 after reaching intermediate service). If this fuel capacity is insufficient for the required range, a gas compressor could be located at each end of the commute, effectively doubling the train's driving range. A third alternative for refueling is to convert the CNG storage system to LNG. This approach is discussed later in this report.

SwRI recommends that the tanks be mounted to the train in a permanent fashion, should the CNG option be pursued. The diesel tankage would be removed except for the possible requirements of a diesel pilot charge for a dual-fuel engine. The batteries and air brake equipment would need to be relocated on the locomotive. We estimate the dual-fuel diesel requirement to be approximately 100 gallons for commuter application. This would allow the train to limp home in the event of a gas fuel system failure.

Compressor Requirements

Two scenarios exist for refueling the trains with CNG. The first scenario includes using two gas compressors for refueling at each end of the commute. The other option consists of using only one compressor for refueling at one end of the route. Naturally, this compressor will need to have twice the capacity of the compressors in the first scenarios. The selection of which scenario makes the most sense will be dependent on the specific driving range required for each commuter route. This topic is discussed in more detail below.

The locomotive compressor requirements will vary according to the amount of time available for the refill, the compressor size and the storage capacity at the refueling station. Refueling station storage capacity must exceed the fuel capacity for each train, otherwise the compressor would be required to operate and fill the trains by itself in the allotted time. This requirement would increase the size and cost of the compressor unnecessarily.

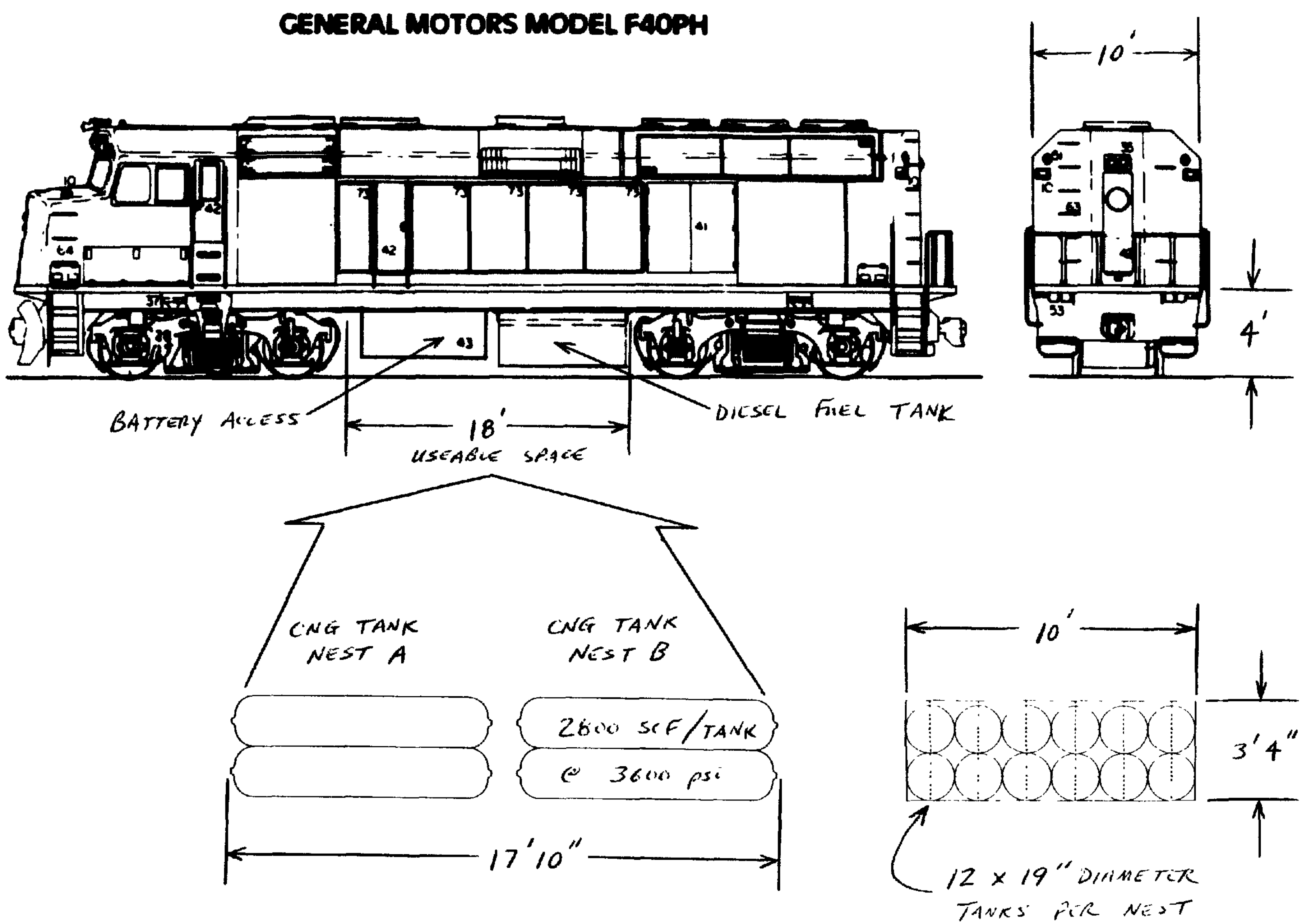
GENERAL MOTORS MODEL F40PH
10'
4'
BATTERY ACCESS
18'
USEABLE SPACE
DIESEL FUEL TANK
CNG TANK
NEST A
CNG TANK
NEST B
2800 SCF/TANK
@ 3600 psi
17'10"
10'
3'4"
12 x 19" DIAMETER
TANKS PER NEST

FIGURE 3

Assuming a total of five locomotives during start-up service, the total gas required for the San Bernardino - LA service is approximately 110,000 for the one way trip. A compressor capacity of 100 SCF per minute (SCFM) at an inlet pressure of 50 psi and an outlet pressure of 4000 psi is required. This compressor would operate about 20 hours per day at approximately 75 hp consuming 1,500 hp-hr per day. An engine-driven compressor of this size could be used with a thermal efficiency of about 26 percent, resulting in a gas consumption of 775 cubic feet per hour for a daily use of 15,500 SCF of gas for compression. The compressor would operate for about 20 hours to fill a cascade type storage system and the locomotives would be refilled in a four hour window from the cascade storage system.

The requirements for one compressor at one end of the commute is essentially double that required of the compressor at each end of the commute. The compressor would need to deliver 200 SCFM, operating at 150 horsepower for 20 hours per day 3,000 hp-hr per day. For the gas driven unit, 1550 cubic feet gas would be consumed per hour for a daily use of 31,000 cubic feet of gas to compress the fuel. The same "rule of thumb" would apply for increasing the cascade storage capacity.

Refueling Time

Calculations were made for the period of time required for the gas compressor to fill the permanent storage tanks with CNG for refueling the locomotives. If a 20-hour period of time is acceptable for filling the permanent storage tanks, a 100 SCFM compressor will be required at each end of the San Bernardino - LA commute during start-up service. For a 10-hour filling period, twice the original compressor capacity will be needed. For a 20-hour filling time with one compressor located at one end of the commute, a 200 SCFM compressor will be needed.

Since all of the trains will be together at one location during the day, and another location at night, the trains would refill at the same time. Permanent cascade-type storage tanks will be required to discharge the compressed gas into the trains. The number of storage tanks is roughly dependent on the number of tanks on-board the trains and the required locomotive refueling times. The number of permanent tanks should exceed the number of tanks on the trains by a factor of three for equal bottle size. The pressure of the permanent tanks should exceed that of the final train tank pressure by 120 percent to insure full tank pressure for the bottles on the train.

Liquified Natural Gas

Maintaining the fuel in its liquid state is a second fuel storage method. For liquified natural gas (LNG), the energy density is substantially better than CNG. Moreover, the LNG tank volume capacity requires only half that of the CNG scenario.

Three separate LNG tank scenarios are discussed. The differences among them are the method of filling the tanks and the installation of the tanks on the locomotive. The first approach is to mount the LNG tanks in a cage. This cage would be placed with a fork truck into the area of the present diesel fuel tank after each fill. The cage would contain three super-insulated tanks of 200 gallon LNG capacity each that would maintain the LNG at a temperature of -260 F with a boil-off* of only 1/2 percent per day. One gallon of diesel fuel is equivalent to 1.75 gallons of LNG; therefore, each tank cage (600 LNG gallons) would contain the diesel equivalent of 300 gallons of fuel (allowing for 10 percent ullage in the tank to contain the tank boil-off). These cages would contain all the necessary equipment to control tank pressure, all the required valving for fill and emptying, all the needed safety devices, and would represent a self-contained package to be placed aboard the locomotive much in the same way as a battery is placed in an automobile. The fuel tank charging would take place in the form of a refill overnight. The tanks would be removed periodically to empty any heavy constituents that may concentrate over a long period of time, where the tanks would never be allowed to warm to the boiling point of the heavy constituents such as ethane, propane, butane or any grouping usually classified as natural gasolines.

LNG could be produced at locations such as the production facility in Sacramento, or at the peak shaver facility near Reno, Nevada. The LNG could be shipped in from these plants to the filling site on tractor trailer units of about 10,000 gallon capacity, or on rail using super-insulated tanks in both cases. These tank units could act as storage units for a bi-weekly fill basis (in the case of the 10,000 gal. trailer), thus precluding the capital expenditure required for a permanent LNG storage tank. Shipments of approximately 400 miles would add roughly $0.10 to the cost of a gallon of LNG. Assuming three trailers were used to service the trains, a backup trailer would be available to prevent unforseen interruption of the shipments. Fill times using this method would be roughly equal to that of the same amount of diesel fuel.

A second LNG scenario, very similar to the first, would use a set of three tanks that would be permanently mounted to the locomotive. The same requirements for tank controls would apply as those of the cage tanks. The filling and emptying operations would be done on-board the locomotive, thus requiring more careful records of each locomotive to be kept.

The third LNG scenario would consist of storing the LNG on board a "fuel tender." This case would allow the capacity of the tender car to carry as much LNG as necessary and to act as a fueling depository or a transport device if necessary. This option does not appear

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* Boil-off here refers to the percent of liquid fuel that boils to a gaseous state, not necessarily the fuel quantity that is vented from the insulated tank. Boil-off is a continuing process that is a function of heat transfer from the surroundings, through the insulation, and into the fuel. Venting is a function of boil-off rate and tank pressure capability. Tanks must be selected that will not vent for 14-28 days from last fuel usage from the tank.

necessary for commuter trains, but is expected to be the most feasible approach for freight application.

Tank Costs - LNG tanks in the range of 200 gallon capacity cost approximately $7,500 each. Tanks in the range of 10,000 gallons for trailer transport cost approximately $350,000 each. Permanent LNG storage tanks in the 10,000 gallon range cost about $150,000 each, not including land costs, site engineering, and permitting costs. A 20,000 gallon LNG tender would be about the same cost of the 10,000 gallon LNG trailer.

Liquefiers - Liquefiers of the capacity found in peak shaver LNG plants can be constructed for $5 to $50M, based on capacity**. Liquefiers can be purchased for less; however, the efficiency decreases and operating costs increase with the smaller liquefiers.

Safety-Related Issues

SwRI recently conducted a world-wide literature search and industry survey to determine the safety record of natural gas vehicles (NGVs) for a foreign client.[20] Data was collected which represented over 7,100 NGVs that had travelled a total of over 434 million miles and compared with the national fleet average for gasoline vehicles in the U.S.. The results of this study indicated a remarkable safety record for natural gas.

We were unable to identify one single incident where natural gas had contributed to the death of even one person. On the other hand, there were a large number of deaths which were attributed to gasoline as an on-board fuel. The lack of deaths associated with the use of natural gas as a vehicle fuel is most likely a result of the fact that natural gas is lighter than air. When a fuel tank is punctured, or ruptured, in the case of a collision, the fuel is released into the atmosphere where it is quickly dispersed and naturally removed from the scene of the accident. Liquid fuels and some gaseous fuels (such as butane and propane) do not "float" away. Instead, they remain at ground level near the accident and mix with the air forming a highly flammable mixture. In many cases, this mixture is ignited from a cigarette or electrical discharge of some type.

The primary safety issue with natural gas as a railroad fuel is not a technical issue, although certain guidelines must be followed for equipment design and fuel handling. The big problem is public perception. Although natural gas is widely accepted for use in homes where leaking gases cannot escape as easily as in the case of vehicles, there is a public resistance to placing compressed natural gas on vehicles. This is particularly true regarding public transportation, even though several successful natural gas projects are currently underway at SCRTD, Houston METRO, and others.

***LNG Information Book 1981*, Operating Report Section, American Gas Association, Catalog No. X00981.

Los Alamos has recently completed an in-depth safety study addressing natural gas as a railroad fuel.[21] This study has just reached the public domain and is expected to provide a more scientific basis for evaluating the safety-related issues with gas as a railroad fuel.

Safety-related issues which merit further investigation include crashworthiness of locomotives and fuel tenders, fuel handling, fire and explosion hazards, etc..

Implementation Schedule

Nine commuter routes have been selected for initial passenger rail service in the LA Basin. Table 8 identifies each of these commuter routes by number, destination, and distance. Table 9 describes the implementation plan for start-up and intermediate diesel service on each route. More detailed information on each route is provided in Appendix C, including the estimated time at each notch position for each route.

TABLE 8. COMMUTER ROUTE IDENTIFICATION

Route*	Service	Length (miles)
2	San Bernardino - LA	56.5
3	Ventura - LA	47
4	Santa Clarita - LA	35
5	Oceanside - LA	87.2
6	Riverside - LA (Ontario)	58.8
7	Riverside - LA (Fullerton)	62.8
8	Hemet - Riverside	39.6
9	San Bernardino/Riverside - Irvine	59
10	Redlands - San Bernardino	12

* Corridors used in accelerated electrification study.

As Table 10 illustrates, gas locomotives are not expected to be available until mid-1993. A mix of new gas locomotives and retrofitted gas conversions have been selected for implementation due to the manufacturing constraints of the locomotive builder and the current plans for adding locomotives to each of the commuter routes.

Air Quality

Nine commuter routes have been selected for analysis in this study. These commuter routes are identified in Table 8. More detailed information on these routes can be found in Appendix C.

Emission Characteristics

The emissions benefit of converting railroads to electricity, natural gas, or other alternative fuels is higher for freight applications than commuter railroads. The increased emissions benefit for freight applications is due to two reasons: 1) the higher load factor and the resulting higher NO_X emissions for freight compared with commuter rails, and 2) the higher utilization of capital equipment for freight compared with commuter trains.

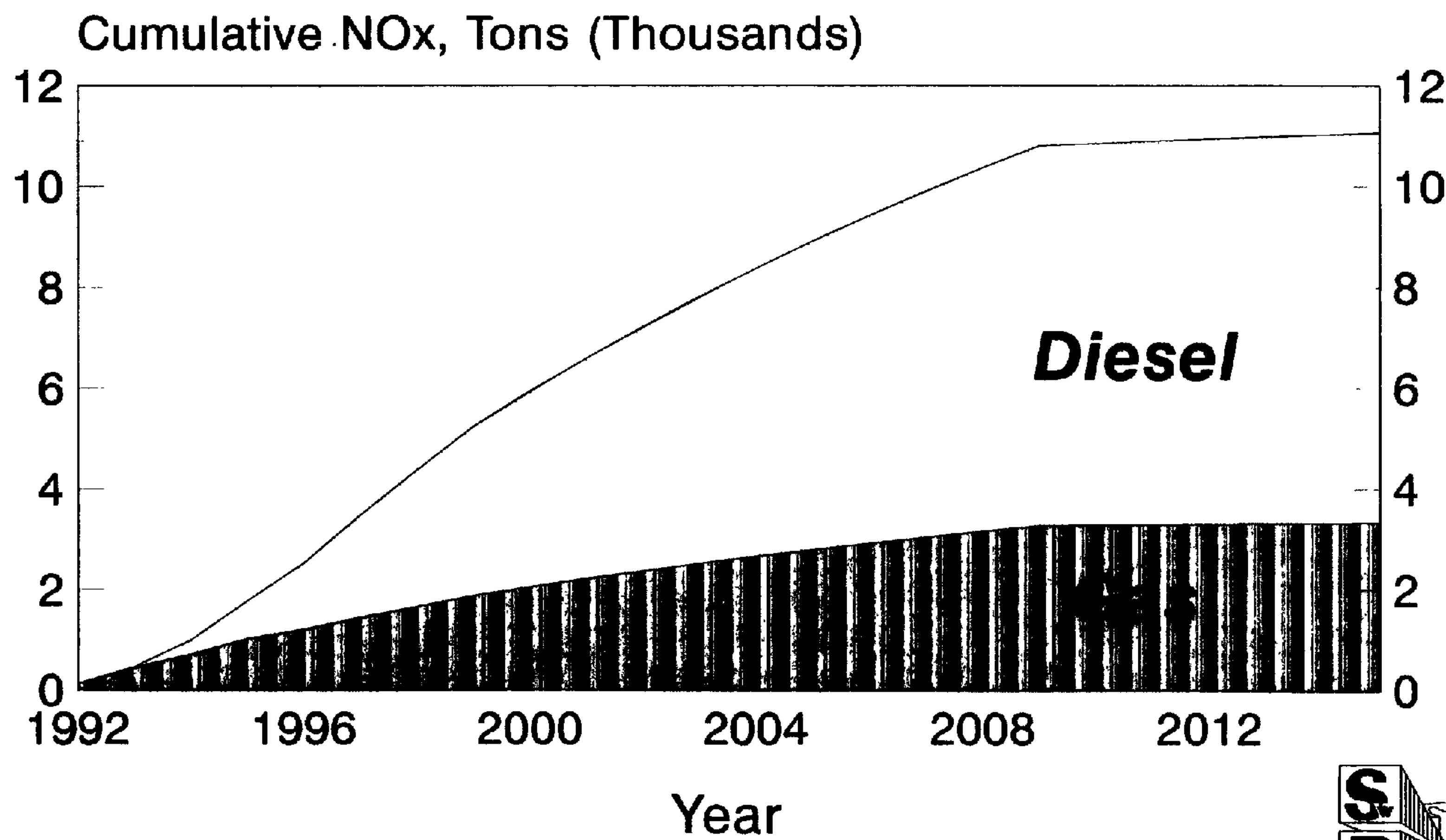
Emission characteristics were calculated for the baseline diesel trains and the gas locomotives based on the data included in Tables 2, 3, 4, and 5, and the implementation schedule described above. The 1991 AQMP plan for electrification of the commuter trains was also taken into account which calls for 15 percent electrification by the year 2000, and 90 percent electrification by the year 2010. Emission characteristics were also based on the assumption that diesel emissions will decrease 5 percent each year beginning in 1996. The same assumption was made for decreasing emissions from gas locomotives.

Due to the very low levels of HC and CO emissions on the baseline diesel locomotive (see Table 3), no reduction in these pollutants is expected when converted to natural gas. non-methane hydrocarbons will be equal to, or greater than, the baseline diesel HC emissions depending on the gas engine technology used. CO emissions should be equal for the natural gas and diesel engines.

The emphasis of the air quality analysis is on NO_X emissions. Particulate emissions will be reduced dramatically with natural gas, but their overall contribution to the LA Basin air pollution problem is considered negligible compared with NO_X emissions. HC and CO emissions are not discussed any further due to the small difference between natural gas and diesel locomotives.

Figure 4 shows the cumulative NO_X emissions for the diesel and gas scenarios according to the implementation schedule described above for the nine commuter routes. This figure illustrates identical NO_X emissions for the diesel and gas trains during 1992 and most of 1993 due to the assumption that gas locomotives will not be introduced until mid-1993.

CUMULATIVE NOx EMISSIONS
Diesel and Gas LA Commuter Trains



Based on 1991 AQMP Plan, File: CH8-001
Baseline Diesel vs Early-Cycle Injection Gas Locomotive
Estimated Values Based on 9 Commuter Line Profiles

FIGURE 4

Figure 4 shows that diesel trains will emit as much as 6000 tons of NO_X by the year 2000 compared with only 2000 tons NO_X if gas locomotives are implemented according to the suggested schedule. Table 11 illustrates the total emissions levels per day and per year from each of the nine commuter routes with diesel and gas locomotives in the year 2000.

TABLE 11. EMISSIONS CHARACTERISTICS FOR INDIVIDUAL COMMUTER ROUTES IN YEAR 2000

Route	NO_X Emissions Tons/Day (Tons/Year)	
	Gas	Diesel
2	0.154 (40.2)	0.618 (160.8)
3	0.113 (29.4)	0.452 (117.6)
4	0.049 (12.9)	0.198 (51.5)
5	0.23 (59.8)	0.918 (238.6)
6	0.101 (26.2)	0.402 (104.6)
7	0.086 (22.4)	0.342 (89.0)
8	0.054 (14.0)	0.216 (56.3)
9	0.161 (41.9)	0.644 (167.4)
10	0.016 (4.2)	0.065 (16.8)

* Does not include 5 percent emissions reduction per year beginning in 1996.

Emission Reductions

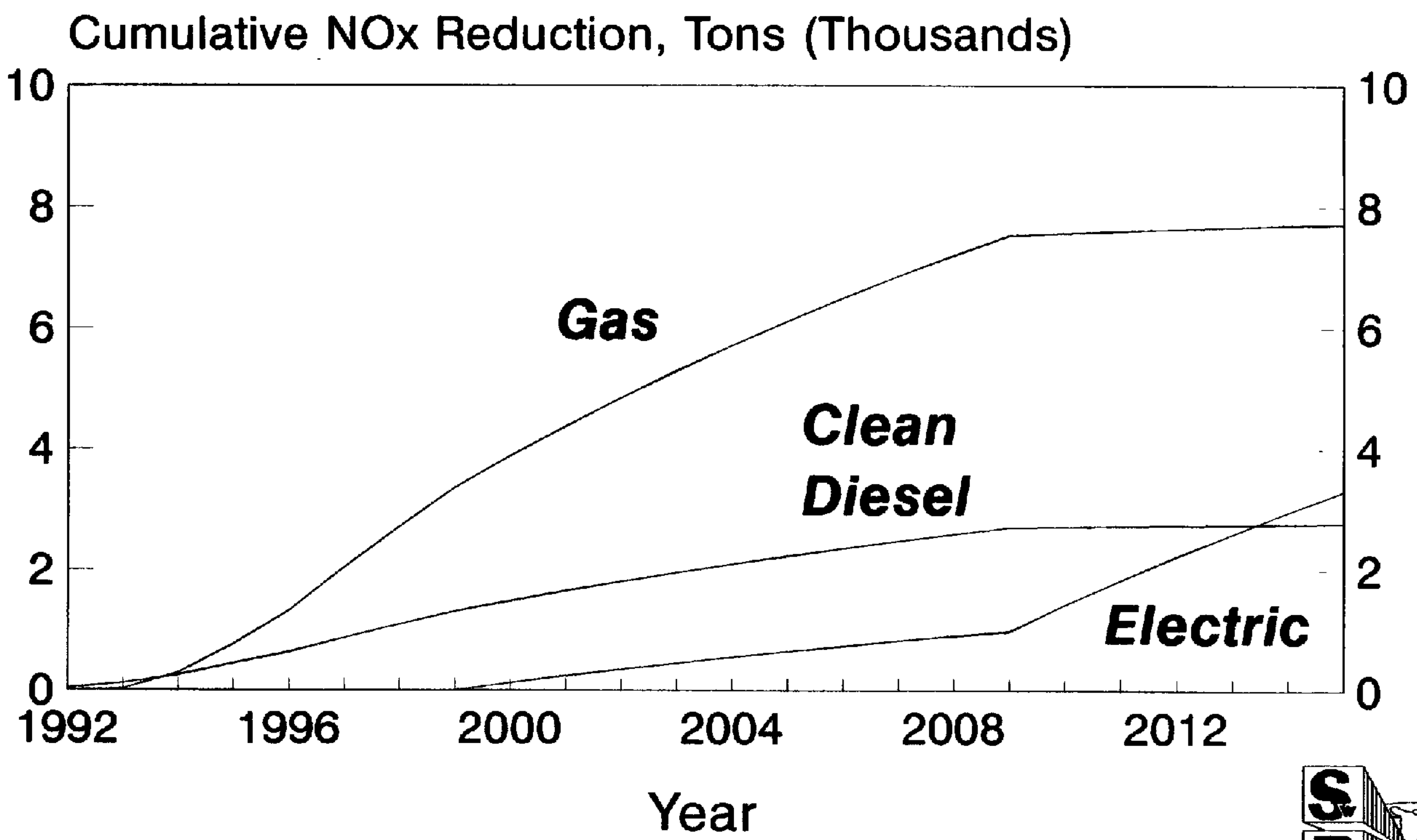
Figure 4 illustrates that gas locomotives can eliminate as much as 7,500 tons of NO_X in the LA Basin by the year 2010 compared with diesel trains according to the assumptions and implementation plan outlined above.

Figure 5 illustrates the cumulative emission reductions that have been estimated for the natural gas, clean diesel, and electric trains. These estimates did not include electric power plant emissions. Therefore, the electric trains were treated as true zero emissions vehicles.

Figure 5 indicates the lack of emission reductions for the electric trains during the next 10 years due to the lead time required to put catenaries, sub-stations, and other electric systems into place. Gas locomotives show an impressive ability to reduce emissions during

NOx EMISSION REDUCTIONS

Electric, Clean Diesel and Gas LA Commuter Trains



Based on 1991 AQMP Plan, File: CH8-002
Derived from Baseline Diesel & Early Injection Gas Engine
Estimated Values Based on 9 Commuter Line Profiles

FIGURE 5

the next 10 to 15 years due to their estimated 75 percent reduction in NO_x emissions and near-term implementation capability. Although clean diesel can be implemented immediately, its relatively low effectiveness (i.e., 25 percent NO_x reduction) yields a much lower emissions benefit compared with natural gas.

Table 12 compares the emissions reduction potential of electric, clean diesel, and gas compared with the diesel baseline. These numbers indicate the benefit of converting each of the nine commuter routes completely to alternative fuel after all commuter routes have achieved intermediate service. No consideration is given to partial electrification for the purposes of this comparison.

The data in Table 11 and Table 12 show that Routes 2, 5, and 9 represent the greatest sources of emissions and the greatest potential for emissions reduction by conversion to natural gas or electricity.

Table 13 gives the NO_x emissions reduction for each of the commuter routes in tons per passenger-mile using clean diesel, gas, and electricity.

Unlike the data in Tables 11 and 12, these data in Table 13 show a surprising similarity between each of the routes in the effectiveness of NO_x reduction when compared on a ton per passenger-mile basis.

TABLE 12. DAILY AND ANNUAL NO_X EMISSION REDUCTIONS FOR INDIVIDUAL COMMUTER ROUTES AT INTERMEDIATE SERVICE LEVEL

Route	NO_X Emissions Reduction Tons/Year [$/Ton]		
	Clean Diesel	Gas	Electric
2	27.1 [194]	120.5 [5,687]	160.7 [98,112]
3	19.2 [198]	88.2 [7,452]	117.6 [114,236]
4	8.6 [194]	38.6 [8,950]	51.5 [184,851]
5	40.0 [195]	179.0 [4,043]	238.7 [97,055]
6	17.6 [195]	78.5 [5,574]	104.6 [147,886]
7	15.0 [194]	66.8 [5,304]	89.0 [181,213]
8	9.5 [194]	42.2 [8,258]	56.3 [188,481]
9	28.2 [195]	125.6 [5,504]	167.4 [97,773]
10	2.8 [194]	12.6 [26,782]	16.8 [239,601]

* Assumes complete conversion to each of the alternative fuels from the baseline diesel, 260 day per year operation.

TABLE 13. EMISSION REDUCTIONS FOR INDIVIDUAL COMMUTER ROUTES AT INTERMEDIATE SERVICE LEVEL ON A TONS/PASSENGER-MILE BASIS

Route	NO_X Emissions Reduction* Tons/Passenger - Mile) $X10^{-6}$		
	Clean Diesel	Gas	Electric
2	0.10	0.46	0.62
3	0.085	0.41	0.54
4	0.097	0.49	0.65
5	0.10	0.45	0.60
6	0.11	0.46	0.62
7	0.11	0.47	0.62
8	0.11	0.46	0.63
9	0.11	0.46	0.62
10	0.095	0.47	0.57

* Assumes complete conversion to each of the alternative fuels from the baseline diesel.

Cost Analysis

This study addresses two primary costs: the capital cost required to install new commuter and freight rail service in the Los Angeles Basin, and the operating and maintenance expenses associated with the new rail service. The cost of these two items varies significantly depending on the energy source selected for powering the commuter trains (i.e., diesel, gas, or electric). For example, electric power has an extremely high capital cost compared with natural gas and diesel fuels. Natural gas has slightly higher initial costs than diesel but potential for lower operating expenses primarily due to the difference in fuel costs. In addition to these costs, the financial cost effectiveness and air quality cost effectiveness are also discussed in this section.

Capital Costs

The LACTC has begun a program to increase the number of commuter trains in the Los Angeles Basin in the near future. This program includes the purchase of 17 new diesel locomotives which will be delivered in mid-1992. The purpose of this cost analysis it to put into perspective low emissions alternatives to diesel trains such as natural gas and electricity.

This cost analysis compares the diesel locomotive commuter rail program which is currently in progress with other alternatives such as natural gas and electrification.

Diesel

The primary capital cost associated with diesel commuter rail service is the cost of the locomotives themselves. These locomotives are estimated to cost approximately $2M each when purchased from the Electro-Motive Division (EMD) of General Motors in a quantity of 17 locomotives (such as those to be delivered in mid-1992). These locomotives will be rated at 3000 hp and used to initially establish three commuter route services. Current plans call for 12 of these locomotives to be used on three commuter lines, which will allow three locomotives to be used for back-up service (one each for each commuter line). Two spare locomotives will be available for miscellaneous requirements. Since the capital cost of the passenger cars will be virtually identical for the diesel, natural gas, and electric scenarios, their costs are not included in this study. Table 9 shows the schedule for start-up and intermediate service of each of the nine commuter routes.

Additional capital costs required for the diesel commuter service will include ticket counters and other facilities for the new commuter services. These costs will be required for all three types of fuel. So, once again, these capital costs will be omitted since they are expected to be the same for each of the three energy sources. Finally, the current program to expand the commuter rail service in the Los Angeles Basin will use existing trackage. Therefore, the capital costs associated with new or renovated trackage is expected to be nominal in the case of the diesel and natural gas commuter rail services.

Natural Gas

When natural gas is used as a means of reducing the emissions from these commuter trains, additional capital costs will be incurred compared with the diesel baseline. Additional capital costs for the natural gas trains include the following:

(1) New engine (or combustion systems) to allow the locomotive to operate on natural gas fuel
(2) CNG or LNG fuel storage tanks on-board the train
(3) New refueling infrastructure (CNG or LNG)

Several combustion systems could be applied to the diesel engine to operate on natural gas. These combustion systems are discussed in more detail in the Technology section, but will also be discussed here for the purposes of the cost analysis.

The least expensive gas combustion system would be a dual-fuel system where the original diesel fuel injection system remains in place and natural gas is substituted in order to displace the use of diesel fuel. This type of combustion system has the potential to reduce particulate emissions by 40 to 60 percent, but will provide only a 20 percent NO_X reduction compared with pure diesel fuel operation. SwRI estimates that a dual-fuel system could be designed and installed on the EMD 12-710G3A locomotive engines for approximately $250,000 per locomotive.

The next level of complexity would include the removal of the diesel fuel injection system and replacement with a spark ignition combustion system. This conversion would allow the engine to run on 100 percent natural gas and would require combustion chamber modifications in order to reduce the compression ratio and optimize the combustion chamber geometry for operation on natural gas. This type of combustion system should be achievable using existing gas engine technology at a cost of approximately $500,000 per locomotive depending on the level of sophistication of the engine control system. Since approximately 35 percent less power is available with this combustion system, multiple locomotives per train may be needed, thus significantly increasing capital cost. The capital cost of additional locomotives for this engine technology has not been included in this study.

A third option to convert the diesel locomotive to natural gas is early-cycle injection of the gas. This system will require a reduction in compression ratio and retrofit with an ignition system and precombustion chamber. This type of combustion system will require substantial development on a locomotive engine and is expected to increase the original diesel locomotive cost by approximately $500,000. A power loss of up to 25 percent may be experienced with this conversion. However, the capital cost of additional locomotives potentially needed for this technology has not been included in this study.

Finally, the most promising near term natural gas combustion system involves the direct injection of natural gas into the cylinder under very high pressure similar to the diesel fuel injection system. This combustion system is currently under research and has been applied to large bore engines, but has not yet been commercially used in locomotives. This combustion system will require optimization of the fuel injection system and combustion process. Once this technology is available, an estimated retrofit cost of $150,000 to $300,000 per locomotive is considered possible for this combustion system.

One other interesting possibility for the natural gas powering of commuter trains in the LA Basin exists. Generation II Locomotive (Minneapolis, Minnesota) has developed a successful engine retrofit for GP-15 through GP-30C locomotives. This retrofit includes the complete renovation of the locomotive and re-engining with a Caterpillar 3516 diesel engine rated at just over 2,000 horsepower. Retrofitted locomotives from Generation II Locomotive range in cost from $800,000 to $900,000 in diesel configuration. However, since low emissions, lean-burn, natural gas combustion and control systems already exist for the 3500 series Caterpillar stationary engines, a remanufactured locomotive could be obtained from Generation II Locomotive operating on natural gas at an estimated cost of approximately $1.5M. The disadvantage of this approach is the reduced horsepower on gas (1,150 horsepower) compared with the 3,000 horsepower EMD 12-710G3A diesel engine. If this reduction in power output can be overcome, then the capital cost to put a natural gas locomotive in place could actually be similar to the cost of the new EMD 12-710G3A diesel engines.

Several options exist for locating fuel storage tanks on the commuter trains to store liquified natural gas (LNG) or compressed natural gas (CNG). For LNG, the existing diesel fuel tank can be removed and replaced with a 600 gallon capacity LNG fuel system. This fuel system would include three LNG tanks. Each tank would have a capacity of over 200 gallons LNG at a cost of approximately $7,500 each. Thus, the LNG fuel tank costs for each train would be in the range of $25,000. This feasible fuel storage approach allows the fuel to be stored on the locomotive and does not require a fuel tender or additional rail car for carrying fuel. For CNG, roughly twice the storage volume of LNG will be required which will make complete storage of CNG on the locomotive more difficult. The Fueling Logistics Section discusses this topic in more detail. The cost for an equivalent on-board fuel storage capacity using CNG tanks is approximately $48,000 per train.

Please note that CNG is considered an option for fuel storage on most of the commuter routes studied. However, due to the vehicle range required for freight rail application, LNG appears to be the only feasible choice for storing natural gas. Air Products & Chemicals, Inc. has recently designed and built a prototype 20,000 gallon LNG fuel tender for rail application. The purchase price of similar LNG tenders is expected to be in the range of $275,000 - 325,000.

In today's fast moving alternative fuels environment, the options for buying or leasing refueling stations is virtually unlimited. For LNG, several options are available. One option includes shipping LNG from an existing liquefaction plant in Sacramento, Reno, or Las Vegas. The capital costs associated with this approach include the purchase of on-highway tankers which are expected to cost $350,000 each for a capacity of 10,000 gallons of LNG. This strategy is described in more detail in the Fueling Logistics section. An alternative approach toward LNG fuel supply would be to install one or more central liquefaction plant(s) in the Los Angeles Basin to supply LNG for the commuter trains. The capital cost to install a reliable liquefaction plant is on the order of $5M to $50M.

For CNG, relatively inexpensive slow-fill compressor stations could be installed at each of the commuter rail yards to fill the trains overnight since they will not be used during the night hours. The cost of a 150 SCFM CNG compressor is in the range of $225,000 and could be expected to provide a sufficient gas supply for five trains.

Electric

Electrification capital costs are extremely high. These capital costs include overhead catenary structures for distributing the electrical power along the railroad line, power substations which are typically located approximately 15 miles apart along the railroad track, and extensive civil engineering and construction (such as raising bridges and lowering the track to pass through tunnels to allow ample overhead space so the electrical power does not ground out). Immunization, or EMI shielding, is another substantial capital cost which must be addressed and will be a critical issue in the LA Basin area. Immunization is necessary to prevent the interference of the high voltage power lines with business computers, residential computers, and other electronic equipment. Additional "right-of-way" purchases for electric tracks also represents a major capital cost. Finally, the cost of the electric locomotives are much higher than the diesel or natural gas locomotive costs.

Table 14 illustrates the capital costs predicted by Booz-Allen, and Hamilton in January of 1991 for electrifying rail service in the Los Angeles Basin Area.

TABLE 14. ELECTRIC TRAIN SYSTEM CAPITAL COSTS

Component	Unit	Unit Cost
Catenary	per track mile	$200,000
Substation	per track mile	$266,000
Civil Works	per track mile	$500,000
Immunization	per track mile	$200,000
Locomotive	each	$4,000,000
	TOTAL	$1.2M per track mile (not including locomotive costs)

Additional data on installing electric rail service in the United States has recently become available. AMTRAK is planning to expand electrification of its northeast corridor (New York City to Boston) at an estimated cost of $1.4M per track mile, not including trains. AMTRAK currently offers electric commuter rail service from New York City to New Haven, Connecticut. However, continuing rail service from New Haven to Boston is powered by diesel. In order for passengers to commute from New York to Boston, or vise versa, they experience a delay in New Haven, where the electric locomotive is switched with a diesel locomotive. This switching operation adds excessive time to the commute and places additional operating costs on AMTRAK due to the need to maintain two different operating lowering tunnels) and immunization where necessary. The $225M does not include the purchase cost of electric locomotives.

The most recent estimates of the capital cost to install electric railroads in the LA Basin range from $2M to more than $6M per track mile. A capital cost of $2M per track mile has been assumed for this analysis. This cost includes all electric system costs except the purchase price of the locomotives which are assumed to be $4M each.

A comparison of the capital costs used for this analysis is given in Table 15.

TABLE 15. CAPITAL COST ASSUMPTIONS

LA Basin Commuter Trains			
Energy Source	**Electrify (track mile)**	**Locomotive (each)**	**Refueling (per Route)**
Electric	$2M	$4M	n/a
Diesel	n/a	$2M	n/a
Gas*	n/a	$2.5M	$1.1M (LNG) $300,000 (CNG)

* Natural gas fuel tanks will also be required for gas. LNG tanks are estimated to be approximately $25,000 per train. CNG tanks are expected to be approximately $48,000 per train.

Operations and Maintenance Costs (O&M)

Diesel

Diesel locomotives have three major operating costs. The first cost is diesel fuel and oil consumption. Today's low sulphur diesel fuel costs approximately $0.75 per gallon in the Los Angeles Basin. The cost of future low aromatic diesel fuels is uncertain at this time. The second cost is operating costs, such as the employees which are needed at the rail yard, ticket counter, intermediate stations, etc. These costs should be the same for each of the rail services whether it be diesel, gas, or electric. Therefore, these operating costs will not be addressed in this study. The third cost is maintenance. The maintenance characteristics of the diesel engine, gas engine, and electric locomotive are expected to be different; so including maintenance figures in the overall operating cost is important as a comparison between each of the three fuels is made.

CALTRAIN operates a diesel commuter rail service from San Jose to San Francisco. This commuter service is considered to be very similar to the service planned for the Los

Angeles Basin Area. CALTRAIN officials indicate that their annual maintenance costs are approximately $37,500 per locomotive. On average, each of these locomotives travel 35,000 miles per year, yielding an average maintenance cost of $1.07/mile. This cost includes all service and repair of the diesel locomotives.

AMTRAK operates both diesel and electric passenger rail service in the northeastern United States. Officials at AMTRAK have also released maintenance records to SwRI on their locomotives. Table 16 compares diesel and electric locomotive maintenance costs.

TABLE 16. DIESEL AND ELECTRIC LOCOMOTIVE MAINTENANCE AND REPAIR COSTS

	Diesel Locomotive	Electric Locomotive
Mfr/Model	EMD/GP40, F40	GM, ABB/AEM 7
Power Output	3,000 horsepower	7,000 horsepower
Average Maintenance Costs*	$17,600/month	$23,400/month
Annual Mileage*	160,000 miles	160,000 miles
Average Cost per Mile	$1.32/mile	$1.76/mile
* Based on 12 month period ending September 1991.		

The figures reported in Table 16 were collected from a fleet of 227 diesel locomotives and 52 electric locomotives. Maintenance costs include all preventative and running maintenance, overhauls, major overhauls, and wreck repair (please note that wreck repair is a small percentage of the total maintenance bill). According to this table, the electric locomotive is about 30 percent more expensive to maintain than the diesel version.

Comparing maintenance costs for a 7,000 horsepower electric locomotive and 3,000 horsepower diesel locomotive directly is difficult. One reason for the increased O&M cost of the electric train is the low production volume of replacement parts. Electric trains have a better reliability rating than diesels, but when they fail the repair cost is much higher than a diesel repair due to the high cost of replacement parts.

New Jersey transit also operates both diesel and electric passenger rail service. Their electric trains have only been in service since July of 1990, so they do not have good cost figures on the electric O&M requirements. However, officials at New Jersey Transit did indicate that electric trains were more expensive to maintain and operate than diesels, but did not have numbers to say just how much.

Based on our investigation of O&M costs, we assume an annual diesel O&M cost of $37,500 per commuter locomotive, since CALTRAIN's data were in the same range as AMTRAK's data. Trains on the San Jose - San Francisco route operate about the same mileage expected for the LA Basin routes.

Natural Gas

The natural gas fuel costs depend on whether LNG or CNG fuels the trains. In addition, the refueling station will also have an impact on the cost to refuel the trains. For example, if LNG is brought in by tractor trailer from a remote location (e.g., Sacramento) the LNG will cost about $0.52 per gallon (i.e., $0.91 per diesel equivalent gallon). In the case of CNG, there are many different scenarios which could be considered.

SoCal Gas has recently obtained preliminary approval of their NGV fuel rates. These fuel rates differ dramatically depending upon whether or not SoCal Gas supplies the refueling station at the operator's facility. Other factors include whether the user purchases its own gas from the field and contracts with SoCal Gas to transmit the fuel or whether it leaves the purchase of the gas and transmission up to SoCal Gas. Looking at the two extremes, if the commuter operator depends on SoCal Gas to procure and transmit the gas to their location and compress the gas to approximately 3,000 to 3,600 psi for refueling operations, then the operator can expect to pay approximately $5.50 per MCF of natural gas. On the other hand, if the operator decides to go out and purchase the gas from the field and contract with SoCal Gas to transmit the fuel, they will only be charged $0.50 per MCF by SoCal Gas. The operator will then be faced with a fuel origination cost of abut $2.00/MCF and the responsibility of installing its own compressor at its site for refueling the CNG storage tanks. Preliminary calculations indicate that the payback period for an operator-owned compressor station is about two to three years compared with buying fully compressed gas from SoCal Gas. Therefore, we based the cost analysis on the assumption that the operator will purchase the refueling station and pay a delivered cost of $3.50/MCF for the gas. The gas cost could be reduced to $2.00/MCF for long-term contracts, but $3.50/MCF has been used for all CNG calculations.

Additional maintenance costs will be required for the LNG fuel system to assure that the fuel composition in the LNG tanks does not change over extended periods of time. These issues are discussed in the Fueling Logistics section, but we account for their cost here. The additional maintenance cost to periodically drain and maintain the LNG tanks is estimated to be in the range of $17,500 per train per year. The maintenance costs will be lower for the CNG fuel system compared with LNG. An additional $7,500 per train per year is expected to maintain the refueling stations for CNG compared with diesel maintenance costs. The locomotive engine maintenance costs for the CNG and LNG are expected to be approximately the same as the diesel-fueled locomotives in terms of major failures and engine rebuilds. This cost assumes that the spark plug and ignition system maintenance for the gas engine will be offset by the reduced number of engine rebuilds due to a cleaner burning engine (i.e., fewer carbonaceous deposits) and the elimination of the diesel fuel injection system.

Electric

Although electric rates are subject to change, SwRI has assumed a cost of \$0.075 per kW-hr of electricity. Sources at Southern California Edison indicate that this energy rate is probably on the low side. However, in the absence of firm numbers, \$0.075 per kW-hr was chosen as a conservative energy rate.

SwRI was unable to locate exact maintenance costs associated with electric train operation compared with the diesel or natural gas operation. However, the information included in Table 16 and the conversations we have had with operators experienced in diesel and electric trains suggests that electric trains will be at least as expensive to maintain as diesels. Thus, we have assumed an annual O&M cost of \$37,500 per electric locomotive (the same as diesel O&M costs).

The electric train operating costs could be artificially low due to the fact that some of the electric power plants that service the LA Basin are located in Arizona and Nevada. Since the electric power plants produce significant emissions which impact air quality, the electric train offers the LA Basin the opportunity to "export" their emissions into neighboring states. While this is attractive for California, the transportation authorities should be aware of the possible costs which the states of Arizona or Nevada could impose on the rail service to pay for that emissions export service. Since SCAQMD has assigned a maximum cost of \$24,500 per NO_x ton per year, the extent to which electric trains reduce NO_x emissions in the Los Angeles Basin could represent a substantial operating cost for the electric trains which is not included in this study. This issue should be investigated and planned for in the future.

Basic assumptions for calculating operating and maintenance (O&M) costs for the different fuels are summarized in Table 17.

TABLE 17. O&M COST ASSUMPTIONS

Fuel	Fuel Cost	Annual Maintenance Cost (per Locomotive)
Electric	\$0.075/kW-hr	\$37,500
Diesel	\$0.75/gallon	\$37,500
Gas	\$0.52/gallon (LNG) \$3.5/MCF (CNG)*	\$55,000 \$45,000
* Does not include compression costs.		

Financial Cost Effectiveness

The financial cost effectiveness was calculated for each of the nine commuter routes operating on diesel, natural gas, and electricity. Financial cost effectiveness calculations were based on intermediate service for each fuel. For the purposes of cost comparisons, operation on 100 percent diesel, natural gas, or electricity was assumed. Partial implementation of gas or electric was not included in these analyses. All financial calculations were based on the assumptions for capital costs and O&M costs outlined in Tables 16 and 17. The results of the capital cost calculations are summarized in Table 18.

Table 18 indicates a much higher (i.e., factor of 10) average capital cost for electric compared with natural gas or diesel trains. Moreover, the capital cost effectiveness of natural gas is only 30 percent worse than for diesel. These numbers are based on an electrification cost of $2M per track mile. If this number is higher, the capital cost effectiveness of electrification will become even worse than these numbers suggest.

Table 19 compares the operating and maintenance (O&M) cost effectiveness of each of the three fuels. In some cases, the gas trains are more cost effective to operate than diesel. However, electric trains are the least cost effective to operate due to their higher energy costs. One way of comparing the fuel costs is on the basis of cost per equivalent gallon of diesel. This comparison is shown in Table 20.

TABLE 18. FINANCIAL COST EFFECTIVENESS FOR LA BASIN COMMUTER TRAINS BASED ON CAPITAL COSTS

Route		($) Capital Cost/Passenger	($) Capital Cost/Passenger-Mile
2	Diesel	0.92	0.008
	Gas	1.21	0.011
	Electric	7.65	0.068
3	Diesel	0.92	0.010
	Gas	1.20	0.013
	Electric	6.67	0.071
4	Diesel	1.03	0.015
	Gas	1.32	0.019
	Electric	9.24	0.132
5	Diesel	0.92	0.005
	Gas	1.24	0.007
	Electric	10.80	0.062
6	Diesel	0.99	0.008
	Gas	1.30	0.011
	Electric	11.63	0.099
7	Diesel	1.03	0.008
	Gas	1.35	0.011
	Electric	14.95	0.119
8	Diesel	1.03	0.013
	Gas	1.33	0.017
	Electric	10.19	0.129
9	Diesel	0.92	0.008
	Gas	1.22	0.010
	Electric	7.91	0.67
10	Diesel	1.03	0.043
	Gas	1.30	0.054
	Electric	4.52	0.188
Average	Diesel	0.98	0.013
	Gas	1.27	0.017
	Electric	9.28	0.171

TABLE 19. FINANCIAL COST EFFECTIVENESS FOR LA BASIN COMMUTER TRAINS BASED ON O&M COSTS

Route		($) O&M Cost/Passenger	($) O&M Cost/Passenger-Mile
2	Diesel	0.38	0.003
	Gas	0.39	0.003
	Electric	0.54	0.005
3	Diesel	0.31	0.003
	Gas	0.33	0.004
	Electric	0.43	0.005
4	Diesel	0.31	0.004
	Gas	0.32	0.005
	Electric	0.42	0.006
5	Diesel	0.49	0.003
	Gas	0.49	0.003
	Electric	0.73	0.004
6	Diesel	0.40	0.003
	Gas	0.39	0.003
	Electric	0.57	0.005
7	Diesel	0.42	0.003
	Gas	0.40	0.003
	Electric	0.60	0.005
8	Diesel	0.32	0.004
	Gas	0.33	0.004
	Electric	0.44	0.006
9	Diesel	0.39	0.003
	Gas	0.40	0.003
	Electric	0.56	0.005
10	Diesel	0.21	0.009
	Gas	0.24	0.010
	Electric	0.25	0.010
Average	Diesel	0.36	0.004
	Gas	0.37	0.004
	Electric	0.50	0.006

TABLE 20. COMPARISON OF FUEL COSTS

Fuel	Fuel Cost	Cost per Gallon (Diesel Equivalent)
Diesel	$0.75	$0.75
Gas (LNG) (CNG)	$0.52/gallon (LNG) $3.50/MCF (Gas)	$0.91 $0.51
Electricity	$0.75/kW-hr	$2.93

Another method for comparing diesel and electric fuel costs is to calculate the cost of providing 1 kW-hr to the electric generator for the traction motors using a diesel engine. This calculation is explained below.

Assuming an average brake specific fuel consumption (BSFC) of 0.40 lb_m/bhp-hr for the diesel engine and a diesel fuel cost of $0.75/gallon yields:

$$\frac{1\ bhp\text{-}hr}{0.40\ lb_m} \times \frac{0.7457\ kW\text{-}hr}{1\ bhp} = \frac{1.86\ kW\text{-}hr}{lb_m}$$

and,

$$\frac{1.86\ kW\text{-}hr}{lb_m} \times \frac{7.3\ lb_m}{gallon} \times \frac{gallon}{\$0.75} = \frac{18.14\ kW\text{-}hr}{\$}$$

or

$$\$0.055/kW\text{-}hr \textit{ using a diesel locomotive}$$

Since electric power is expected to cost $0.075/kW-hr from the utility company, this calculation indicates the diesel locomotive offers a 26 percent savings in electric power generation compared with the electric system. This comparison does not take into account the losses between the operator's electric meter and the on-board generator or traction motors. Additional losses will be experienced when transmitting electric power through the catenaries, train poles, and on-board electrical system.

Air Quality Cost Effectiveness

Based on the results of this study, natural gas has the potential to achieve a very positive air quality cost effectiveness. Natural gas has the potential to reduce NO_x emissions from commuter trains by more than 700 tons per year at an additional cost of about \$4.6M per year compared with the diesel baseline (based on projections for 1997 including a 20 year amortization of all capital costs at an annual interest rate of 10 percent). These numbers translate into an NO_x emissions reduction cost of about \$6,500/ NO_x ton/year. If electricity were capable of achieving the same level of implementation by the year 1997, it would be expected to reduce NO_x emissions by almost 950 tons per year at an additional cost of about \$125M. These numbers yield an NO_x emissions reduction cost of over \$131,000/NO_x ton/year. Since electrification was assumed to cost \$2M per track mile, this number could increase by a factor of two, or even three, depending on the final cost of electrification.

Figure 6 compares the average air quality cost effectiveness for each of the commuter routes after achieving intermediate service status with each of the three fuels: clean diesel, natural gas, and electricity. Clean diesel is clearly the most cost effective measure for emissions reduction since its only increase in cost was assumed to be higher fuel consumption (1 percent increase). It offers, however, limited potential for making significant reductions in NO_x emissions as shown before in Figure 5.

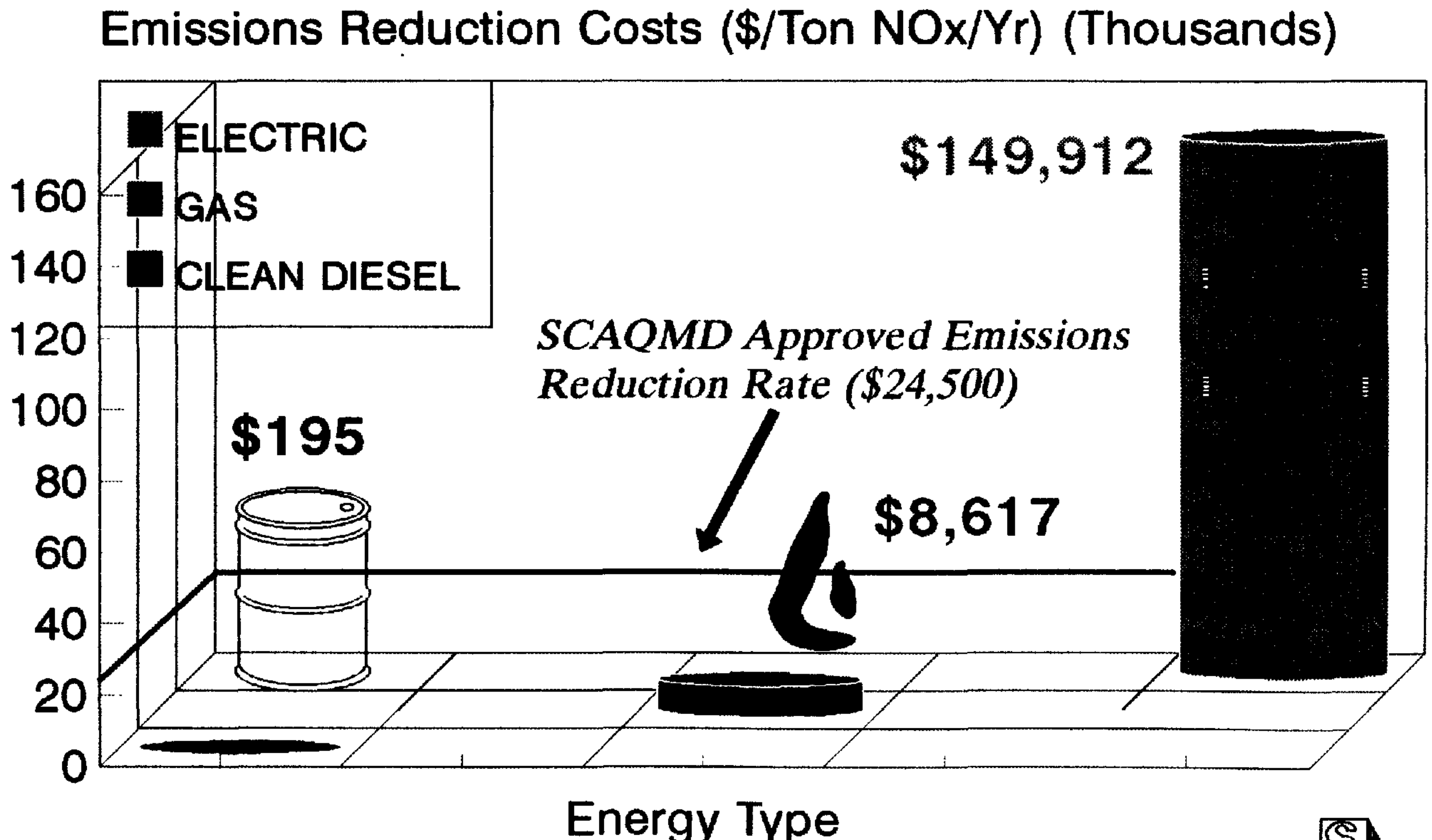
Environmental

Natural gas is expected to offer several advantages regarding general environmental characteristics compared with diesel. For example, combustion noise from a natural gas engine is typically lower than that of the original diesel engine, thereby, reducing overall engine noise. Likewise, engine vibration is normally reduced to some extent when converting from diesel fuel to natural gas fuel. A visual improvement in using natural gas will also occur due to the reduction (and virtual elimination) of visible smoke from the engine's exhaust.

Environmental issues such electromagnetic fields (EMF), construction, and energy/utilities requirements which are key issues with the electric rail system are not anticipated to be key issues for the natural gas train. However, land use will need to be evaluated carefully for natural gas application due to the need for locating CNG refueling stations and eventually LNG liquefaction plants.

Vehicular traffic is expected to be improved with the natural gas trains compared with the electric. The basis for this statement is the possibility of natural gas locomotives traveling outside the LA Basin without the requirement of switching from a natural gas to diesel locomotive. This possibility will only exist if CNG or LNG refueling stations are also available outside the LA Basin but would not require the heavy capital expense of extending electric service outside the Basin. Safety related issues with natural gas have been discussed in the Technologies section and will be mentioned again in the Key Issues section below.

AIR QUALITY COST EFFECTIVENESS
GAS, ELECTRIC, AND CLEAN DIESEL



Based on 9 Commuter Routes, Intermediate Service
File: CH8-003

FIGURE 6

Funding

Level of Funding Required

Figure 7 illustrates the projected expenditures for each of the three railroad systems (i.e., diesel, natural gas, and electric) from 1992 through the year 2015. These expenditures are based on the implementation schedule outlined in the Technologies section above and the 1991 AQMP Plan for Electrification. This figure illustrates the nominal increase in capital costs to implement natural gas trains compared with the escalated cost of putting electric trains into service. The numbers represented in this figure were based on a capital cost of $2M per track mile for electrification, therefore, the electric costs could be increased due to potentially higher actual electrification costs.

Funding Opportunities

No data available for this section.

Potential for Rate Basing

No data available for this section.

Key Issues

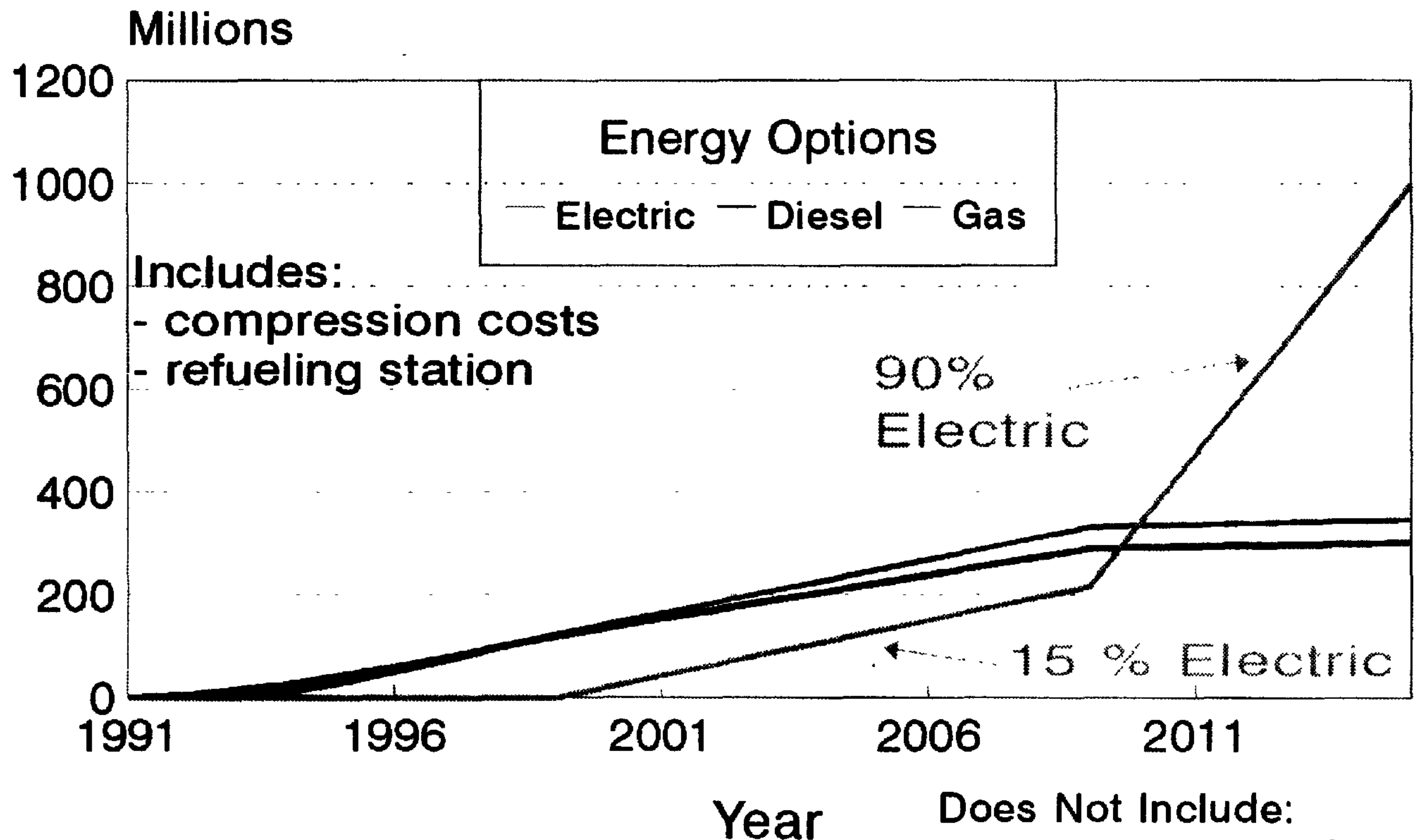
Several key issues exist regarding the entire LA Basin commuter rail system. For example, all calculations and discussions in this chapter assume that each commuter train will make only one round trip per day. This operating strategy puts a very low utilization factor on the equipment and should be investigated further to determine the advantage of running each train on multiple round trips per day. If the utilization of the natural gas commuter trains increases, they will very quickly exceed their capacity for fuel storage on CNG and a switch to LNG will be required to provide a full day's driving range. This scenario is discussed further in the Evaluation and Summary section of this chapter.

Another key issue regarding natural gas locomotives is refueling. The analysis conducted in this chapter assumes that each of the nine commuter rails will use CNG for fuel storage during the start-up and intermediate service and that a switch will be made to LNG after all commuter routes have achieved intermediate status. The exact number and location of LNG plant(s) will be critical in optimizing the efficiency of the commuter rail system. For example, locating one or more LNG plants outside the downtown Los Angeles area and cycling the natural gas locomotives through the commuter rail system to refuel them at the required intervals may be more feasible. Additional study will be needed to address this issue and make specific recommendations.

Other key issues regarding natural gas trains include safety and regulatory approvals which may be required at the state and federal level. Several key safety studies will be

COST COMPARISONS

LA Basin Commuter Trains



Does Not Include:
- New Power Plant Cost
- Emissions "Export" fee

FIGURE 7

File: CH8-004

available in the very near future to help evaluate these issues. Additional study needs to be made regarding regulatory requirements for fueling locomotives with CNG and LNG, both as an on-board fuel for the locomotive and in the form of an LNG fuel tender for freight applications.

Public perception regarding the safety of natural gas locomotives has been discussed by several individuals and organizations. While many experts in this industry predict that public perception will be a major problem, Burlington Northern has experienced just the opposite. They report that, once properly trained and educated, their staff prefer to be involved in the natural gas locomotive projects compared with the existing diesel locomotives. Although this issue will certainly need to be addressed, it is not expected to be a show-stopper for natural gas trains.

Service Quality

Depending on the conversion technology selected for natural gas locomotives, some impact on travel time could be experienced due to the reduction in power output from the locomotive. Additional analyses and combustion system investigations will be needed to quantify the actual impact on travel time for passenger and freight applications. In general, the horsepower per trailing ton for the commuter trains is already very high compared to freight application. Therefore, the perception of reduced service quality may not be significant in the case of commuter operations.

Shared Use Potential

In addition to the positive air quality cost effectiveness of natural gas compared with electricity, the strong potential for shared usage of existing track between diesel and natural gas locomotives raises the importance of evaluating natural gas as a transitional alternative fuel before electric railroads are put into place. Natural gas locomotives and diesel locomotives should be completely interchangeable on any commuter or freight rail application. Changes to existing trackage or signaling will not be required. The only operational difference will be in the refueling location and procedure used for natural gas compared with diesel. Therefore, the fact that natural gas and diesel trains will be capable of running side-by-side on existing trackage should be noted. This flexibility will not exist after electric service becomes operational for two reasons: electric trains cannot run on diesel tracks due to the absence of an energy source, and diesel trains should not be run on an electric track with overhead catenaries due to the heavy soot formation that will develop on the overhead contacts for the electric train.

CLEAN DIESEL

Technology

The following technologies will be considered for reducing the oxides of nitrogen and particulate emissions from railroad locomotives by retrofit of existing locomotives.

a. Low Temperature Intercooling
b. Injection Retard
c. Reoptimized Combustion
d. Exhaust Gas Recirculation
e. Intake Charge Chilling
f. Emulsions of Water and Water Injection

Low Temperature Intercooling

This is some times called air-air intercooling as it rejects heat from the compressed air charge through a heat exchanger, called intercooler, to the surrounding air. If the intercooler is 80 percent effective then it can cool the charge from 100 to 36°C. A plot of the response of oxides of nitrogen emission to intake charge temperature is shown in Figure 8 and it is clearly an effective way to reduce oxides of nitrogen emissions without penalty to fuel consumption, or significant cost penalty. Some slight reduction in particulate emissions can also be expected. Because of these advantages, on-highway truck engines are almost exclusively air-air intercooled. The response of NO_x to reduced combustion air temperature may not be as significant on the locomotive engines.[22] This is because the emissions plotted here are cycle averaged with 50 percent weighting for idle. Idle NO_x emissions are not significantly effected by charge temperature. In addition, there was considerable reheating of the intake charge being passed between the intercooler and the engine. This reheat could be eliminated by insulation of the passage from the intercooler to the engine.

Increasing the effectiveness of the air-air intercooler on locomotives could require too much space on the locomotive. If this is the case, then low temperature intercooling can still be achieved by so called "lo-flow" intercooling. This entails taking a fraction of the coolant then passing it through a multipass radiator so it is cooled to about 40°C and then using this cooled coolant to intercool the intake charge to about 50°C. On rejoining the remaining coolant, the cooled fraction of the coolant reduces the temperature of the total coolant to the same temperature as it would be if it had passed through a conventional radiator. Though sounding complicated, this system requires less space than an air-air intercooler and radiator combined.

Retard of Injection Timing

The retard of injection timing is an effective way to reduce NO_X, but unless it is accompanied by counter measures then particulates, fuel consumption and hydrocarbon emissions will also increase.[22] The counter measures basically involve reoptimizing the combustion for retarded conditions. The optimum configuration of a combustion system for normal timing will not be the same as for more retarded timings. The injection pressure, injector nozzle hole configuration, combustion chamber shape and swirl level may all require changing to reoptimize the system. In addition to reoptimizing the combustion for retarded timing additional optimization can be done for reduced particulate emissions.

Oil Consumption Control

As much as half of the lubricating oil consumed by an engine will not be burnt and will then become particulates. Oil consumption is a significant contribution to the total particulates of the engine and the EMD and GE locomotive engines are know to have high oil consumption. The oil consumption can be controlled are reoptimizing the design of the piston, piston rings and cylinder liner possibly using recently developed materials.

Exhaust Gas Recirculation (EGR)

The effect of recirculating spent combustion gases back into the intake system to reduce NO_X in the exhaust has long been known and utilized in the gasoline engine industry. The technique is called exhaust-gas recirculation (EGR). EGR serves as a diluent in the intake air/fuel stream, hence displacing an amount of oxygen that is no longer available for combustion with the fuel. This serves to reduce the peak combustion temperature and the rate of the combustion process. It is the rate of pressure rise that directly attributes to the undesirable phenomenon of knock or pre-ignition. Furthermore, the formation of NO_X is closely related to the peak burned-gas temperature. Therefore, a reduction in the peak burned-gas temperature due to the introduction of EGR reduces the amount of NO_X formed.

With spark-ignition (SI) engines, a substantial reduction in NO_X emissions can be achieved with 10 to 25 percent EGR.[23] The amount of EGR any engine will tolerate is dependent upon the combustion characteristics, the speed and load, and the equivalence ratio. EGR is used for part-throttle conditions where economy and not power is the principal concern. EGR percentages in the 15 to 30 range are about the maximum amount of EGR an SI engine will tolerate under normal part-throttle conditions.

The addition of too much EGR causes cyclic variability and eventually misfire. The increase in HC emissions with the increase in EGR is small until the engine begins to misfire. The addition of EGR has a negligible effect on CO_2 emissions.

The concept of employing EGR in diesel engines is now being used with some light-duty diesel engines.[22] The idea of using EGR with diesels is not new. The main barriers with using EGR with diesels in the past have been associated with oil contamination, intake system contamination, wear, and further increasing an already high level of particulate emissions.

If low temperature intercooling and injection retard cannot meet the required NO_X levels, then exhaust gas recirculation is the next most effective technology to apply.

Intake Charge Chilling

The benefit of low temperature intercooling has already been discussed. However, the minimum manifold temperature that can be obtained at rated power with air-to-air intercoolers is 36°C. Consequently, little data is available in the literature correlating manifold temperature, NO_X, and particulate emissions at temperatures below 40°C.

Intake manifold temperatures lower than 40°C may be required to meet very severe emission standards. The effect of manifold temperature on NO_X emissions is modeled in Figure 8. NO_X emissions decrease with decreasing manifold temperature. However, the model used to produce Figure 8 does not account for the change in ignition delay with manifold temperature. Ignition delay increases with decreasing manifold temperature. Longer ignition delays result in more premixed combustion, high initial heat release rates, and might result in higher NO_X emissions. Therefore, SwRI suspects there may be an optimum manifold temperature for lowest NO_X emissions. This temperature cannot be easily determined using computer models because engine and/or fuel modification may be required.

The effect of low-manifold temperature (below 40°C) on particulates must also be determined to minimize the NO_X-particulate tradeoff. Currently, no engine models can predict particulate emissions. Reducing manifold temperature will affect spray penetration, fuel-air mixing, and thus particulate formation. Engine tests will be required to determine the correlation between manifold temperature, NO_X, and particulate emissions. It is anticipated that the combustion system will require optimization for the lower manifold temperatures. The potential problems of water condensation in the manifold and icing should also be addressed.

One possible scheme for achieving lowered intake manifold temperatures is shown in Figures 9 and 10. In this arrangement the turbocharged and intercooled engine has a conventional turbocharger and compressor that compresses the intake charge and cools it to say 62°C as shown at '3' in Figure 10. At this point it is compressed again then passed through a second intercooler to '5' where it is at 38°C. At this point it is expanded semi-adiabatically through an expander, possibly a modified turbocharger turbine, so the charge is cooled to 6°C in the case shown in FigureS 9 and 10. Temperatures less than 0°C are possible with this arrangement. However, there are several questions concerning the viability of this scheme such as the condensation and icing of the water vapor in the air, the fuel consumption penalty and the transient response of the device.

RELATIONSHIP BETWEEN INTAKE MANIFOLD TEMPERATURE AND NO_X CONCENTRATION FOR DIESEL ENGINE

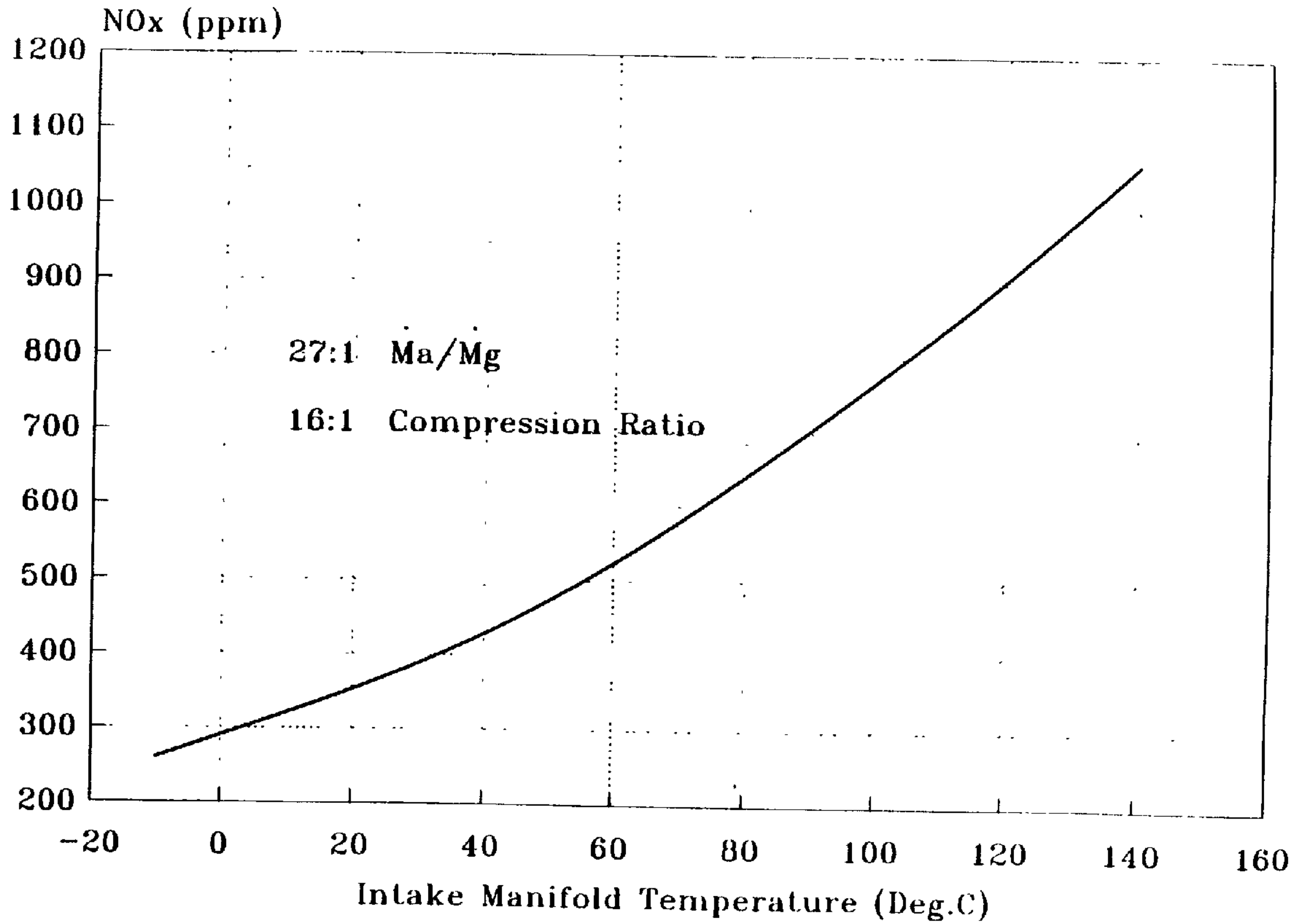
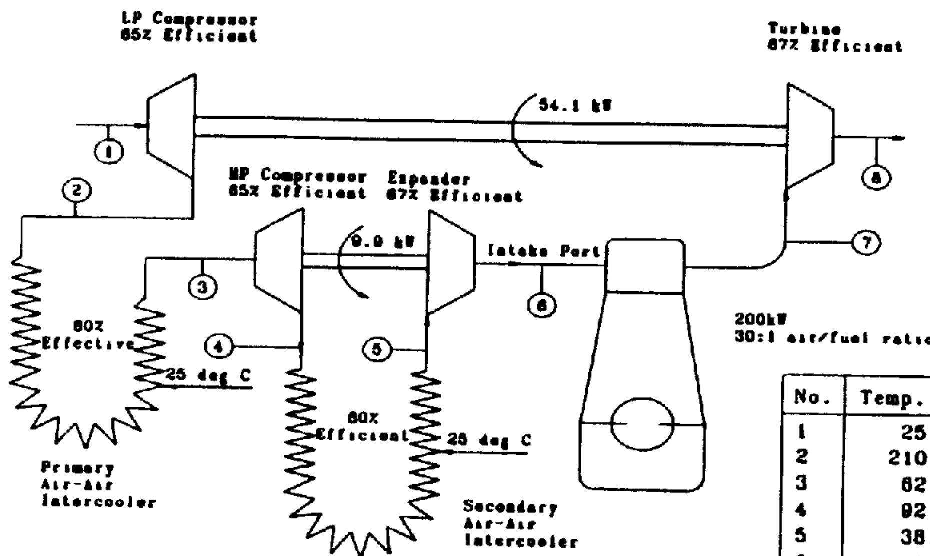


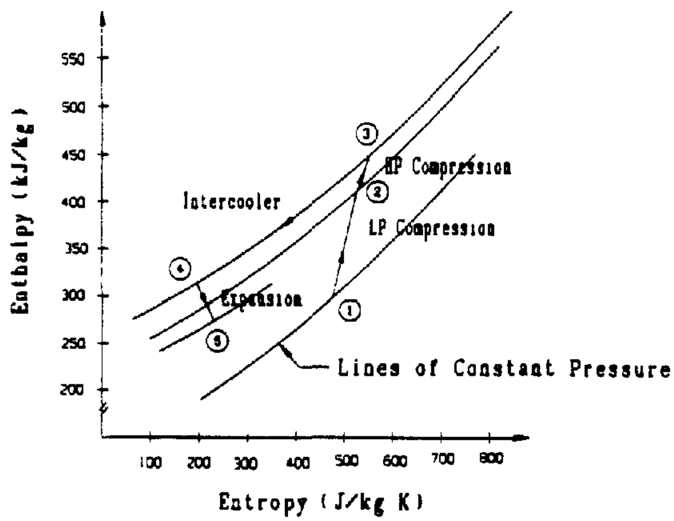
FIGURE 8



No.	Temp. (deg C)	Pres. (Bar)
1	25.0	1.00
2	210.7	3.29
3	62.1	3.20
4	92.6	3.92
5	38.5	3.82
6	6.6	2.20
7	626.9	3.20
8	455.1	1.00

CHRGEXP EPS

FIGURE 9



Cooling Intake by Charge Expansion H-S Chart

FIGURE 10

Emulsions and Water Injection

Water injection in diesel and gasoline engines has been examined several times[23,24,25] as a method of reducing NO_X emissions. The researchers also observed significant reductions in smoke when using water injection, so it could be that particulate emissions would be reduced by water injection as well.

Water injection is believed to assist combustion in different ways:

(1) Water will instantly vaporize to super-heated steam on injection to the cylinder. If the injected droplets are a mixture of water and fuel, the vaporizing water will fracture the droplets by what has been called "micro-explosions" and so increase the degree of atomization and burning.

(2) The latent heat of vaporization of the water is sufficient to reduce temperatures during the combustion process so that NO_X is reduced by as much as 50 percent. The water vapor is also a working fluid so some of the heat it gains from the fuel is converted to useful work on the piston.

(3) An indirect advantage of water injection is that as the heat absorbed by the water is 9 percent of the calorific value of the same mass of fuel, the heat rejection to the coolant would be reduced by some value less than 9 percent.

Two methods of water injection have been tested:

(1) Injection of a mixture (emulsion) of fuel and water through the same injector.

(2) Separate water injection into the intake port or directly into the cylinder.

Researchers report better results with the first method, probably because the fuel and water are mixed in the same droplet and can give the "micro explosions" mode of atomization. However, handling a larger capacity fuel pump does pose some practical problems, such as requiring a larger capacity fuel pump to pump both the water and the fuel. Also, water would be injected at all engine operating conditions, such as light load and cold start, where it is not necessarily needed. It is claimed, however, that the emulsion is not corrosive.

When water is injected into the port by a phased gasoline-type injector, it could be modulated, perhaps electronically, to occur only at high load conditions where it would have a maximum effect on reducing NO_X and particulates.

Since published results show that water injection reduces full load smoke by up to 50 percent, the effects of water injection on particulate emissions may be dramatic. Furthermore, the researchers did little to reoptimize the combustion system to adjust to the water injection, even when the water injected was 80 percent of the fuel mass. If the combustion bowl and injector geometry were reoptimized to account for water injection, then the benefits may be greater than those that have been realized.

Low Aromatic Diesel Fuel

Particulate emissions from diesel engines are lowered with a reduction of the aromatic content of diesel fuel. This is because aromatic compounds have a higher carbon-to-hydrogen ratio than other hydrocarbon molecules in the fuel. The state of California has mandated that in 1993 the aromatic content of diesel fuel will be reduced from the current 32 percent to 10 percent. The work on references[26, ...31] indicates that this reduction in aromatic content will reduce particulate emissions by only 6 percent.

Catalytic After-treatment

Exhaust catalysts will be used in heavy duty trucks in 1994 to meet the emission standards. These catalysts oxidize the soluble fraction of the particulates and are typically 60 percent effective in oxidizing these particulates. These catalysts only operate when the exhaust temperature rises above a certain temperature so they are not effective at light load and idle. The amount of space required for the catalyst is less than needed for a particulate trap and the catalyst could be combined with the muffler. It therefore appears a good choice for a retrofittable method of reducing particulate emissions, however as it is only effective on the soluble fraction of the particulates its overall effect on particulates will depend on the amount of soluble particulates the engine happens to have.

This approach should be more effective on EMD locomotives compared with GE locomotives due to the higher soluble fraction of particulates in the EMD engine's exhaust.

Particulate Traps

Particulate traps are used on some applications for gathering particulates in a filter then regenerating them or burning them away periodically. Traps are probably not suitable for railroad engines as they are expensive, large, and maintenance intensive.

RAPRENOx

RAPRENOx is a chemical treatment of combustion or exhaust gases with cyanuric acid. Today, this is a very speculative technology and very much in the research stages. Unlike other technologies, speculative or otherwise, all the work on RAPRENOx has been done by just one person. Different organizations (DoE, PG&E, Cummins, and others) have supported the work at different times, but the actual work has been done by the same person. The bulk of this has been in flow reactors on the bench. Cyanuric acid is a powder. At high temperatures (> 1000 degrees C), cyanuric acid goes through a complex series of reactions, reducing NO_X to nitrogen and oxygen. In this process, cyanuric acid is consumed. This technology is not considered feasible for locomotive application.

Selective Catalytic Reduction

This technology has been applied to boilers, and in a limited number of cases to very large, lean-burn natural gas engines used for power generation. It has not yet seen wide application in internal combustion engines. This is a very selective catalytic process, hence the name. Ammonia is injected in the exhaust (flue) gases which pass over a catalyst. The catalyst selectively causes a complex set of reactions between ammonia and NO_X, even in the presence of oxygen, to reduce NO_X to N_2.

These systems are not readily available and are reported to be cost prohibitive. In addition, the technical and safety characteristics of this system are unproven for transportation application. This technology will need to be demonstrated before it can be considered as a possibility for locomotive application.

Electro-Catalytic Reduction

Electro-catalytic reduction is a relatively new technology. It can only be considered to be in the very early research stages. It has not been tried on an engine, not even in a laboratory setting. Limited results on a bench set-up from a single laboratory are available. Lean-burn engines contain excess oxygen in the exhaust. In the presence of excess oxygen, it is not possible to catalytically reduce NO_X, because under such conditions O_2 would preferentially react with NO giving NO_2. For this reason, industrial processes and power generation stations have used selective catalytic reduction with ammonia injection under lean conditions, as discussed in the previous section. Electro-catalytic reduction presents an alternative way to potentially reduce NO_X in the presence of excess oxygen.

Air Quality

SwRI has predicted the general emissions benefits for each of the technologies described in the previous section. These benefits are based on a percent improvement (or penalty) compared with the diesel baseline described earlier in this chapter in Table 3. A summary of the emissions benefits (and penalties) are shown in Table 21.

TABLE 21. SUMMARY OF CLEAN DIESEL EMISSIONS CHARACTERISTICS

Emissions Reduction Techniques	Percent Change in Emissions Relative to Diesel Baseline	
	NO_X	PM
Low Temperature Intercooling	-5 percent	-2 percent
Retarded Injection Timing	-15 percent	+-2 percent
Oil Consumption Control	0 percent	-10 percent
EGR	-10 percent	+5 percent
Intake Charge Chilling	-10 percent	-2 percent
Emulsions and Water Injection	n/a	n/a
Low Aromatic Diesel Fuel	0 percent	-6 percent
Catalytic Aftertreatment	n/c	n/c
Particulate Traps	n/a	n/a
RAPRENOx	n/a	n/a
SCR	n/a	n/a
Electro-Catalytic Reduction	n/a	n/a
n/a = not applicable n/c = not considered		

It is very important to note that each of the improvements listed in Table 21 are not additive. In other words, the combination of low temperature intercooling, retarded injection timing, increased EGR, and intake charge chilling will not produce a 40 percent reduction in NO_X. Instead, we estimate the combination of each of the applicable technologies listed above represents the potential for a 25 percent reduction in NO_X compared with the baseline diesel data shown in Table 3. This improvement in NO_X is not expected to produce a net effect on particulate emissions. Therefore, the assumptions made for clean diesel emissions reduction include a 25 percent reduction in NO_X emissions and zero reduction (or penalty) in particulate matter.

Emulsions and water injection technology is not considered applicable to the locomotive application due to the requirement for significant amounts of water on-board the locomotive and the added complexity of this system. Catalytic aftertreatment could reduce the NO_X and particulate matter emissions further than the numbers included in this report. However, the size and cost of catalytic aftertreatment equipment for locomotives is unknown at this point, and no consideration was given in this analysis to the application of this technology. Similarly, particulate traps, RAPRENOx, selective catalytic reduction, and electro-catalytic reduction were all considered non-applicable technologies for clean diesel operation in locomotives in the near future due to their high cost and technical risk.

Cost Analysis

Capital Costs

The additional capital costs to retrofit the low temperature intercooling, retarded injection timing, improved oil consumption control, and EGR systems on the diesel locomotive were considered to be negligible. Therefore, the capital cost of the clean diesel locomotive was not increased relative to the baseline diesel locomotive for the purposes of this analysis.

Operating and Maintenance Costs

Maintenance costs were assumed to be identical for the clean diesel engine technology and the baseline diesel locomotive. However, the operating cost will be slightly higher for clean diesel due to an estimated 1 percent increase in fuel consumption. This increase in operating cost was included in the cost analysis for clean diesel technology discussed earlier in this chapter.

Environmental

There are no environmental concerns for any of the clean diesel technologies which are considered applicable to today's locomotive engines. However, several environmental concerns exist regarding the RAPRENOx and selective catalytic reduction systems. These environmental concerns were part of the rationale for not including their effect on emissions in this report. The RAPRENOx system is considered potentially hazardous due to its dependence on the use of cyanuric acid for NO_x emissions reduction.

Selective catalytic reduction systems have been proven in very limited and specialized applications, but the potential for ammonia emissions to the environment is significant with these systems. Therefore, they represent a potentially harmful environmental hazard.

Funding

The clean diesel technology will not have a significant effect on funding requirements for the locomotives. Therefore, no discussion is given to this topic.

Service Quality

Clean diesel technology, as outlined above, should have no significant impact on service quality relative to the baseline diesel.

EVALUATION/SUMMARY

This chapter clearly indicates the potential for substantial reductions in NO_X and particulate emissions by converting diesel locomotives to alternative fuels. natural gas has been estimated to provide approximately 75 percent reduction in NO_X emissions compared with the baseline diesel locomotive and the air quality cost effectiveness appears to be at a reasonable level.

Based on the results of the alternative fuels analysis, we strongly recommend that alternative fuels be planned for commuter routes 2, 5, and 9 during the transition from diesel locomotives to rail electrification. The use of alternative fuels on these three routes alone could reduce the cumulative NO_X emissions to the LA Basin by more than 5,500 tons by the year 2010. All applicable clean diesel technology should be applied to the remaining diesel locomotives as a minimum; although alternative fuels would provide increased emissions benefits on the remaining six commuter routes as well. Additional studies should be conducted to analyze the effect of converting all nine commuter routes to alternative fuels as soon as possible with regard to refueling logistics and operational considerations.

In conclusion, rail electrification offers the ultimate potential for reducing railroad emissions in the LA Basin; however, the long lead-time and high capital costs to implement electric railroads opens the opportunity to take advantage of lower cost and more immediate emissions reduction measures provided by alternative fuels.

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APPENDIX A

LIST OF ASSUMPTIONS

LIST OF ASSUMPTIONS

- 1 spare locomotive will be purchased for each route
- Passenger capacity: -- 140 passengers in cab car
  -- 160 passengers in all other cars
- No. of passenger cars: -- 4 cars per train for start-up service
  -- 7 cars per train for intermediate service
- Passenger occupancy: -- 70% of capacity for start-up
  -- 100% of capacity for intermediate
- Head-end power requirements: -- continuous operation at 50% rated power during start-up service
  -- continuous operation at 100% rated power during intermediate service
- Operation: 260 days per year
- Maintenance Costs Held Constant Each Year

CNG Compression Costs: Calculated for all trains (totalled) per route

Refueling Station Capacity:

$$\frac{SCFM}{1}\ \frac{utilization\ correction\ factor}{1} x \frac{.85\ hp}{SCFM} x \frac{20\ hr}{day} x \frac{2545\ btu}{day}$$
$$\frac{1\ SCF}{1000btu} * \frac{260\ day}{yr} * \frac{1\ MCF}{1000\ SCF} = \frac{MCF}{yr} * \frac{\$}{MCF} = \frac{\$}{yr}$$

Electric Energy Consumption:

$$\frac{bhp}{1} * \frac{\min}{day} * \frac{hr}{60\ \min} * \frac{.7457\ kWhr}{bhp\text{-}hr} *$$
$$\frac{260\ day}{yr} * \frac{1}{0.9} = \frac{kWhr}{yr}$$

Fuel Consumption:

$$\frac{gallons}{HR} = \frac{bhp}{1} \times \frac{lb_m}{bhp\text{-}hr} \times \frac{gallon}{7.3\ lb_m}$$

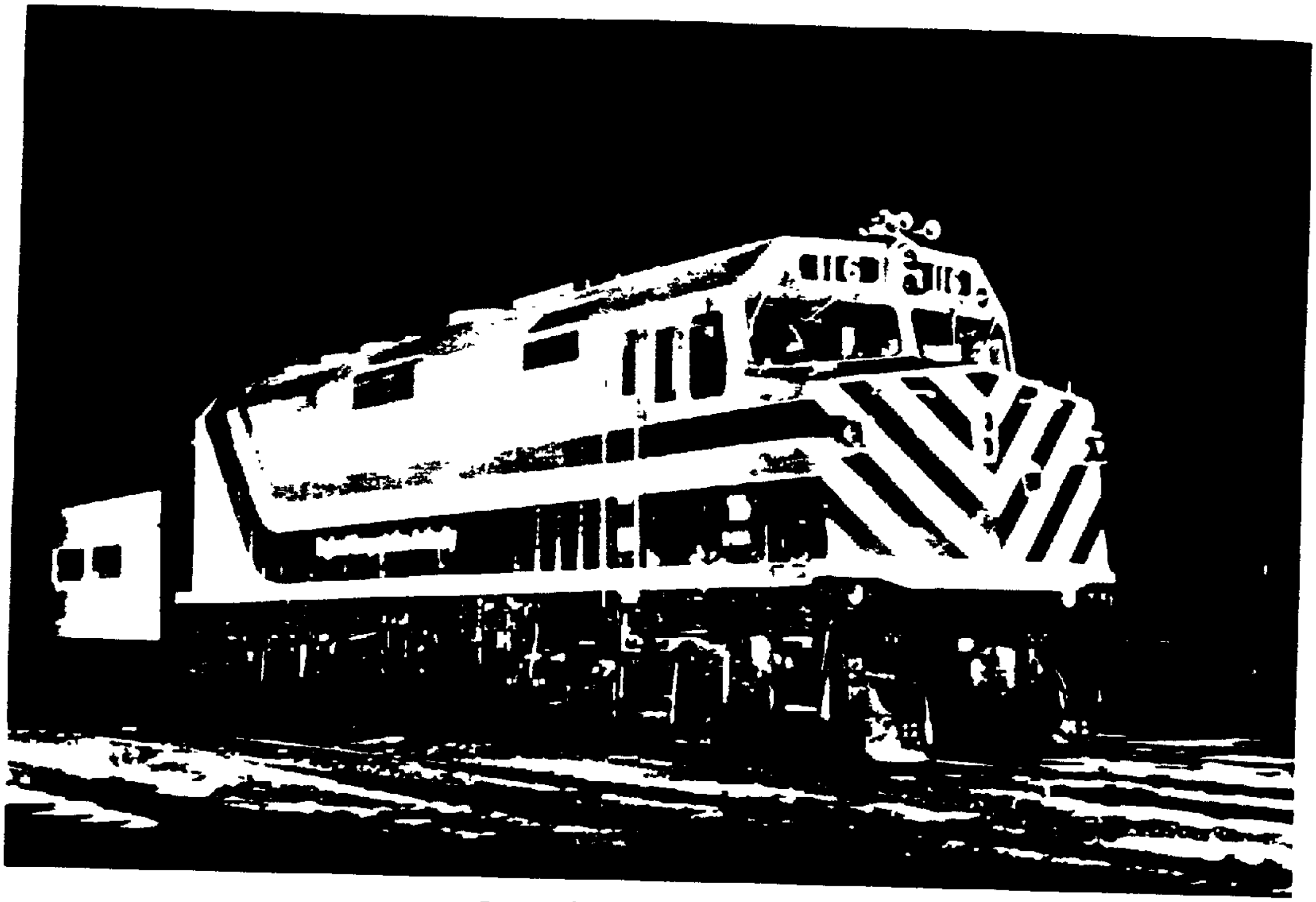
Emissions Rate:

$$\frac{tons}{HR} = \frac{bhp}{1} \times \frac{gm}{bhp\text{-}hr} \times \frac{lb_m}{454\ gm} \times \frac{ton}{2000\ lb_m}$$

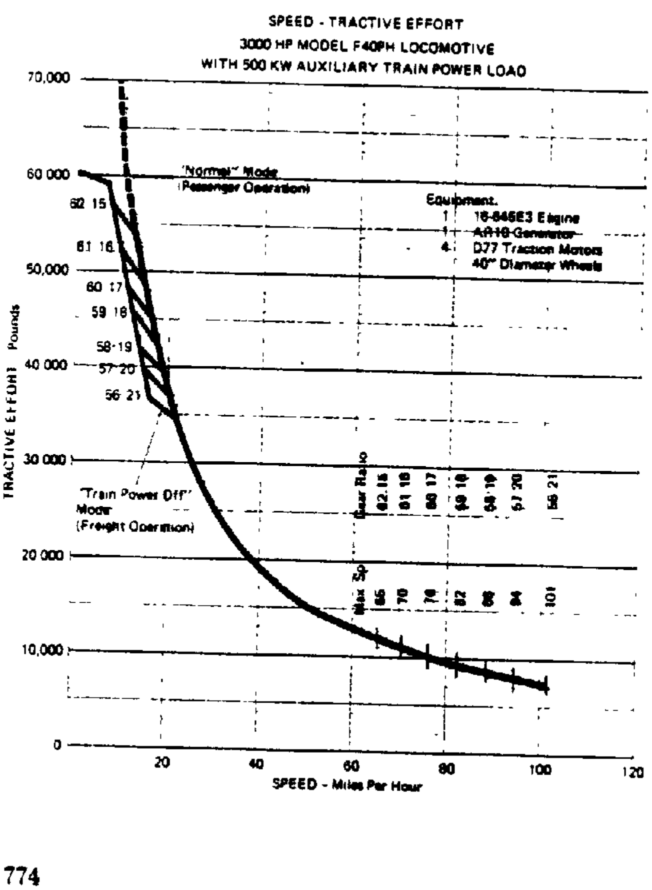
APPENDIX B

LOCOMOTIVE SPECIFICATIONS

Source: **The Car and Locomotive Cyclopedia, Simmons - Boardman Publishing Corp., 1980**



General Motors Model F40PH



General Characteristics, Weights and Dimensions

Model . F40PH 3000 HP Four Motor Diesel-Electric Locomotive

Type:

AAR DESIGNATION	B-B
Common Designation	0440

Arrangement .... The Locomotive consists of one unit complete with engine, generator, trucks and all accessories for single unit operation, with a control cab between the long and short hoods.

Nominal dimensions:

Distance pulling face of coupler to centerline of truck	11'7"
Distance between bolster centers	33'0"
Truck-rigid wheel base	9'0"
Distance pulling face front coupler to rear coupler	56'2"
Width over cab sheeting	10'0"
Height over cooling fan hatch	15'7"

Drive

Driving motors	Four
Driving wheels	4 Pair
Diameter wheels	40"

Weights and Supplies:

Total loaded weight on rails (approximately)	259,000# ±3500
Fuel (basic)	1,500 gal.
Fuel capacity option	1,800 gal.
Sand	26 cu. ft.
Cooling water	254 gal.
Lubricating oil	243 gal

APPENDIX C

COMMUTER ROUTE CHARACTERISTICS

Route 2 — San Bernardino - LA
Length: 56.5 Miles
Start-up Date: 1992
Number of Trains: Start-up: 5
Intermed: 8

Time at Notch Position (minutes)		
Notch	Eastbound	Westbound
idle	18.8	20.6
1	3.7	8.1
2	6.4	6.5
3	5.7	9
4	6.1	11.9
5	9	4.4
6	7.7	6.4
7	6.7	1.3
8	30.9	23.8
Total	95.0	92.0

Route 3 — Ventura - LA
Length: 47 Miles
Start-up Date: 1992
Number of Trains: Start-up: 4
Intermed: 8

Time at Notch Position (minutes)		
Notch	Eastbound	Westbound
idle	15.5	12.3
1	6.1	5.4
2	12.2	4.8
3	7.1	6.6
4	2.3	12.2
5	2.7	4.4
6	6.0	6.4
7	3.2	3.5
8	16.9	17.4
Total	72.0	73.0

Route 4 Santa Clarita - LA
Length: 35 Miles
Start-up Date: 1992
Number of Trains: Start-up: 3
Intermed: 4

Time at Notch Position (minutes)		
Notch	Northbound	Southbound
idle	9.4	15.2
1	2.1	5.8
2	2.5	5.7
3	6.0	7.0
4	5.3	3.7
5	6.1	2.8
6	5.0	2.6
7	3.9	1.6
8	21.7	13.6
Total	62.0	58.0

Route 5 Oceanside - LA
Length: 87.2 Miles
Start-up Date: 1993
Number of Trains: Start-up: 8
Intermed: 8

Time at Notch Position (minutes)		
Notch	Eastbound*	Westbound*
idle	27.5	30.3
1	7.5	9.0
2	13.3	10.7
3	11.8	14.2
4	8.6	17.5
5	11.2	7.3
6	11.8	9.7
7	8.7	4.0
8	43.8	34.5
Total	144.2	137.2

* CF = 0.63, from mileage weighted composite

Route 6	Riverside - LA (Ontario)
Length:	58.8 Miles
Start-up Date:	1993
Number of Trains:	Start-up: 3
	Intermed: 5

Time at Notch Position (minutes)		
Notch	Eastbound*	Westbound*
idle	19.6	21.4
1	3.9	8.4
2	6.7	6.8
3	6.0	9.4
4	6.3	12.4
5	9.4	4.7
6	8.0	6.7
7	7.0	1.4
8	32.1	24.8
Total	99.0	96.0
* CF = 1.04, from Route 3		

Route 7	Riverside - LA (Fullerton)
Length:	62.8 Miles
Start-up Date:	1995
Number of Trains:	Start-up: 2
	Intermed: 4

Time at Notch Position (minutes)		
Notch	Eastbound*	Westbound*
idle	20.9	22.9
1	4.1	9.0
2	7.1	7.2
3	6.3	10.0
4	6.8	13.2
5	10.0	4.9
6	8.5	7.1
7	7.4	1.4
8	34.3	26.4
Total	105.4	102.1
* CF = 1.11, from Route 3		

Route 8 — Hemet - Riverside
Length: 39.6
Start-up Date: 1995
Number of Trains: Start-up: 2
Intermed: 4

Time at Notch Position (minutes)		
Notch	Eastbound*	Westbound*
idle	13.2	14.4
1	2.6	5.7
2	4.5	4.6
3	4.0	6.3
4	4.3	8.3
5	6.3	3.1
6	5.4	4.5
7	4.7	0.9
8	21.6	16.7
Total	66.6	64.5

* CF = 0.70, from Route 3

Route 9 — San Bernardino/Riverside - Irvine
Length: 59 Miles
Start-up Date: 1995
Number of Trains: Start-up: 4
Intermed: 8

Time at Notch Position (minutes)		
Notch	Eastbound*	Westbound*
idle	19.6	21.4
1	3.9	8.4
2	6.7	6.8
3	6.0	9.4
4	6.3	12.4
5	9.4	4.7
6	8.0	6.7
7	7.0	1.4
8	32.1	24.8
Total	99.0	96.0

* CF = 1.04, from Route 3

Route 10 | Redlands - San Bernardino
Length: | 12 Miles
Start-up Date: | 1995
Number of Trains: | Start-up: 2
| Intermed: 4

Time at Notch Position (minutes)		
Notch	Eastbound*	Westbound*
idle	3.9	4.3
1	0.8	1.7
2	1.3	1.4
3	1.2	1.9
4	1.3	2.5
5	1.9	0.9
6	1.6	1.3
7	1.4	0.3
8	6.5	5.0
Total	19.9	19.3

* CF = 0.21, from Route 3

Total Miles: 138.5

Mileage Weighted Composite for Routes 2, 3, 4		
Total Time at Notch Position (minutes)		
Notch	Eastbound	Westbound
idle	43.7	48.1
1	11.9	14.3
2	21.1	17
3	18.8	22.6
4	13.7	27.8
5	17.8	11.6
6	18.7	15.4
7	13.8	6.4
8	69.5	54.8
Total	229.0	218.0

APPENDIX 8-2

ICI Products

Diesel-Electric Locomotive Tests on Engines Fuelled With Ignition-Improved Methanol (Methanol/AVOCET)

1.0 Summary

Tests were conducted on two typical locomotives minimally modified to run on methanol/AVOCET.

1.1 GE SG10B: a low compression ratio V8 four stroke turbocharged locomotive.

1.2 GM SW1002: a higher compression ratio two stroke locomotive.

Both were successfully run on methanol fuel and each achieved higher thermal efficiency than the diesel baseline. Engine [1] performed poorly before warm-up. Engine [2] performed normally under all conditions. No emissions tests were conducted, but the exhausts were free of visible smoke.

2.0 Conclusion

2.1 Engine Conversion

Locomotive engines can be readily converted to run on methanol fuel when a suitable ignition-enhancer is utilized. Normal power outputs are obtained. The tests confirmed feasibility only. An optimization program would need to be established for conversion methodology to achieve maximum cost effectiveness and component reliability.

2.2 Emissions Benefits

By analogy with emissions tests on similar heavy duty engines, it may be expected that, compared with diesel fuel, the methanol locomotive engines would emit very low particulate levels having zero carcinogenic smoke component, and NOx would be cut by one-half to one-third. Organics (such as CO, HCHO and other VOC's) could be catalytically oxidized to very low levels (catalysts are very suitable for use with methanol fuelled engines). AVOCET required for smooth running could be minimized if compression ratios were increased, and NOx could be minimized if timing were retarded.

3.0 Test Conditions and Results

Both engines were instrumented and load box test runs were performed. Full data logging included cylinder pressure traces, injector needle lift, various temperatures and pressures during operation, fuel consumption, and power measurements.

3.1 GM SG10B

3.1.1 Engine

Type: GE V8 four-stroke turbocharged diesel
Rating: 1320 HP at 1,000 r.p.m.
Compression Ratio: 12.2 : 1

3.1.2 Fuel System Modifications

Governor-to-injector linkage modified to give 35mm rack at Notch 8 (normal length 22mm). Injectors fitted from a 1,500 HP GE engine, but with the standard SG10B injector nozzles.

3.1.3 Results

With coolant temperatures over 50°C, normal operation (i.e. power output, rates of pressure rise and cylinder peak pressure) achieved were all normal, but below 50°C erratic was firing observed even when timing was advanced 5 degrees.

Thermal efficiency at Notch 5 was 34.2%. No exhaust emissions were tested; no visible smoke was observed.

3.2 GM SW1002

3.2.1 Engine

Type: EMD 8E-645 with blower
Rating: 1,000 HP at 900 r.p.m.
Compression Ratio: 16 : 1

3.2.2 Fuel System Modification

Larger injectors (12.65 mm plunger diameter versus 10.7 mm standard), and larger nozzles (0.38 mm hole diameter versus 0.34 mm standard) installed. Number and location of spray holes were unchanged.

3.2.3 Other Modifications

The governor-to-injector linkage was modified, with terminal shaft rack readings as follows:

	Standard (mm)	Methanol/Avocet (mm)
Low Idle	44-5	45-8
Notch 8	21-1	Max 15 (Notch 7)
Notch 8 Fuel Dlvy	630 μℓ/stroke	Max 1162 μℓ/stroke

Fuel for each test was supplied at 200-250 KPa.

3.2.4 **Results**

During cold start, idling and warm-up the engine ran normally when fuelled with methanol/AVOCET. The engine continued to run normally when injection was retarded up to 9 degrees from standard. A thermal efficiency of 35% was observed for the diesel baseline when running at Notch 5 with a static 4 degree BTDC. The comparable methanol figures were 37.6% at Notch 5 with 7 degree retardation from standard, and 38.2% at 9 degree retardation.

No emissions tests were performed; no visible smoke was seen during the methanol tests.

Glyn D. Short
Business Development Manager

11059102.GDS

APPENDIX

Conditions/Data for SG10B Tests

	Diesel	Methanol/Avocet
Throttle Setting	Notch 8	Notch 8
Engine Speed, rpm	1062	1062
Turbo Speed, rpm	16320	17340
Generator Output V	487.9	510.3
Generator Output A	1622	1717
Generator HP (uncorrected)	1130	1251
Generator HP (kw)	843	934
Fuel Rate kg/min	3,51	8,25
Fuel Lower HV, MJ/kg	42,3	19,8
Thermodynamic Efficiency, %	33,8	34,3
Exhaust Gas Temp °C		
Before Turbo	578	567
After Turbo	461	425

NB: Difference in power at Notch 8 mainly because modified governor linkage over compensated slightly for the lower calorific value of fuel (injectors were thus of ample capacity).

Notes:

- Locomotive engines in AAR practice are tested at governed speed/power settings (Notch 1 - Notch 3). Only Notch 8 is full load, other notches are all at partial load.
- Locomotive SG10B: Full comparison data only at Notch 8.
- Locomotive SW1002: Comparison at all throttle notches, attached table and graph.
- Avocet Concentration 5,0% by volume in fuel.
- No materials incompatibilities encountered (but tests were short-term only).
- Exhaust temperatures SG10B at Notch 8 and GW1002 at all notches give in tables/graphs herewith.
- Hot return fuel from injectors was cooled in a very ad hoc way in a trackside fuel cooler consisting of 10m of copper pipe (NB: unsuitable material) coiled into a container with a trickle of cold water flowing over it.

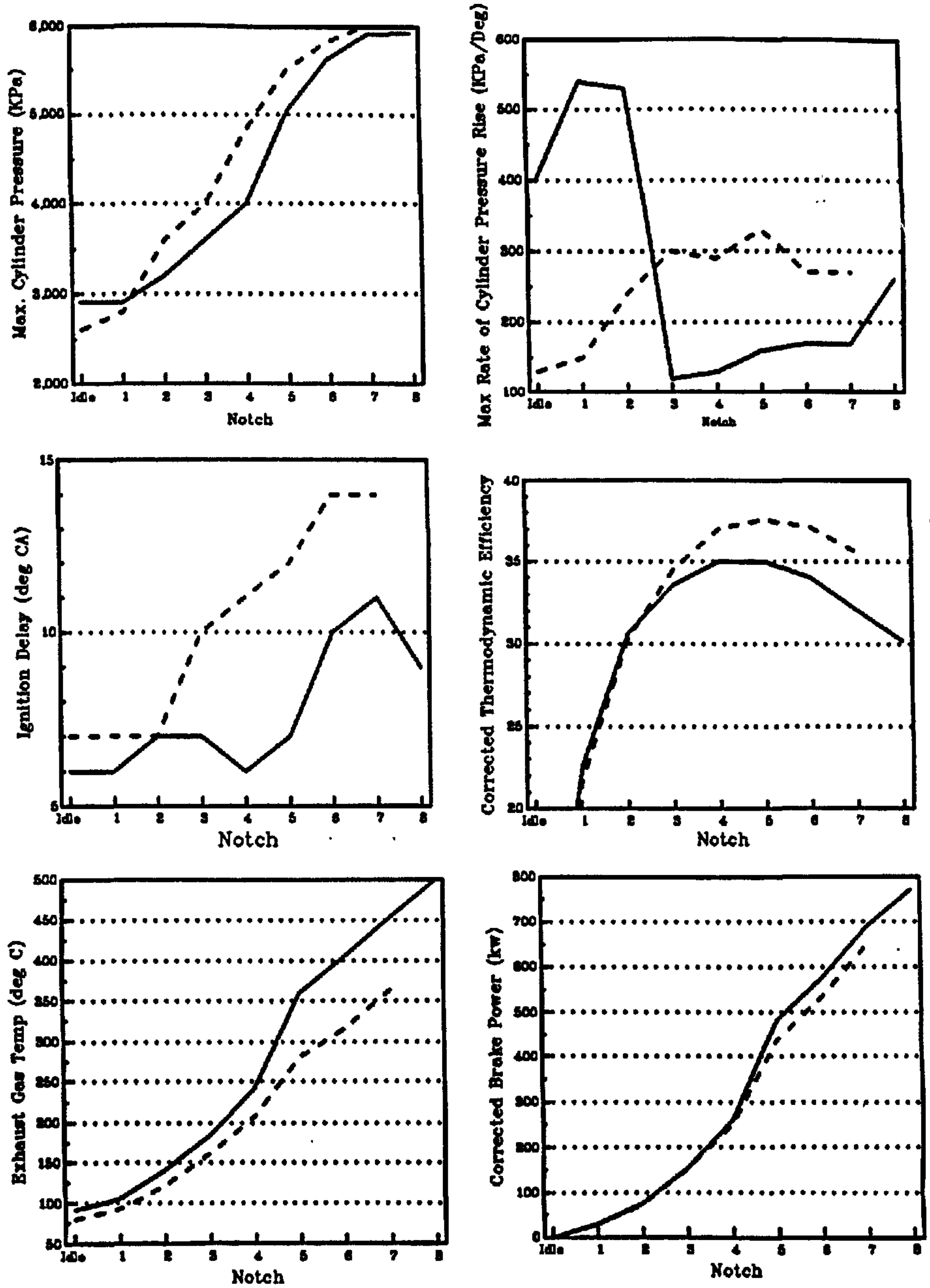
Results

SW 1002 LOCD - EMD 8E-645 Engine

		Max. Cylinder Pressure	Max Rate of Pressure Rise	Ignition Delay Degree	Exhaust Gas Temp	Corrected Brake Power	Engine Speed	Thermal Efficiency Temp Power
		KPa	KPa/deg	CA	°C	KW	RPM	%
Diesel Fuel								
Baseline								
Idle		2900	400	6	91	-	318	-
Notch	1	2900	539	6	106	29	312	22,6
	2	3200	530	7	141	74	378	30,6
	3	3600	120	7	184	153	498	33,6
	4	4000	130	6	242	261	570	35,0
	5	5020	160	7	359	484	648	35,0
	6	5620	170	10	404	576	738	34,0
	7	5920	170	11	453	688	825	32,1
	8	5930	260	9	499	770	912	30,2
Methanol/Avocet								
Idle		2600	130	7	79	-	312	-
Notch	1	2800	150	7	92	28	312	21,7
	2	3600	240	7	122	73	384	30,3
	3	4000	300	10	161	151	492	34,5
	4	4800	290	11	208	250	606	37,0
	5	5500	330	12	280	438	660	37,6
	6	5820	270	14	316	536	732	37,1
	7	6020	270	14	363	650	828	35,6

NB: Injection timing Methanol/Avocet 7 deg retarded standard diesel setting

CATS EMD 8E-645 METHANOL/AVOCET TEST



Diesel Baseline (standard injection) Methanol/Avocet (7 deg. retarded)

NB: Injectors for Methanol had insufficient capacity to reach Notch 8.

APPENDIX 8-3

HEALTH EFFECTS INSTITUTE

H E I

SPECIAL REPORT

Automotive Methanol Vapors and Human Health:
An Evaluation of Existing Scientific Information
And Issues for Future Research

Report of the Institute's
Health Research Committee

May 1987

STATEMENT FROM THE HEI BOARD OF DIRECTORS

The manufacturers of motor vehicles and the Environmental Protection Agency (EPA) have a responsibility under the Clean Air Act to ensure that any new technology affecting mobile source emissions will not pose an "unreasonable risk to the public health." (Section 202 (a) (4)). EPA has been requesting the Health Effects Institute (HEI) since 1983 to undertake a research program to determine what emissions-related health problems, if any, would emerge if methanol were to become more widely used as an automotive fuel.

Methanol-fueled vehicles emit both formaldehyde and methanol vapors. In 1985, HEI began to fund a research program to investigate the potential health effects of aldehydes, including formaldehyde. The HEI Health Research Committee, with our approval, decided to undertake additional analysis before proceeding with research on methanol vapors. This report contains the Committee's assessment. We are publishing it because we believe it will provide considerable guidance to government and industry, as policies relating to methanol fuel are considered.

The report focuses on the potential health effects of exposure of the general public to methanol vapor that might result from an introduction of methanol-powered motor vehicles in the general fleet. The report also evaluates, insofar as present knowledge permits, the likely health implications of such exposure. The report excludes analysis of the effects of accidental spills, ingestion, and worker exposure.

We have examined the report carefully, and we believe it represents a responsible summary of the current state of knowledge about the effects of methanol and the likely impact of exposure to its vapors. The Health Research Committee's analysis of the available evidence indicates that chronic exposure of people to low levels of methanol emissions is not likely to trigger known mechanisms of methanol's toxicity.

There has not been, however, sufficient research to eliminate entirely the possibility that health effects could occur at low levels of chronic exposure to methanol. A study of non-human primates chronically exposed to methanol vapor at moderate to high concentrations was recently completed in Japan. The summary report of that study, although rather sketchy, indicates the possibility of biological effects at exposure levels toward the upper end of the range of levels that have been predicted to arise from vehicular emissions. Accordingly, the specific findings of this study must be obtained, clarified if possible — a difficult and time-consuming task — and the research pressed further, if necessary. This appears particularly important if one goes beyond the foreseeable future and contemplates the immense scale of methanol use that would result if methanol were to become a dominant fuel in the next century.

On balance, we believe that, given the anticipated uses of methanol as a motor vehicle fuel in the foreseeable future, the weight of available scientific evidence indicates that exposure to methanol vapors is not likely to cause adverse health effects. Health concerns regarding methanol vapor should not prevent government and industry from encouraging the development and use of methanol fuels, assuming that such development and use are otherwise in the public interest.

The Health Effects Institute and other research organizations are continuing to investigate the potential health effects from increased formaldehyde emissions that may result from methanol's use. The results of those inquiries will become available over the next several years. We believe that prudent public policy suggests that an additional modest research investment be made by appropriate research institutions, and perhaps by HEI, to reduce uncertainties further in estimating the health risks of low-level exposures to methanol, and to enhance the public's confidence in methanol technology.

Problems at relatively minor usage levels might only become evident as billions of gallons are introduced annually. It seems wise to ensure now that the possibility of adverse health consequences is minimized. It is in this light that any further research is prudent. But our best current assessment is that methanol fuel, under intended conditions of use, does not pose an unreasonable risk to the public health attributable to emission of methanol vapors from the tailpipe of motor vehicles.

In addition to thanking the entire HEI Health Research Committee for its efforts in shaping this document, we would particularly like to thank Dr. Walter Rosenblith, Chairman of the Committee, who directed this effort, Dr. Robert Kavet, who was the primary author of this report when he served as Senior Staff Scientist at HEI, and Dr. Roger McClellan, who gave generously of his time to ensure the quality of this effort.

Archibald Cox, Chairman
William O. Baker
Donald Kennedy
Charles W. Powers

May, 1987

AUTOMOTIVE METHANOL VAPORS AND HUMAN HEALTH:

An Evaluation of Existing Scientific Information And Issues for Future Research

EXECUTIVE SUMMARY

Methanol has the potential to become a major automotive fuel in the United States in the next century. One attractive feature linked to methanol's use is that emissions from methanol-fueled vehicles are expected to result in ambient concentrations of criteria pollutants that are no greater than and, quite likely, lower than those that result from gasoline or diesel emissions. However, the introduction of methanol also may result in increased exposure of the public to methanol and formaldehyde, both currently unregulated. The Environmental Protection Agency (EPA) has identified the importance of technically evaluating these relevant health issues. The Health Effects Institute (HEI) shares the EPA's concern and already has initiated laboratory research to investigate the health effects of aldehydes.

This report, prepared by HEI at the EPA's request, evaluates specifically the health consequences to humans that may result from inhalation of methanol vapors either emitted from methanol-fueled vehicles or during self-service refueling. The report's objectives are (1) to review the nature and mechanisms of methanol's toxicity, (2) to evaluate whether or not methanol's known effects might be expected at the anticipated low levels of intermittent exposure associated with increased use of methanol as a vehicle fuel, and (3) to identify both the areas in which critical knowledge is lacking and the research that could supply the needed information.

Anticipated Exposure Levels of Methanol

Data that estimate the range of potential exposure concentrations of methanol are essential to establish whether or not particular biologic or health effects are likely to occur. The EPA has conducted studies that project concentrations of methanol that will occur in a variety of scenarios. These include (1) three traffic situations - street canyon, roadway tunnel, and expressway; (2) exposures in both public parking and personal garages; (3) and exposures during self-service refueling. The analyses take into account both the driving conditions and the vehicle operating mode, as well as the contribution to emissions of vehicles that are not operating according to certification standards.

The highest exposures are expected in the garage scenarios, particularly the personal garage. Worst-case exposure will probably occur in the personal garage immediately after ignition turn-off when a vehicle produces "hot-soak" evaporative emissions. In most cases, however, personal garage exposures are unlikely to last more than several minutes. The EPA projects that worst-case (i.e., hot-soak) personal garage exposure levels (those from a malfunctioning vehicle in an unventilated garage) may be as high as approximately 240 milligrams per cubic meter (mg/m^3) of methanol, but that, under more realistic conditions (normal ventilation), levels are unlikely to exceed 130 mg/m^3. For the traffic situations evaluated, methanol concentrations are projected to be much lower (less than 6 mg/m^3), even if the fleet is 100% methanol-fueled. One other exposure situation that merits attention is that in which a customer at a self-service filling station will be exposed to roughly 50 mg/m^3 of methanol vapor for 3 to 4 minutes during refueling. The personal garage and self-service refueling scenarios are important not only because they represent relatively high exposure levels, but also because the methanol concentration, in these cases, is independent of the penetration of methanol-fueled vehicles into the fleet. As a point reference, the American Congress of Governmental Industrial Hygienists' (ACGIH) threshold limit value (TLV) for occupational exposure is 260 mg/m^3 (200 ppm); this standard is a time-weighted average for an 8-hour period.

Toxicity of Methanol

Nearly all of the available information on methanol toxicity in humans is related to the consequences of acute, rather than chronic, exposures. Acute methanol toxicity evolves in a fairly well-defined pattern. A toxic dose results from intake of a large quantity of methanol in a short period of time, and initially produces a transient, mild depression of the central nervous system. An asymptomatic latent period follows, and may last from several hours to two days or more. The latent period gives way to the onset of a syndrome that consists of an uncompensated metabolic acidosis with superimposed toxicity to the visual system. The physical symptoms, in severe cases, may progress to coma and death; for those who survive, the visual symptoms may, within days to weeks, reverse or progress to permanent visual impairment. The effects that appear after the latent period are attributable to metabolites of methanol, most prominently, formic acid (which dissociates to formate plus a hydrogen ion), and not to methanol itself.

The minimum lethal dose of methanol (in the absence of medical treatment) ranges between 0.3 and 1.0 grams per kilogram of body weight (g/kg). The maximal dose of methanol expected in the EPA's exposure scenarios, by comparison, is under 1 milligram per kilogram of body weight (0.001 g/kg). However, the clinical literature indicates that susceptibility to methanol's sub-lethal acute effects may vary widely among individuals. Two of the known determinants of susceptibility are (1) co-exposure to ethanol, which greatly slows methanol's entrance into its metabolic pathway, and (2) the level of liver folate, which is crucial to the oxidation of formate, the key toxic metabolite of methanol.

Until the 1950s, a major obstacle to understanding and treating methanol poisoning was the lack of understanding of some of the mechanisms of methanol toxicity. This situation existed because of the lack of appreciation that non-primate species are not suitable models of acute human methanol toxicity. Gilger and Potts, in 1955, demonstrated that, of all common laboratory species tested, only non-human primates experience methanol toxicity, including ocular pathology, which is characteristic of humans. The non-human primate model has been confirmed, and has enabled a systematic exploration of the metabolic bases, kinetics, and mechanisms of methanol's acute toxic syndrome.

Data on humans or non-human primates exposed to low levels of methanol vapors are scarce and not well-developed. The epidemiologic literature provides weak suggestive evidence that prolonged occupational exposure to methanol vapors at levels above the TLV (260 mg/m^3) may produce symptoms such as headache and blurred vision. However, the conclusions are based on symptom reporting, a less preferable source of data than clinical examination, and assessments of exposures are generally inadequate.

In human clinical experiments, two separate Russian studies reported effects of low-level, short-duration methanol exposures (less than 10 mg/m^3, approximately 5-minute exposures) on neurobehavioral endpoints, specifically, dark adaptation and EEG-conditioned thresholds. These reports, however, fail to provide descriptions of critical methodological and analytical procedures, as well as complete descriptions of study subjects, and provide only limited data that describes the results. Upon close examination, the results from the two studies are not consistent, and they are not entirely plausible.

In acute and chronic animal experiments published to date in the peer-reviewed scientific literature, there are no indications that adverse health effects are expected at the potential methanol exposure levels discussed earlier. In Japan, the Institute for Applied Energy, with sponsorship of the New Energy Development Organization (NEDO), conducted an extensive research program in which rodents and non-human primates were exposed to methanol vapors either briefly or for extended periods of time. Although the report issued by NEDO indicates potential effects to the central nervous system of non-human primates exposed to 13 mg/m^3 for extended periods of time, the details available in that document are insufficient to permit critical evaluation. Further evaluation of these studies will be necessary.

Finally, in people, both methanol and its toxic metabolite, formate, are present at background levels that result from normal dietary intake and natural metabolic processes. A major contributor to the body burden of methanol in many people is the artificial sweetener, aspartame, now found in many foods. Following ingestion, 10% of the aspartame molecule enters the circulation as methanol.

Metabolism of Methanol and Mechanisms of Toxicity

Methanol distributes readily and uniformly to all organs and tissues in direct relation to their water content. For short-term inhalation exposures, an upper-bound estimate of initial body burden assumes total absorption of the inhaled vapor. A 70 kg person breathing at a ventilation rate of 20 m^3/day (twice resting), who is exposed to 200 mg/m^3 methanol vapor for 15 minutes (as in a worst-case hot-soak garage scenario), accumulates a methanol body burden of 0.0006 g/kg — at least 500 times lower than doses of acute clinical significance.

Following its uptake and distribution, methanol clears from the human body with half-times of a day or more for high doses (greater than 1 g/kg), and about three hours for the low doses of relevance to this report's objectives (less than 0.1 g/kg). Methanol is either excreted unchanged, mainly in urine and exhaled breath, or enters a metabolic pathway (in the liver) whose ultimate products are carbon dioxide (which is exhaled harmlessly) and water. For the body burdens of methanol that follow a worst-case exposure, metabolism is the dominant pathway, accounting for over 90% of methanol's clearance. This is a key point because methanol's toxic properties are linked to intermediate metabolites, not to the alcohol itself.

In all mammalian species studied, the sequence of metabolic intermediates leading from methanol to its end products is the same:

$$\text{Methanol} \xrightarrow{1} \text{Formaldehyde} \xrightarrow{2} \underset{(+H^+)}{\text{Formate}} \xrightarrow{3} CO_2 + H_2O$$

The toxic properties of methanol, and the basis of species susceptibility, are rooted in the factors that govern the relative rates of formic acid generation (steps 1 and 2) and formate oxidation (step 3). In short, the toxic syndrome sets in if formate generation continues at a rate that exceeds its rate of metabolism to carbon dioxide (CO_2). This imbalance, if protracted, leads to an accumulation of formate coupled, eventually, to an uncompensated metabolic acidosis. The acidosis, if untreated, can prove lethal; formate, even at physiologic pH, is associated with ocular toxicity. In both rats, which are methanol-resistant, and in non-human primates, which are susceptible, the folate pathway in the liver mediates formate metabolism to carbon dioxide. The efficiency of this process is linked to the availability of tetrahydrofolate (THF), the molecule that initially complexes with formate. Non-primate species dispose of formate efficiently at any dose and, thus, escape toxicity, whereas, at sufficiently high doses, humans and non-human primates accumulate toxic metabolites and, thus, are at risk to adverse consequences. As an aside, formaldehyde is not believed to play a role in methanol toxicity.

The mechanisms responsible for injury to the visual system in acute methanol poisonings are not yet understood, but several investigators have postulated that formate, at sufficiently high blood levels, may inhibit cellular respiration in the proximal portion of the optic nerve, leading to a compression type of injury to the nerve's axons that ultimately affects vision. An acidotic state may accelerate such an injury.

Although formate possesses toxic potential, the levels it will achieve in people following worst-case environmental exposures to methanol will not come close to challenging the metabolic capacity of the folate pathway. The small increases of formate levels that have been observed in the blood and urine of adult humans following either occupational exposure to methanol vapors or experimental administration of aspartame reflect normally operating metabolic pathways. The blood levels of formate that follow worst-case (i.e., hot-soak, personal garage) environmental exposure to methanol vapor will, in all likelihood, not be discriminated from the background level of blood formate.

Evaluation and Recommendations

- **Discussion**

The implementation of methanol as a vehicle fuel is likely to increase the exposure of the general public to methanol vapors. EPA analyses predict that the highest exposure levels will occur in personal garages during engine hot-soak, at the self-service pump during refueling, and, with increasing penetration of methanol technology into the fleet, in public parking garages. By comparison, exposure concentrations in traffic situations, even with 100% penetration of methanol-fueled vehicles, will be very low.

The health effects of methanol are best recognized and studied for cases in which subjects have orally ingested large single doses. The clinical literature documents many case histories of methanol poisoning; its course, which consists of metabolic acidosis and visual disturbance that follow a symptomless latent period, is well characterized. Methanol's toxicity, in these cases, is attributable to its metabolite, formate. Methanol as an unmetabolized substance is not considered toxic unless it is taken in narcotic doses. The discovery, in the 1950s, of the non-human primate as a model of acute human toxicity was perhaps the single most important event to lead to our current understanding of methanol's acute toxicity.

The characteristics of methanol's chronic effects, on the other hand, are not well known. The literature from studies of non-human primates is of little value in evaluating the dose- and time-effect characteristics for protracted exposures of people. The limited evidence from epidemiologic studies and case reports suggests that chronic effects, if they appear, are similar to those described for acute toxicity (e.g., headache, blurred vision), but are less severe. Thus, acute and chronic effects may share common pathways of action. In the small number of instances that report chronic effects attributable to methanol, exposure levels exceed the ACGIH TLV of 260 mg/m^3.

In the worst-case exposure scenario (hot-soak, personal garage), the inhaled body burden of methanol (0.0006 g/kg) will be approximately equivalent to the pre-existing background levels of methanol (0.0005 g/kg) for a brief period of time following exposure. For self-service refueling, the contribution will be roughly 10 times less. The average daily intake of methanol from aspartame in the diet (approximately 0.0003 to 0.0015 g/kg) is on the same order of magnitude as uptake from a single worst-case exposure in the hot-soak garage. Even more importantly, however, worst-case methanol exposures will not lead to blood formate levels that challenge the folate pathway's capacity to oxidize formate. Furthermore, the increase expected in blood formate following worst-case exposure will be negligible in comparison to the background levels of blood formate.

- **Conclusion**

Based on the foregoing evidence, if methanol produces health effects in normal subjects at or near the exposure levels of concern, these effects would not likely be attributable to the generation of formate. However, the effects of low-level formate accumulation in potentially susceptible subjects has not been examined.

A firm conclusion about the potential health effects from chronic exposures cannot be drawn yet. To date, no human epidemiologic studies have reported effects that could be linked to chronic methanol exposures below the TLV of 260 mg/m^3. However, careful investigations of people exposed chronically to levels below the TLV are not available, and would, no doubt, prove very useful if the levels of exposure were rigorously quantitated.

An analysis of the available peer-reviewed literature produces no evidence upon which to base a conclusion that exposure to methanol vapors will result in adverse health effects. This conclusion applies only to exposures that will occur as a result of methanol's normal use as a vehicular fuel, and not to exposure that may occur either from ingesting methanol fuels or from spillage.

Although adverse effects have not been indicated in this analysis, further research targeted to answer specific questions would help in further reducing the uncertainties of estimating the health effects of protracted or repeated low-level exposures, and would serve to reinforce the certainty of conclusions about the public's health. Such research should attempt to elucidate the potential consequences of protracted or repeated low-level exposure, using human epidemiologic approaches and animal experimentation. In the latter, further work could be conducted that would more completely describe the dose- and time-effect relationships between formate concentrations in the body and effects to the visual system. Achieving these objectives would lead to a better understanding of metabolic processes in suspected target tissue.

APPENDIX 9-1

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

OFFICE OF DISTRICT COUNSEL

MEMORANDUM

DATE: September 10, 1991

TO: Hank Wedaa, Vice Chairman
Larry Berg, Member
South Coast Air Quality Management District Governing Board

FROM: Peter M. Greenwald, District Counsel PG

SUBJECT: District's Authority to Regulate Emissions from Locomotives

Pursuant to your request, this memorandum analyzes the authority of the South Coast Air Quality Management District ("District") to regulate emissions from locomotives. Specifically addressed is the authority of the District to adopt regulations implementing AQMP Measure 14, which proposes electrification of rail operations in the South Coast Air Basin.

CONCLUSIONS

- Under state law, the District and the California Air Resources Board ("CARB") have authority to establish emission limitations applicable to locomotives.

- State law prohibits the District from specifying the "design of equipment, type of construction, or particular method to be used" in reducing the release of air contaminants from locomotives. The District thus could not explicitly mandate a particular control technology such as electrification. CARB is not subject to this limitation and, under state law, likely could mandate specific control technologies, including use of locomotives powered solely by electricity.

- Under state law, the District could encourage, or potentially even mandate, electrification by establishing a low emissions limit applicable to locomotives or a low mass emissions cap applicable to rail systems.

- Under the 1990 amendments to the federal Clean Air Act, neither the District nor CARB may establish "any standard or other requirement relating to the control of emissions from" new locomotives or new engines used in locomotives. While the exact impact of this prohibition has not been defined by the courts, there is a reasonable basis to conclude that a District regulation imposing a mass emissions cap applicable to a rail system would be permissible.

- Under the 1990 Amendments to the federal Clean Air Act, the federal EPA must provide authorization before California may enforce standards or other

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requirements relating to the control of emissions from locomotives (other than state regulations applicable to new locomotives, which regulations are prohibited). Such authorization should be obtainable if the District demonstrates a need for locomotive emission limitations and coordinates its rulemaking actions with other local jurisdictions and the state to prevent conflicting locomotive emission control requirements.

- Under the United States Constitution, any regulation of locomotives must be crafted so as to avoid an undue interference with interstate commerce. EPA authorization for District locomotive regulations should help in demonstrating compliance with this requirement.

DISCUSSION

AQMP Measure 14

AQMP Measure 14 proposes electrification of rail operations in the South Coast Air Basin. The measure proposes that by 1995 the federal Environmental Protection Agency ("EPA") and the Federal Railway Administration conduct a feasibility study of railroad electrification. It is proposed that EPA and the Federal Railway Administration direct installation by 2010 of overhead or third rail electrical distribution systems applicable to 90 percent of rail operations in the basin, totaling approximately 571 route miles. It is projected that this measure would result in a 90% reduction in railroad emissions as long as new power needed is generated outside of the basin. See 1991 AQMP, Appendix IV-E, p. I-197.

Measure 14 is proposed to be implemented by federal agencies. EPA, however, proposed to take no action to approve Measure 14 for inclusion in the State Implementation Plan when California submitted the measure to EPA as part of the 1989 AQMP. 55 Fed.Reg. 36490 (Sept. 5, 1990). EPA's stated reason for proposing to deny approval of Measure 14 was that the description of the measure required additional detail. Id. To date, EPA has taken no final action on the 1989 AQMP, primarily due to extensions of planning deadlines and changes in SIP approval criteria made by the 1990 Amendments to the Clean Air Act, and it is not known when or to what extent EPA will approve the 1991 revision to the AQMP. The lack of a federally-approved SIP which designates responsibilities for federal agencies limits the ability of the District to compel the federal government to implement controls such as Measure 14. These circumstances, coupled with the importance of the emission reductions achievable through railroad electrification, underscore the need to determine whether or not the District and/or state have authority to implement Measure 14.

District Authority Under State Law to Regulate Emissions from Locomotives.

The District was established by the California Legislature and derives its authority from state law. The California Health and Safety Code provides that local and regional authorities such as the District have the "primary responsibility for control of air pollution from all sources, other than emissions from motor vehicles." Health & Saf. Code Sec. 40000, see also Secs. 39002, 39060. The control of emissions from motor vehicles is generally the responsibility of the CARB. Id. The term "motor vehicle," is defined in Section 415 of the Vehicle Code, which does not reference locomotives. See, Health & Saf. Code Sec. 39039. The District thus has general statutory authority under state law to regulate emissions from locomotives. The District has a longstanding practice of exercising this authority by, for example, requiring locomotives to comply with the emissions opacity limits of District Rule 401.

The conclusion that the districts have authority to establish emissions limitations applicable to locomotives is buttressed, and limited, by Health and Safety Code Section 40702. This section provides that:

> "No order, rule, or regulation of any district shall . . . specify the design of equipment, type of construction, or particular method to be used in reducing the release of air contaminants from railroad locomotives."

While Section 40702 prohibits the districts from specifying the type of equipment to be used in controlling emissions from locomotives, it evidences an intent on the part of the state legislature that the districts have authority to adopt regulations limiting locomotive emissions.

Other state statutes which govern regulation of emissions from locomotives relate primarily to CARB and do not limit the districts' general rulemaking authority over locomotives. For example, the Health and Safety Code generally requires CARB to "endeavor to achieve the maximum degree of emission reduction possible from vehicular and other mobile sources in order to accomplish the attainment of the state standards at the earliest practicable date." Health & Saf. Code Sec. 43018(a). Section 43013(b) of the code authorizes CARB to adopt "standards and regulations" for offroad and nonvehicle engine categories, including locomotives. The code requires CARB to conduct hearings to consider adoption of regulations applicable to several types of offroad and nonvehicular sources, a class which includes locomotives, not later than November 15, 1991.

The code provides that CARB may not adopt any standard or regulation affecting locomotives until a final study, required by AB 234 adopted in 1987, has been completed and submitted to the Governor and the Legislature. Health & Saf. Code Sec. 43013(d). The study required by AB 234 must review locomotive emissions and technology available to reduce those emissions, evaluate the economic impact on the railroad industry of utilizing present and proposed control technologies, and analyze public and employee safety issues that may result from the use of these technologies. This study, which was directed by a locomotive emission advisory committee ("LEAC"), has been completed and was approved by CARB on August 8, 1991.

The above-described provisions do not preempt local air quality districts from exercising their general rulemaking authority to regulate locomotive emissions. In general, preemption of local authority will be found if legislative intent to preempt local regulation is explicitly stated or is implied from the statutory scheme.[1]

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1 The California Supreme Court has described the test for implied preemption as follows:

> "In determining whether the Legislature has preempted by implication to the exclusion of local regulation we must look to the whole purpose and scope of the legislative scheme. There are three tests: '(1) the

However, with the exception of Section 40702, which prohibits district rules that specify particular types of control equipment, no explicit preemption of local authority to regulate locomotives is stated in the Health and Safety Code. In addition, based on a recent California Supreme Court case, the doctrine of implied preemption likely does not apply to the authority of air quality management districts to regulate locomotive emissions. In the case of Western Oil and Gas Association v. Monterey Bay Unified Air Pollution Control District, 49 Cal.3d 408, 261 Cal.Rptr. 384 (1989), the Court was faced with a claim of preemption by the Tanner Act, which, like the statutory provisions governing CARB's authority to regulate locomotive emissions, specifies requirements and procedures for CARB to adopt toxic air contaminant control measures. The Court ruled that the Tanner Act does not preempt or repeal by implication pre-existing district authority to regulate toxic emissions. Moreover, in discussing the doctrine of implied preemption, the Court noted that Health and Safety Code Section 41508 states that "[e]xcept as otherwise specifically provided in this division . . . any local or regional authority may establish additional stricter standards than those set forth by law or by the state board for nonvehicular sources." The Court therefore questioned whether an implicit restriction on district authority would ever be effective in light of this statutory reservation of local authority. Id. at 419, note 15, 261 Cal.Rptr. at 390, note 15.

In view of the above provisions and case law, the code provisions applicable to CARB should be interpreted only as an authorization (Section 43013(b)) and mandate (Section 43018(d)(3)) for CARB to take certain actions to control locomotive emissions. Those code provisions should not be interpreted to preempt or repeal the authority of the District to regulate locomotive emissions.

District Authority Under State Law to Mandate Railroad Electrification.

Under the statutory provisions described above, both the District and CARB have authority to establish emission limitations applicable to locomotives. The LEAC study identified several emission control techniques which could be applied to locomotives to meet such regulatory emission limitations. These techniques include operations-related changes such as reducing idling time, relatively near-term technology-based actions including retarded injection timing and retrofittable high-rate injectors which are capable of being made during normal maintenance and rebuilding of existing locomotives, and intermediate and longer term technology development strategies, including increased after-cooling, selective catalytic

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subject matter has been so fully and completely covered by general law as to clearly indicate that it has become exclusively a matter of state concern; (2) the subject matter has been partially covered by general law couched in such terms as to indicate clearly that a paramount state concern will not tolerate further or additional local action; or (3) the subject matter has been partially covered by general law, and the subject is of such a nature that the adverse effect of a local ordinance on the transient citizens of the state outweighs the possible benefit to the municipality.'" People ex rel. Deukmejian v. County of Mendocino, 86 Cal.3d 476, 485, 204 Cal.Rptr. 897, 683 P.2d 1150 (1984).

An alternative means by which the District could regulate locomotive emissions would be to establish a mass emissions cap for the entire rail system or portions thereof. Included within the cap could be all emission sources associated with the rail system. The regulation could provide that the cap would decline over time. Such a regulation would be authorized as an exercise of the District's general rulemaking authority or, possibly, as an indirect source control measure.[5]

The chief legal question under state law regarding a District rule mandating a low or zero emission limitation for locomotives or rail systems would be whether or not such an emission limitation would be tantamount to a prohibited specification of a particular control method since electrification would likely be the only technology which could be used to achieve compliance. The District regulation should be upheld, however, because it would meet the letter of Health and Safety Code Section 40702 by not specifying the "design of equipment, type of construction, or particular method" to be used in reducing locomotive emissions. Moreover, there would likely be several "particular methods" which could be employed to electrify a railroad in order to comply with a District emission limit (e.g., overhead transmission lines, third rail transmission, diesel electric retrofits, or new electric locomotives). Finally, it should be noted that virtually all regulatory emission limitations are based upon contemplation of a particular control technology or technologies.

<u>Limitations on District Authority Imposed by the Federal Clean Air Act.</u>

<u>Preemption of State Regulation of New Locomotives</u>. The federal Clean Air Act as adopted in 1970 and amended in 1977, imposed no limitations on the authority of the state or its political subdivisions to regulate emissions from locomotives. This situation changed with adoption of the 1990 Amendments to the Clean Air Act. The 1990 Amendments added paragraph 209(e)(1) to the Act, which prohibits states and their political subdivisions from adopting or attempting to enforce

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are diesel electric. This design involves a diesel engine which drives a generator that provides electricity for the operation of traction motors mounted on the locomotive wheels. In theory, such locomotives could be retrofitted to receive electricity from overhead wires or a third rail. According to District and CARB staff, a transformer would be required to convert alternating current from transmission lines into the direct current used by locomotive traction motors. If space for a transformer is not available on a locomotive to be retrofitted, it may be possible for a rail car containing the transformer and electricity pick up to be connected behind the locomotive when in the District. Alternatively, all-electric locomotives could be acquired for use in the District.

5 The Health and Safety Code authorizes the District to adopt regulations to control emissions from indirect and area-wide sources. Health & Saf. Code Secs. 40440(a)(3), 40716(a)(1), 40462, 40918(a)(4). The terms "indirect source" and "area-wide source" are not defined in the Health and Safety Code. The term "indirect source is generally understood, however, to include facilities such as highways and housing developments which do not emit air contaminants but which attract sources of air contaminants, such as motor vehicles. This definition could conceivably include railway systems.

> "<u>any standard or other requirement relating to the control of emissions from</u> either of the following new nonroad engines or nonroad vehicles subject to regulation under this Act -- (A) New engines which are used in construction equipment or vehicles or used in farm equipment or vehicles and which are smaller than 175 horsepower. (B) <u>New locomotives or new engines used in locomotives</u>. Subsection (b) shall not apply for purposes of this paragraph." (Emphasis added.)

Subsection (b) of Section 209 is the "California waiver" from preemption of state motor vehicle emissions standards. Thus, unlike the law applicable to motor vehicles, the preemption of state authority to regulate emissions from new locomotives applies even to California.

With regard to federal control of emissions from locomotives, new Section 213 of the Act requires that by November 15, 1995, EPA shall promulgate regulations containing standards applicable to emissions from new locomotives and new engines used in locomotives. Such standards must achieve

> "the greatest degree of emission reduction achievable through the application of technology which the Administrator determines will be available for the locomotives or engines to which such standards apply, giving appropriate consideration to the cost of applying of such technology within the period of time available to manufacturers and to noise, energy, and safety factors associated with the application of such technology." Sec. 213(a)(5).

Standards under this section are required to take effect at the "earliest possible date considering the lead time necessary to permit the development and application of the requisite technology, giving appropriate consideration to the cost of compliance within such period and energy and safety." Sec. 213(b). This language provides EPA with considerable discretion to consider cost, technology and other factors in establishing regulations and compliance deadlines. There certainly is no assurance under this language that EPA would mandate railroad electrification.

The preemption provision in Section 209(e)(1) would preclude the states, including California, from adopting "any standard or other requirement relating to the control of emissions" from "new" locomotives or "new" engines used in locomotives. The exact impact of this language is not clear. The legislative history regarding this provision does not clearly indicate how it should be interpreted but it appears to have been an effort to preclude numerous different state standards applicable to the manufacture of new locomotives, construction and farm equipment.

The preemption provision had its genesis in the "Waxman/Dingell compromise" regarding tailpipe emission standards for motor vehicles. That compromise included a preemption provision applicable to all "nonroad vehicles and engines." Such vehicles and engines were, and currently are, defined extremely broadly and could include virtually any nonstationary source employing an internal combustion engine, except automobiles and trucks.[6] The House/Senate conference committee agreed to scale back this preemption to construction and farm equipment of less than 175 horsepower and new locomotives. In explaining the reduced scope of preemption, Senator Baucus, chairman of the conference committee, said that the states retain their ability to regulate nonroad vehicles other than those in the three specified categories (locomotives, construction, and farm equipment) and may regulate emissions from all types of existing or in-use nonroad vehicles. Senator Baucus said:

> "As the members know, it was with great reluctance that the Senate conferees agreed to the partial preemption of state authority to control emissions from some new nonroad engines and vehicles. We did so only after the preemption was strictly limited to (sic) that it applied only to new engines in three distinct categories, locomotives, new farm equipment with engines smaller than 176 horsepower and new construction equipment with engines smaller than 176 horsepower. The preemption is limited only to these categories of nonroad vehicles; states retain all of their existing authority to fully regulate all other types of new nonroad equipment.
>
> "States also fully retain existing authority to regulate emissions from all types of existing or in-use nonroad engines or vehicles by specifying fuel quality specifications, operational modes or characteristics or measures that limit the use of nonroad engines or equipment." Congressional Record, October 27, 1990, p. S16976.

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6 Section 216(a)(10) of the Clean Air Act defines "nonroad engines" as:

> "an internal combustion engine (including the fuel system) that is not used in a motor vehicle or a vehicle used solely for competition, or that is not subject to standards promulgated under section 111 or section 202."

Section 216(a)(11) of the Clean Air Act defines "nonroad vehicle" as:

> "a vehicle that is powered by a nonroad engine and that is not a motor vehicle or a vehicle used solely for competition."

Section 111(a)(3) of the Clean Air Act states in part:

> "Nothing in Title II of this Act relating to nonroad engines shall be construed to apply to stationary internal combustion engines."

Senator Chafee made a similar statement:

> "States retain their existing authority to regulate all remaining new nonroad engines or vehicles. In addition, because the preemption is limited to new engine standards only, States can continue to require existing and in-use nonroad engines to reduce emissions by setting fuel requirements, operational conditions or limits on the use of such equipment." Congressional Record, October 26, 1990, p. S17237.

Several points may be gleaned from these statements. First, the statements evidence an intent that the preemption provisions of Section 209 should be narrowly construed. This is consistent with case law under which the courts are encouraged to avoid statutory interpretations leading to preemption unless congressional intent to preclude local regulation is clear. Jones v. Rath Packing Company, 430 U.S. 519, 525, 97 S.Ct. 1305, 1309, 51 L.Ed.2d 604 (1977) (a law may be interpreted to interfere with state and local police power only to the extent congressional intent is "clear and manifest"); Rice v. Santa Fe Elevator Corp., 331 U.S. 218, 230, 67 S.Ct. 1146, 1152, 91 L.Ed. 1447 (1947) (it is presumed that Congress did not intend preemption in areas traditionally subject to the police power).

Second, the statements evidence an intent to allow the states to regulate existing and in-use locomotives. This is consistent with the statutory language limiting preemption to "new" locomotives. While the statements of both Senator Baucus and Chafee refer to fuel specifications and operational restrictions as regulations which could be imposed by the states, nothing in the statutory language explicitly limits permissible state action to fuel and operational requirements. State requirements mandating retrofit of existing locomotives would also comport with the statutory language. Consistent with this interpretation, CARB has evaluated certain retrofit techniques as part of its LEAC Study and Plan for the Control of Locomotive Exhaust Emissions.[7]

Finally, because the congressional statements recognize the ability of the states to regulate in-use locomotives, they, and the statutory language, indicate an intent to preempt only state regulation which may impact the manufacture of new locomotives. This is a logical interpretation since only regulations which specify requirements for new locomotives coming off the assembly line would create the specter of numerous potentially conflicting state requirements which could make

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[7] As stated by CARB staff in its notice of hearing to consider the LEAC study, "the 1990 Amendments to the federal Clean Air Act preempted California's authority to regulate new locomotives and new locomotive engines. Therefore any locomotive emissions control regulations to be considered by the Board must focus on the existing locomotive fleet." In recognition of these limitations CARB, in its regulatory plan for the control of locomotive emissions, only proposed to consider regulatory options affecting in-use engines. Such options include mandating specific retrofit fuel injectors, injection retard, reduced idle time, clean diesel fuel, well as market-based control strategies such as a system-wide mass emission cap.

manufacturing difficult, if not impossible.[8] Thus, if a state or local locomotive regulation could be complied with through means other than the manufacture of a particular type of new locomotive, such regulation should be consistent with the terms and intent of Section 209. A District regulation which could be complied with through retrofitting of existing locomotives should therefore stand a reasonable chance of being upheld.

A District locomotive regulation would be most likely to be upheld if it were in the form of a system-wide mass emissions cap rather than an emission limit applicable to locomotives. Because a system-wide mass emission cap would provide flexibility to the railroad to utilize fuels, operational constraints, or equipment modification, it is least likely to be found to be prohibited regulation of new locomotives. Of course, if the system-wide mass emission cap were set very low, it could be claimed that the regulation is tantamount to a requirement that locomotives be manufactured in a form which is compatible with an electrified system. However, if the regulation did not impose any explicit requirement applicable to new locomotives, and if it could be shown that retrofitting existing locomotives to be compatible with an electrified system is possible (whether or not the railroads chose to retrofit), the District would have a reasonable position in claiming that the regulation does not impose prohibited requirements applicable to new locomotives.

Requirement for EPA Authorization of Locomotive Regulations. The final provision of the 1990 Amendments to the Clean Air Act which would affect the ability of the District to adopt regulations applicable to locomotives is Section 209(e)(2). That section governs state regulation of nonroad vehicles other than those subject to the preemption described above. Section 209(e)(2) requires EPA to "authorize" California to adopt standards relating to the control of emissions from such nonroad vehicles if the state finds that such "California standards" will be at least as protective of public health as the applicable federal standards. However, authorization may not be granted by EPA if that agency finds, among other things, that California does not need such California standards to meet "compelling and extraordinary conditions." Sec. 209(e)(2)(ii). The section goes on to provide that any state other than California may adopt and enforce standards relating to control of emissions from nonroad vehicles or engines (other than those for which the preemption described above applies) if such standards are identical to the California standards authorized by EPA. Sec. 209(e)(2)(B).

This provision has two potential negative impacts on District rulemaking authority. First, California must obtain EPA authorization in order to regulate emissions from locomotives. The state should, however, be able to demonstrate that its standards are at least as protective of public health as applicable federal standards, and that they are needed to meet compelling and extraordinary conditions, and thereby obtain EPA authorization. Second, and more significantly, by referring to "California standards," and by authorizing other states to adopt standards which are

[8] State regulations requiring retrofit create the potential for other problems, specifically inconsistent requirements applicable to locomotives traveling from state to state. However, this is also the case for state fuel specifications which were stated to be permissible by both Senators Baucus and Chafee. The provisions of Section 209(e)(2), which authorize California to adopt locomotive standards and require that any locomotive standards adopted by other states be identical to the California standards, should mitigate this potential problem. (See discussion, infra.)

identical to "the California standards," this section may indicate congressional intent to require that California may only have a single set of standards applicable to locomotives, which in turn could be argued to preclude regulation of locomotives by political subdivisions such as the District. In support of this interpretation, it could be argued that Congress intended to avoid a multiplicity of standards applicable to nonroad vehicles and engines and therefore authorized only two sets of standards, i.e., federal standards and California standards.

On the other hand, the provision does not explicitly prohibit regulation by political subdivisions of the state and, like the rest of the Act, does not require a state to apply all emissions regulations statewide. Moreover, the federal Clean Air Act generally does not specify the rights or obligations of political subdivisions of any state. Rather, the Act leaves it to each state to determine which state and local entities will be responsible for implementing the requirements of the Act. (See, e.g., Section 174 authorizing state to designate appropriate planning and implementation agencies.) Thus, if California sees fit to assign some responsibility to develop "California standards" for locomotives to the District, this would be a matter legitimately within the authority of the state.

There appears to be a reasonable basis to conclude that under state law a District locomotive regulation could be part of the "California standards" authorized by Section 209(e)(2) and would not, as a matter of law, be preempted. CARB, as the state entity responsible for compiling the SIP required by federal law, would presumably be the entity requesting authorization for any state or local regulation of locomotives. SIP revisions adopted by any district in California must be approved by CARB before submission to EPA. See, e.g., Health & Saf. Code Sec. 40469. CARB must determine that any SIP revision submitted by a district meets applicable federal requirements. Id. Thus, CARB would have the right to determine whether or not locomotive regulations adopted by any district in California are necessary to meet "compelling and extraordinary conditions" as required by Section 209(e)(2). This authority should enable CARB to play a coordinating role to ensure that the districts adopt only those locomotive regulations that are necessary, and would give CARB some authority to avoid inconsistent of conflicting requirements throughout the state. Even absent such a role for CARB, the District could coordinate its rulemaking action with other local jurisdictions and the state to prevent inconsistent regulations. If inconsistent regulations are avoided, then a reasonable argument could be made that a locomotive regulation adopted by the District and approved by CARB for submission to EPA as part of the SIP would be part of the "California standards" authorized by Section 209.

A final effect of Section 209(e)(2) could be positive for the District. Because Section 209(e) provides that EPA shall "authorize" adoption of California locomotive standards, it may be argued that such state standards are adopted pursuant to congressional authorization. Such authorization should bolster the District's position against any claim of federal statutory preemption or any claim that a District locomotive regulation unduly interferes with interstate commerce in violation of the U.S. Constitution. (See, infra.)

<u>Constitutional Prohibition on Interference with Interstate Commerce.</u>

Assuming that the state and federal statutory hurdles can be overcome, a final issue presented by District or state regulation of locomotives is the constitutional prohibition on state and local interference with interstate commerce. Article I, Section 8 of the United States Constitution grants Congress authority to "regulate commerce . . . among the states." From this grant of authority the Supreme Court has read self-executing limits on state legislation even where Congress has not acted. The Court has consistently rebuffed attempts by states to advance local interests in a manner which unreasonably interferes with national concerns, including the free-flow of interstate commerce, e.g., Kassel v. Consolidated Freightways Corp., 450 U.S. 662, 101 S.Ct. 1309, 67 L.Ed.2d 580 (1981) (alleged safety justification for state regulation of trucks deemed insufficient to outweigh burden on interstate commerce).

The line between permissible state regulation and a prohibited interference with interstate commerce is not clearly defined in precedent, but rather must be determined on a case-by-case basis through a careful examination of the impacts of the state legislation, and a balancing of competing state and national interests. The Supreme Court has summarized the factors which are considered in determining the validity of a state statute affecting interstate commerce as follows:

> "Where the (state) statute regulates even-handedly to effectuate a legitimate local public interest, and its effects on interstate commerce are only incidental, it will be upheld unless the burden imposed on such commerce is clearly excessive in relation to the putative local benefits." Pike v. Bruce Church, Inc., 397 U.S. 137, 142, 90 S.Ct. 844, 847, 25 L.Ed.2d 174 (1970); see also, Minnesota v. Clover Leaf Creamery Co., 449 U.S. 456, 472, 101 S.Ct. 715, 728, 66 L.Ed.2d 659 (1981) (test articulated in Pike is appropriate for evaluating environmental statutes imposing incidental burdens on interstate commerce).

The District stands a good chance of prevailing on this issue if an adequate evidentiary record is created. Air pollution is clearly a legitimate local interest. Moreover, the regulation would affect interstate commerce even-handedly -- i.e., not discriminate against out-of-state locomotives, producers or individuals, and the effects on commerce would be only incidental -- the purpose of the regulation would be to control air pollution, not to affect commerce. The fact that electrification appears to be technically feasible and may even result in long-term cost savings would aid the District's position. The case would likely turn upon the conclusion reached by the court after a balancing of the air quality benefits of the locomotive regulation against its impact on interstate commerce, e.g., the need for trains entering the basin to switch to locomotive equipment which is compatible with an electrified system.

The District's position could be bolstered by the Clean Air Act Section 209(e)(2) which requires the state of California to receive authorization from EPA prior to adopting regulations applicable to locomotives. If such authorization is granted, it would appear that the federal government had consented to a local regulation affecting interstate commerce. The courts have held that congress may redefine the distribution of power over interstate commerce by clearly consenting to state regulation which would otherwise be impermissible under the Commerce Clause. Norfolk Southern Corp. v. Oberly, 822 F.2d 388, 392-393 (3d Cir. 1987) (quoting South-Central Timber Development, Inc. v. Wunnicke, 467 U.S. 82, 87-88, 104 S.Ct. 2237, 2240, 81 L.Ed.2d 71 (1984)). Moreover, because Section 209(e) prohibits any state other than California from adopting regulations applicable to nonroad vehicles such as locomotives unless such regulations are identical to California's standards, the potential for a multiplicity of state and local locomotive standards which might impair interstate commerce has been minimized. These factors, if joined by an appropriate rulemaking record, should enable the District to establish a reasonably strong position if presented with a challenge under the Commerce Clause.

PMG:je
cc: All Governing Board Members

(pmg:nonroad)

APPENDIX 9-2

Southern California Regional Rail Electrification Program

Data Sheets

13 Routes

Track Ownership

805.7 Route Mile System

Jan. 18, 1992

Data Sheet
Southern California Regional Rail Electrification Program
13 Routes

Track Ownership

1. SP/UP Corridor

		OWNER	ROUTE MILEAGE
61-	Yermo-Daggett	UP	5.2
60-	Daggett- Barstow	ATSF	7.2
59-	Barstow- Victorville	ATSF	36.9
58-	Victorville - Summit	ATSF	19.5
57-	Summit - Keenbrook	ATSF	14.5
66-	Keenbrook - Dike	ATSF/SP	0.1
63-	Keenbrook/Dike - N. Bridge	SP	7.8
62-	N. Bridge - W. Colton	SP	5.8
42-	W. Colton - S. Montclair	SP	19.9
41-	S. Montclair - Pomona	SP	3.5
40-	Pomona - Industry	SP	13.3
49-	Industry - Puente Jct	SP	1.6
51-	S. Montclair - Montclair	SP/UP	0.1
34-	Montclair- Spadra	UP	7.2
50-	Spadra-Pomona	UP/SP	0.1
33-	Spadra- Puente Jct	UP	11.7
32-	Puente Jct. - Bartolo	UP	6.4
31-	Bartolo - East Yard	UP	8.4
30-	East Yard - Soto St. Jct.	UP	1.0
46-	East Yard - Hobart	UP	0.2
29-	Soto St. Jct. - J Yard	UP	1.5
28-	J Yard.- Dolores	SP	15.1
28-	Dolores-(ICTF)- Port of Long Beach	UP	4.3
28-	Dolores-(ICTF) - Port of L. A.	SP	5.0
43-	W. Colton - Colton	SP	1.0
44-	Colton - Indio	SP	72.2
45-	Indio - Yuma	SP	124.0
			393.5

Use- Freight traffic only.

Data Sheet

Southern California Regional Rail Electrification Program

13 Routes

Track Ownership

Route	Name	Ownership	Route Mileage
2. Baldwin Park Branch (SCRRA)			
	Alt. Rt.-Bench (Rialto)- ATSF Jct. Claremont	SCRRA	24.3*
9-	San Bernardino- Claremont	ATSF	23.2
7-	SCRRA Conn. - N Pomona	ATSF	1.2
6-	N. Pomona - Bassett	SCRRA	17.2
5-	Bassett- El Monte	SCRRA	2.7
4-	El Monte-State Street	SCRRA	11.6
3-	State Street - East Jct.	SCRRA	0.2
2-	East Jct. - Mission Tower	SCRRA	0.3
1-	Mission Tower - LAUPT	Catellus	0.6
			57.0

Use- Commuter Rail Only.

Total Route mileage if electrified separately = **57.0.**

Data Sheet

Southern California Regional Rail Electrification Program

13 Routes

Track Ownership

ROUTE | **OWNER** | **ROUTE MILEAGE**

3. Moorpark Line

```
15-   Moorpark - Gemco..................SP............ ..29.0**
14-   Gemco- Burbank Jct.     ..........SCRRA/SP....9.5.....7.3
12-   Burbank Jct.- Commuter Rail Int....SP............... 9.1**
10-   Commuter Rail Int.-East Jct..... .SCRRA..............1.2**
2-    East Jct. - Mission Tower.........SCRRA......0.3........
1-    Mission Twr- LAUPT...............Catellus....0.6........
12/10Burbank Jct.- Mission Tower......SCRRA......10.6........
                                                          46.6
```

** Note: The track from Gemco to Burbank Jct, 9.5 miles , is SCRRA owned and is parallel to the SP, therefore not counted as route mileage. Similarly, a second track from Burbank Jct. to Mission Tower (10.6 miles), is parallel to the SP with each railroad sharing the other's track and therefore not counted in the route mileage.

Use- Commuter Rail Only. Amtrak and Freight would remain diesel.

Addition of electrification to Santa Barbara from Moorpark (55 miles) would allow electrification of Amtrak 6 trains per day).

Total Route Mileage if electrified separately = **47.5.**
Total Route Mileage if electrified to Santa Barbara = **102.5.**

4. Saugus Line

```
13-   Santa Clarita- Burbank Jct.........SP...............23.7**
2/12/10Burbank Jct.- Mission Tower....SCRRA.....10.6.........**
1-    Mission Tower- LAUPT...........Catellus.....0.6.........
                                                          23.7
```

Note **- Only the outer 23.7 miles is counted as route mileage because the trackage between Burbank Jct. and LAUPT was covered under "3" above. Also note that Burbank Jct. has three Milepost designations in the SP timetables. There is a 0.5 mile gap on the Saugus line.

Use- Commuter Rail only. Freights would remain diesel operated.

Total Route Mileage if electrified separately = **34.9.**

Data Sheet

Southern California Regional Rail Electrification Program

13 Routes

Track Ownership

Route		Ownership	Mileage
5. LOSSAN Corridor			
25-	National City- San Diego	ATSF	5.6
24-	San Diego - Oceanside	ATSF	41.1
23-	Oceanside - San Juan Capistrano	ATSF	29.2
72-	San Juan Capistrano - Irvine	ATSF	18.1
22-	Irvine- Olive Jct	ATSF	6.2
21-	Olive Jct. - Fullerton	ATSF	7.9
20-	Fullerton - DT Jct.	ATSF	12.9
19-	DT Jct. - Hobart	ATSF	7.6
18-	Hobart - Redondo Jct	ATSF	1.3
17-	Redondo Jct. - Mission Tower	ATSF	3.2
1-	Mission Tower - LAUPT	Catellus....0.6	.....
			133.1

Note: The .6 miles from Mission Tower to LAUPT was covered under "3" above and not duplicated here.

Use- Amtrak San Diegans, San Diego County Commuter Rail, Orange County Commuter Rail, SCRRA Commuter Rail. Freight trains would remain diesel.

Total Route Mileage if electrified separately = 133.7.

Data Sheet

Southern California Regional Rail Electrification Program

13 Routes

Track Ownership

Route		Ownership	Route Mileage
6. Riverside Line (via UP)			
71-	Riverside-W. Riverside	ATSF	0.8
35-	W. Riverside - Montclair	UP	19.9
34-	Montclair - Spadra	UP	7.2.*
33-	Spadra - Puente Jct	UP	11.7.*
32-	Puente Jct. - Bartolo	UP	6.4.*
31-	Bartolo - East Los Angeles Yard	UP	8.4.*
30-	East Yard - Soto St	UP	1.0.*
37-	Soto Street - East Jct	SCRRA	2.8
2-	East Jct. - Mission Tower	SCRRA	0.3
1-	Mission Tower - LAUPT	Catellus	0.6.**
			23.5

* Previously covered under Route 1 UP/SP Corridor.
** Previously covered under Route 3 Moorpark.

Total Mileage for route 6 if electrified separately = **59.1**

Use- Commuter Rail only.

Data Sheet

Southern California Regional Rail Electrification Program

13 Routes

Track Ownership

ROUTE	OWNER	ROUTE MILEAGE

7. Riverside - LAUPT via Fullerton

Segment	Route	Owner	Mileage	Note	Route Mileage
71-	Riverside- West Riverside	ATSF	0.8	*	
27-	West Riverside - Atwood	ATSF			30.0
26-	Atwood - Fullerton	ATSF			5.4
20-	Fullerton - DT JCT	ATSF	12.9	**	
19-	DT JCT. - Hobart	ATSF	7.6	**	
18-	Hobart - Redondo Jct.	ATSF	1.3	**	
17-	Redondo Jct.- Mission Tower	ATSF	3.2	**	
1-	Mission Tower - LAUPT	Catellus	0.6	***	
					35.4

* Covered under Route 6- Riverside via Ontario.
** Covered under Route 5- Lossan Corridor.
*** Covered under Route 2- Baldwin Park Commuter.

Total Mileage for Route 7 if electrified separately = **61.8**

Use- Commuter Rail only.

8.Hemet - Riverside

Segment	Route	Owner	Route Mileage
69-	Hemet - Highgrove Jct	ATSF	36.0
52-	Highgrove Jct. - Riverside	ATSF	3.1
			39.1

Use- Commuter Rail Only.

Data Sheet

Southern California Regional Rail Electrification Program

13 Routes

Track Ownership

Route	Owner	Route Mileage
9. San Bernardino - Irvine		
55- San Bernardino - B Yard	ATSF	1.0
54- B Yard - Colton	ATSF	2.7
53- Colton - Highgrove Jct	ATSF	3.5
52- Highgrove Jct. - Riverside	ATSF....3.1.*	
71- Riverside - W. Riverside	ATSF....0.8.**	
27- W. Riverside - Atwood	ATSF...30.0.***	
48- Atwood - Olive Jct.	ATSF	5.5
22- Olive Jct. - Irvine	ATSF... 6.2.****	
		12.7 *

Previously covered under Route 8 - Hemet - Riverside.
** Previously covered under Route 6 - Riverside via Ontario.
*** Previously covered under Route 7 - Riverside via Fullerton.
**** Previously covered under Route 5 - LOSSAN Corridor

Total Route mileage for Route 9- San Bernardino - Irvine if electrified separately = **52.8.**

Use- Commuter Rail Only.

If electrified in conjunction with Routes 12 and 5 could serve freight trains, Barstow to San Diego.

10- Redlands Commuter Line

68- Mentone - San Bernardino	ATSF	12.0
		12.0

Use- Commuter Rail Only.

Data Sheet

Southern California Regional Rail Electrification Program

13 Routes

Track Ownership

	Route	Ownership	Route Mileage
11-	**Southern Pacific Rts. Port to Yuma**		
28-	Port of Los Angeles - Dolores	SP	5.0 *
28-	Dolores (ICTF) - J Yard	SP	15.1 *
29-	J Yard - Soto St. Jct.	SP	1.5 *
37-	Soto St. Jct. - East Jct.	SCRRA	2.8 **
38-	East Jct. - Alhambra	SP	5.8
39-	Alhambra - El Monte	SP	6.9
5-	El Monte - Bassett	SP	2.7***
70-	Bassett - Industry	SP	3.7
40-	Industry - Pomona	SP	13.3 *
41-	Pomona- S. Montclair	SP	3.5 *
42-	S. Montclair - W. Colton Yd	SP	19.9 *
43-	W. Colton - Colton	SP	1.0 *
44-	Colton - Indio	SP	72.2 *
45-	Indio - Yuma	SP	124.0 *
			16.4

* Previously covered under Route 1 - UP/SP Corridor.
** Previously covered under Route 6 - Riverside via Ontario.
*** Segment 5 is not double counted. It appears on Route 2 as a parallel track owned by SCRRA.

Total Route Mileage if electrified separately = **281.7**

Use- Freight Only.

Data Sheet

Southern California Regional Rail Electrification Program

13 Routes

Track Ownership

12- Santa Fe Railroad Barstow to Ports

	Route	Ownership		Route Mileage
28-	Dolores (ICTF) - J Yard	SP	24.4.*	
36-	J Yard - Redondo Jct	SP		0.6
18-	Redondo Jct. - Hobart	ATSF	1.3.**	
19-	Hobart - DT Jct	ATSF	7.6.**	
20-	DT Jct. - Fullerton	ATSF	12.9.**	
26-	Fullerton - Atwood	ATSF	5.4.***	
27-	Atwood - W. Riverside	ATSF	30.0.***	
52-	W. Riverside - Riverside	ATSF	0.8.****	
71-	Riverside - Highgrove Jct.	ATSF	3.1.*****	
53-	Highgrove Jct. - Colton	ATSF	3.5.******	
54-	Colton - B Yard	ATSF	2.7.******	
55-	B Yard.- San Bernardino	ATSF	1.0.******	
56-	San Bernardino- Keenbrook	ATSF		11.9
57-	Keenbrook - Summit	ATSF	14.5.*	
58-	Summit - Victorville	ATSF	19.5.*	
59-	Victorville - Barstow	ATSF	36.9.*	
				12.5

*   Previously covered under Route 1 UP/SP Corridor.
**   Previously covered under Route 5 LOSSAN Corridor.
***   Previously covered under Route 7 Riverside via Fullerton.
****   Previously covered under Route 6 Riverside via Ontario.
***** Previously covered under Route 8 Hemet.
****** Previously covered under Route 9 San Bernardino - Irvine.

Total Mileage for Route 12 if electrified separately = **176.1**

Use- Freight only.

If Redondo Jct. to LAUPT were added (3.8 miles), Route could be used by Amtrak (4 trains per day Barstow to Los Angeles) plus Route 7 Riverside to LAUPT via Fullerton Commuter Trains.(61.8 Route Miles)

Data Sheet

Southern California Regional Rail Electrification Program

13 Routes

Track Ownership

13- Union Pacific Ports to Yermo

	Route	Ownership		(Previously Covered Under)	Route Mileage
28-	Port of Long Beach - Dolores	UP	24.4	(1)	
29-	J Yard - Soto St. Jct.	UP	1.5	(1)	
30-	Soto St. Jct. - E. LA Yard	UP	1.0	(1) (6)	
31-	E. LA Yard - Bartolo	UP	8.4	(1) (6)	
32-	Bartolo - Puente Jct.	UP	6.4	(1) (6)	
33-	Puente Jct.- Spadra	UP	11.7	(1) (6)	
34-	Spadra- Montclair	UP	7.2	(1) (6)	
35-	Montclair - W. Riverside	UP	19.9	(6)	
52-	W. Riverside - Riverside	ATSF	0.8	(6) (7) (9) (12)	
71-	Riverside - Highgrove Jct.	ATSF	3.1	(8) (9) (12)	
53-	Highgrove Jct. - Colton	ATSF	3.5	(9) (12)	
54-	Colton - B Yard	ATSF	2.7	(9) (12)	
55-	B Yard- San Bernardino	ATSF	1.0	(9) (12)	
56-	San Bernardino- Keenbrook	ATSF	11.9	(12)	
57-	Keenbrook - Summit	ATSF	14.5	(1) (12)	
58-	Summit - Victorville	ATSF	19.5	(1) (12)	
59-	Victorville- Barstow	ATSF	36.9	(1) (12)	
60-	Barstow - Daggett	ATSF	7.2	(1)	
61-	Daggett - Yermo	UP	5.2	(1)	
					0.0

Total Route Mileage of Route 13- Union Pacific, Ports to Yermo if electrified separately = **186.8.**

Use- Freight Only.

If Soto Street to LAUPT were added (3.7 miles), could also be used by Route 6 Riverside - LAUPT via Ontario commuter trains. (190.5 miles).

APPENDIX 10-1

APPENDIX 10-1

Proposed Rail Electrification Project
Information Requirements

Information Needed	Explanation
A. Purpose and Need Statement	An explanation of the objective or objectives of the project, accompanied by an analysis of the reason(s) why attainment of these objectives is necessary or desirable.
B. Project Description	
1. Project Location	
a. Track Information	
(1) Route map of rail line	A map of suitable scale of the purposed routing showing details of the right-of-way in the vicinity of settled areas, parks recreational areas, scenic areas, and existing electrical transmission lines within one mile of the proposed route.
(2) Track ownership	
(3) Locations and lengths of new track and new existing track on existing right-of-way	
(4) Locations and lengths of new rights-of-way and new track	
(5) Width of right-of-ways, both existing and new	
(6) Track grades, location and length	
(7) Other parallel and crossing facilities both above ground and below ground	

Information Needed	Explanation

2. Electrical System Information

   a. Commuter

      (1) Train schedules for initial and ultimate operation

      (2) Operation Plans

      (3) Electrical load requirements, peak demand and energy use

      (4) System Operating Characteristics

   b. Freight

      (1) Train schedules for initial and ultimate operation

      (2) Operation plans

      (3) Electrical load requirements, peak demand and energy use

      (4) System Operation Characteristics

3. Project Facilities

   a. Locomotives

      (1) Commuter

      - Electrical rating

      - Characteristics of electric drive motors and conversion equipment

OII 22 /ai

ENVIRONMENTAL IMPACT ASSESSMENT SUMMARY

	Impact	Significance
LAND-USE IMPACTS. Will the project either directly or indirectly:		
1. Conflict with the present land use of the area in which it will be located?		
2. Conflict with any elements of adopted environmental plans, policies, or goals of the communities affected?		
3. Conflict with established recreational, educational, religious or scientific uses of the area?		
4. Occupy or affect any prime farmland?		

	Impact	Significant
9. Alter or modify any unique geologic or physical features such as beaches, marshes or tidelands?		
10. Contribute to the erosion potential of the site?		
11. Cause or result in unstable earth or exposure of people or property to seismic or geologic hazards such as earthquakes, landslides, mudslides, or ground failure?		
12. Affect soil productivity?		

	Impact	Significance
ATMOSPHERIC IMPACTS. Will the project either directly or indirectly:		
13. Violate or cause a violation of any federal, state or local air quality standard?		
14. Result in substantial emissions of any air pollutant?		
15. Affect ambient air quality?		
16. Expose sensitive receptors to increased pollutant concentrations?		

	Impact	Significance
17. Change prevailing air circulation patterns, moisture, temperature, or any other climatic condition?		
18. Cause objectionable odors?		

HYDROLOGIC IMPACTS.
Will the project either directly or indirectly:

	Impact	Significance
19. Violate or cause a violation of any federal, state or local water quality standard?		
20. Result in the release of substantial effluent?		

	Impact	Significance
21. Affect existing water quality condition?		
22. Affect any public water supply?		
23. Affect the quantity or quality of ground waters?		
24. Alter or affect existing drainage patterns?		

	Impact	Significance
25. Alter or affect any ocean, lake, river or stream or any bed, channel, or shore?		
26. Affect any flood-prone area?		
27. Affect any water oriented recreation area?		
BIOLOGICAL IMPACTS. Will the project either directly or indirectly:		
28. Affect any rare or endangered species or habitat thereof?		

	Impact	Significance
29. Alter the diversity of species, or numbers of any species of plant or animal?		
30. Create or remove a barrier to the migration or movement of any fish or wildlife species?		
31. Affect any highly productive habitat of wildlife species or sport, spectator, commercial, or educational value?		
32. Affect any relatively undisturbed or unique vegetation communities?		

	Impact	Significance
33. Affect any areas of low vegetation potential?		
34. Reduce the acreage of any agricultural crop?		
35. Cause the removal of any mature trees from urban locations?		

SONIC IMPACTS.

Will the project either directly or indirectly:

	Impact	Significance
36. violate or cause a violation of any federal, state or local noise standard?		

	Impact	Significance
37. Increase existing noise levels in the area?		

VISUAL IMPACTS
Will the project either directly or indirectly:

	Impact	Significance
38. Affect any resources or unique scenic value, or result in the obstruction of any scenic vista?		
39. Affect the view from any public recreation areas, parklands, or residential areas?		
40. Affect the setting of any feature of unusual architectural significance?		

	Impact	Significance
SOCIOECONOMIC IMPACTS. Will the project wither directly or indirectly:		
41. Divide or disrupt present population patterns?		
42. Alter migrational trends, including migrational trends of different socio-economic groups into and out of the area?		
43. Affect neighborhood character or stability?		
44. Affect property values or the local tax base?		

	Impact	Significance
45. Affect local industry or commerce?		
46. Affect existing housing or housing demand?		
47. Affect any community facilities such as medical, educational, scientific, or recreational?		
48. Affect community services such as police, fire, emergency, etc.?		

	Impact	Significance
49. Affect other utility services?		
50. Affect existing transportation systems?		
51. Alter present patterns of circulation for movement of people or goods?		
52. General additional traffic?		
53. Increase traffic hazards to motor vehicles, bicyclists or pedestrians?		

OII 22 /ai

	Impact	Significance
54. Increase or promote the use of off-the-road vehicles?		
55. Increase or decrease access to areas?		
PUBLIC HEALTH AND SAFETY IMPACTS. Will the project either directly or indirectly:		
56. Affect public health or expose people to potential health hazards?		
57. Increase any public safety risks?		

Appendix I

Environmental Checklist Form

(To be completed by Lead Agency)

1. Background

1. Name of Proponent____

2. Address and Phone Number of Proponent____________________

____

____

____

3. Date of Checklist Submitted______________________________

4. Agency Requiring Checklist_______________________________

5. Name of Proposal, if applicable__________________________

____

II. Environmental Impacts
(Explanation of all "yes" and "maybe" answers are required on attached sheets.)

Earth. Will the proposal result in:	Yes	Maybe	No
a. Unstable earth conditions or in changes in geologic substructures	☐	☐	☐
b. Disruptions, displacements, compaction or overcovering of the soil?	☐	☐	☐
c. Change in topography or ground surface relief features?	☐	☐	☐
d. The destruction, covering or modification of any unique geologic or physical features?	☐	☐	☐
e. Any increase in wind or water erosion of soils, either on or off the site?	☐	☐	☐
f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion which may modify the channel of a river or stream or the bed of the ocean or any bay, inlet or lake?	☐	☐	☐
g. Exposure of people or property to geologic hazards such as earthquakes, landslides, mudslides, ground failure, or similar hazards?	☐	☐	☐
2. Air. Will the proposal result in:			
a. Substantial emissions or deterioration of ambient air quality?	☐	☐	☐

	Yes	Maybe	No
b. The creation of objectional odors			
c. Alteration of air movement, moisture or temperature, or any change in climate, either locally or regionally?			
3. Water. Will the proposal result in:			
a. Changes in currents, or the course or direction of water movements, in either marine or fresh waters?			
b. Changes in absorption rates, drainage patterns or the rate and amount of surface water runoff?			
c. Alterations to the course or flow of flood waters?			
d. Change in the amount of surface water in any water body?			
e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen or turbidity?			
f. Alteration of the direction or rate of flow of ground waters?			
g. Change in the quantity of ground waters, either through direct additions or with-drawals, or through interception of an aquifer by cuts or excavations?			
h. Substantial reduction in the amount of water otherwise available for public water supplies?			
i. Exposure of people or property to water related hazards such as flooding or tidal waves?			
4. Plant Life. Will the proposal result in:			
a. Change in the diversity of species, or number of any species of plants (including trees, shrubs, grass, crops, and aquatic plants.			
b. Reduction of the number of any unique, rare or endangered species of plants?			
c. Introduction of new species of plants into an area, or in a barrier to the normal replenishment of existing species.			

	Yes	Maybe	No
d. Reduction in acreage of any agricultural crop?			
5. Animal Life. With the proposal result in			
a. Change in the diversity of species, or any species of animals (birds, land animals including reptiles, fish and shellfish, benthis organisms or insects)?			
b. Reduction of the numbers of any unique, rare or endangered species of animals?			
c. Introduction of new species of animals into an area, or result in a barrier to the migration or movement of animals			
d. Deterioration to existing fish or wildlife habitat?			
6. Noise. Will the proposal result in: a. Increases in existing noise levels?			
b. Exposure of people to severe noise levels?			
7. Light or Glare.			
Will the proposal produce new light or glare?			
8. Land Use.			
Will the proposal result in a substantial alteration of the present or planned land use of an area?			
9. Natural Resources. Will the proposal result in:			
a. Increase in the rate of use of any natural resources?			
b. Substantial depletion of any nonrenewable natural resource?			
10. Risk of Upset. Will the proposal involve:			
a. A risk of an explosion or the release of hazardous substance (including, but not limited to , oil, pesticides, chemical or radiation) in the event of an accident or upset conditions?			
b. Possible interference with an emergency response plan or an emergency evacuation plan?			
11. Population.			
Will the proposal alter the location, distribution, density, or growth rate of the human population of an area?			

	Yes	Maybe	NO
12. Housing.			
Will the proposal affect existing housing or create a demand for additional housing?			
13. Transforation/Circulation. Will the proposal result in:			
a. Generation of substantial additional vehicular movement?			
b. Effects on existing parking facilities, or demand for new parking?			
c. Substantial impact upon existing transportation systems?			
d. Alterations to present patterns of circulation or movement of people and/or goods?			
e. Alterations to waterborne, rail or air traffic?			
f. Increase in traffic hazards to motor vehicles, bicyclist or pedestrians?			
14. Public Services. will the proposal have an effect upon, or result in a need for new or altered governmental services in any of the following areas:			
a. Fire protection?			
b. Police protection			
c. Schools?			
d. Parks or other recreational facilities?			
e. Maintenance of public facilities, including roads?			
f. Other government services?			
15. Energy. Will the proposal result in:			
a. use of substantial amounts of fuel or energy			
b. Substantial increase in demand upon existing sources of energy, or require the development of new sources of energy?			
16. Utilities. Will the proposal result in a need for new systems, or substantial alterations to the following utilities:			
a. Power or natural gas?			

	Yes	Maybe	No
b. Communications systems?	☐	☐	☐
c. Water?	☐	☐	☐
d. Sewer or septic tanks?	☐	☐	☐
e. Storm water drainage?	☐	☐	☐
f. Solid waste and disposal?	☐	☐	☐
17. Human Health. Will the proposal result in:			
a. Creation of any health hazard or potential health hazard (excluding mental health)?	☐	☐	☐
b. Exposure of people to potential health hazards?	☐	☐	☐
18. Aesthetics.			
Will the proposal result in the obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to public view?	☐	☐	☐
19. Recreation. Will the proposal result in an impact upon the quality or quantity of existing recreational opportunities?	☐	☐	☐
20. Cultural Resources.			
a. Will the proposal result in the alteration of or the destruction or a prehistoric or historic archaeological site?	☐	☐	☐
b. Will the proposal result in adverse physical or aesthetic effects to a prehistoric or historic building, structure or object?	☐	☐	☐
c. Does the proposal have the potential to cause a physical change which would affect unique ethnic cultural values?	☐	☐	☐
d. will the proposal restrict existing religious or sacred uses within the potential impact area?	☐	☐	☐

21. Mandatory Findings of Significance.

a. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause of fish or wildlife population to drop below self sustaining levels, threaten to eliminate a plant or animal community, reduce the

	Yes	Maybe	No
number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	▯	▯	▯
b. Does the project have the potential to achieve short term, to the disadvantage of long-term, environmental goals? (a Short-term impact on the environment is one which occurs in a relatively brief, definitive period of time which long-term impact will endure well into the future.)	▯	▯	▯
c. Does the project have impacts which are individually limited, but cumulatively considerable? (A project may impact on two or more separate resources where the impact on each resource is relatively small, but where the effect of the total impacts on' the environment is significant.	▯	▯	▯
d. Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly.	▯	▯	▯

III. Discussion of Environmental Evaluation

IV. Determination
(to be completed by the Lead Agency)

On the basis of this initial evaluation:

☐ I find the proposed project COULD NOT have a significant effect on the environment, and a NEGATIVE DECLARATION will be prepared.

☐ I find that although the proposed project could have a significant effect on the environment, there will not be a significant effect in this case because the mitigation measures described on an attached sheet have been added to the project. A NEGATIVE DECLARATION WILL BE PREPARED.

☐ I find the proposed project MAY have a significant effect on the environment, and an ENVIRONMENTAL IMPACT REPORT is required.

DATE____
(Signature)

For______________________________

CALIFORNIA ENVIRONMENTAL QUALITY ACT

INITIAL STUDY

(As required by Section 15080(f) of the Public Resources Code)

To be complete by the lead agency.

I. BACKGROUND

1. Name of applicant ______________________________.

2. Address and Phone Number of Applicant

____

____

____

3. Project Address ______________________________

4. Date of Checklist Submitted ______________________________

5. Agency Requiring Checklist - City of Burbank

6. Name of Proposal, If applicable ______________________________

____

7. Project Description: ______________________________

____

____

II. <u>ENVIRONMENTAL IMPACTS</u>
(Explanations of all "yes" and "maybe" answers are required on attached sheets.)

	Yes	Maybe	No
1. <u>Earth</u>. Will the proposal result in:			
a. Development of a site that evidence indicates has unstable geologic or soil conditions?	☐	☐	☐
b. Unstable soil conditions or in changes in geologic substructures?	☐	☐	☐
c. Disruptions, displacements, compaction or overcovering of the soil?	☐	☐	☐
d. Change in topography or ground surface relief features?	☐	☐	☐

1. Earth. (Con't)

	Yes	Maybe	No
e. The destruction, covering or modification of any unique geologic or physical features?	▒	▒	▒
f. Any increase in wind or water erosion of soils, either on or off the site?	▒	▒	▒
g. Changes in siltation, deposition or erosion which may modify the channel of a river, stream, wash, or other natural drainage course or the bed of a body of similar	▒	▒	▒
h. Exposure of people or property to geologic hazards such a earth-quakes, landslides, mudslides, ground failure, or similar hazards?	▒	▒	▒
i. Proposed or probable grading, excavation or fill in areas designated by the California State Mining and Geology Board as contain designated mineral deposits of statewide or regional significance?	▒	▒	▒
j. Proposed or probable grading, excavation or fill in areas classified MRZ-2 or MRZ-3 by the California State Mining and Geology Board?	▒	▒	▒

2. Air.

	Yes	Maybe	No
a. Exposure of residential or institutional project occupants to carbon monoxide concentrations vehicle emissions, or hazardous substances, in excess of any state of federal ambient air quality standards?	▒	▒	▒
b. Substantial emissions in an area where state of federal ambient air quality standards have been greatly or frequently exceeded?	▒	▒	▒
c. The creation of objectionable odors or the discharge of smoke, dust or chemicals?	▒	▒	▒

2. Air Con't

	Yes	Maybe	No
d. Alteration of air movement, moisture or temperature, or any water body?	▒	▒	▒

3. Water. will the proposal result in

	Yes	Maybe	No
a. Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff?	▒	▒	▒
b. Alterations to the course or flow of flood waters or flood control channels?	▒	▒	▒
c. Changes in currents or the course of direction of water movements?	▒	▒	▒
d. Change in the amount of surface water in any water body?	▒	▒	▒
e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen or turbidity?	▒	▒	▒
f. Alteration of the direction or rate of flow of ground waters?	▒	▒	▒
g. Change in the quantity of ground waters, either through direct additions or withdrawals, or through interception of an aquifer by cuts or excavations?	▒	▒	▒
h. Change in the quantity of ground waters, either through direct additions or withdrawals, or through interception of an aquifer by cuts or excavations?	▒	▒	▒
i. Substantial reduction in the amount of water otherwise available for public water supplies?	▒	▒	▒
j. Exposure of people or property to flood related hazards?	▒	▒	▒

	Yes	Maybe	No
4. Plant Life. Will the proposal result in:			
a. Alteration or elimination of the habitat utilized by a threatened, rare, or endangered plant species, as identified by the U.S. Fish Wildlife Service or the California Department of Fish and Game?	☐	☐	☐
b. Effects on a sensitive habitat including but not limited to streamside (riparian) vegetation, oak woodlands, wetlands or coastal chaparral?	☐	☐	☐
c. Effects on distinctive stands of mature trees?	☐	☐	☐
d. Creation of a barrier to dispersion of a plant species or to the normal replenishment of existing species?	☐	☐	☐
e. Change or diminution in the diversity of species or number of any species of plants (including tress, shrubs, grass, crops, microflora and aquatic plantlife)?	☐	☐	☐
f. Introduction of a non-native species plant into a natural area?	☐	☐	☐
5. Animal Life. Will the proposal result in:			
a. Alteration or elimination of the habitat utilized by a threatened, rare, or endangered plant species, as identified by the California Department of Fish and Game, the U.S. fish and Wildlife Service or other responsible organizations (including birds, Land animals, reptiles, shellfish, amphibiams, benthic organisms, insect, or microfauna)?	☐	☐	☐
b. Alteration or elimination of the habitat utilized by a unique, sensitive fully protected species as identified by the California Department of Fish and Game or other responsible organizations?	☐	☐	☐
c. Creation of a barrier to migration movement or dispersion of an animal species?	☐	☐	☐
d. Change or reduction in the diversity of an animal species or number of any species of animals	☐	☐	☐

5. Animal Life - Con't

	Yes	Maybe	No
e. Introduction of a new species of animal(s) into an area?			
f. Deterioration of an existing fish or wildlife habitat?			
6. Noise Will the proposal result in:			
a. Current or future noise levels that will exceed standards specified in the City's Noise Element of the General Plan or in the BMC?			
b. General of noise incompatible with nearby land uses according to the City's General Plan Noise Element, the BMC or within the 65 CNEL/Aviation easement area of the Burbank/Glendale/Pasadena Airport?			
c. Incompatibility with noise levels established for Burbank/Glendale/ Pasadena Airport?			
d. Increases in short-term or long-term existing noise levels?			
7. Light and Glare. Will the proposal result in:			
a. New Light or glare			
b. Reduced access to sunlight by adjacent properties due to shade and shadow?			
c. Current or future light and glare incompatible with nearby land uses?			
d. current or future light and glare levels from an external source that exceed standards recommended in the IES lighting handbook?			

III. DISCUSSION OF ENVIRONMENTAL EVALUATION

See attached

IV. DETERMINATION
(To be completed by the Lead Agency)

On the basis of this initial evaluation:

___ I find that the proposed project DOES NOT have any significant impacts that have not been address in a previous Environmental Impact Report.

___ I find the proposed project COULD NOT have a significant effect on the environment, and a NEGATIVE DECLARATION will be prepared.

___ I find that although the proposed project could have a significant effect on the environment, there will not be a significant effect in this case because the mitigation measure described n the attached sheet have been added to the project. A NEGATIVE DECLARATION WILL BE PREPARED.

___ I find the proposed project MAY have a significant effect on the environment, and an ENVIRONMENTAL IMPACT REPORT is required.

Date: ______________________

____
Rick Pruetz
City Planner
For: City of Burbank

CALIFORNIA ENVIRONMENTAL QUALITY ACT

ENVIRONMENTAL INFORMATION FORM

(As required by Section 15063(e) of the CEQA Guidelines)

To be complete by the applicant

Date files: ______________________________

GENERAL INFORMATION: ______________________________

1. Name and address of the applicant

____

____

2. Address of project: ______________________________

Legal description: ______________________________

____

Assessor's Parcel Number: ______________________________

3. Name, address, and telephone number of person to be contacted concerning this project

____

Division: ______________ Telephone: (818) ________

4. Indicate permit application number or the project wo which this form pertains:

____

5. List and describe an other related permits and other public approvals required for this project, including those required by city, regional, state and federal agencies:

____

____

6. Are federal, state and/or county funds involved in this project_____

If so, specify:____________________

7. Existing zoning district: ____________________

8. a) Proposed useof site (project for which this form is filed). If project involves demolition and new construction, describe total project, e.g. demolition, grading, excavation, construction, include age of building(s) to be demolished:

____

PROJECT DESCRIPTION

9. Site size: ____________________

10. Square footage of building(s):____________________

11. Number of floors of construction: ____________________

12. a) Amount of off-street parking provided:

Existing:__________ New:__________ Total:__________

b) Number of spaces required by coded: ____________________

c) Does the off-street parking to be provided meet the City code requiements?____________________

13. Attach plans:____________________

a) Do plans show parking? Yes _____ No ______

14. Proposed scheduling: ____________________

15. Associated projects:____________________

16. Anticipated phasing of development: ____________________

____

17. If residential, include the number of units, schedule of unit range of sale prices or rents, and type of house household size expected.

____

18. If commercial, indicate the type, whether neighborhood-city-or regionally-oriented, square footage of sales area, square footage of office area, loading facilities, and number of employees.

____

19. a) If industrial, indicate type, estimated employment per shift, number of shifts and loading facilities.

____

b) Will paints, solvents, asbestos, pressurized gas, cleaning fluids, acids or other chemical be used in the business? ____________________

____

c) Do you have a hazardous materials list on file with Burbank Fire Department? Yes____ No____

20. If institutional, indicate the major function, estimated employment per shifts, estimated occupancy, loading facilities, and community benefits to be derived from the project.

____

21. If the project involves a variance, conditiona use permit, street vacation or rezoning application, state this and indicate clearly why the application is required.

____

____

Are the following items applicable to the project or its effects? Discuss below all items checked yes (attach additiona sheets as necessary).

YES	NO		
___	___	22.	Change in existing features of any hills, or substantial alteration of ground contours: grading, cut, fill.
___	___	23.	Change in scenic views or vistas from existing residential areas or public lands or roads.

___ ___ 24. Change in pattern, scall or character of general area or project. If new construction alters land use from existing patterns, requies a variance or condition use permit, or increases size or bulk of existing uses, discuss in #36 below.

___ ___ 25. Significant amounts of solid waste or litter.

___ ___ 26. Change in dust, ash, smoke, fumes or odors in vicinity.

___ ___ 27. Change in ground water quality or quantity, or alteration of existing drainage patterns.

___ ___ 28. Substantial change in existing noise or vibration levels in the vicinity.

___ ___ 29. Site on filled land or on slope of 10 percent or more.

___ ___ 30. Use of disposal of potentially hazardous materials, such as toxic substance, flammables or explosives.

___ ___ 31. Substantial change in demand for municipal services (police, fire, water, electricity, sewage, etc.).

___ ___ 32. Substantial increase fossil fuel consumption (electricity, oil, natural gas, etc.).

___ ___ 33. Relationship to a larger project or series of projects. If new construction or expansion of present facilities will take place after demolition, the action is part of a large project.

ENVIRONMENTAL SETTING

34. Describe the project site as it exists befor the project, including information on topography, soil stability, plants (including mature trees) and animals, and any cultural, historical or scenic aspectts. Describe an existing structures on the site, the use of the structures and the year(s) in which hte structures were built. attach photographs of the site. Snapshots or poloaroid photos will be accepted. (Use attachment if necessary).

Year(s) built: _________

____

____

35. Describe the surrounding proerties, including information on plants (including mature trees) and animals and any cultural, historical or scenic aspects. Indicate the type of land use (residential, commercial, etc.), intensity of land use (one-family, apartment houses, shops, department stores, etc.), and scale and approximate age of development (height, frontage, set-back, rear yard, etc.). Attach

36. Describe the effects of the project as it will alter existing patterns of land use, require discretionary approval and/or increase size and bulk existing uses.

____

____

<u>CERTIFICATION:</u> I hereby certify that the statements furnished above and in the attached exhibits present the data and information required for this initial evaluation to the best of may ability, and that the facts, statements, and information presented are true and correct to the best of my knowledge and belief.

Date: __________________ ________________________

(Signature)

____

(Name)

For City of Burbank

ADDENDUM TO INITIAL STUDY

(Address - Centered)

The following contains discussion of all "yes" and "maybe" responses in the Environmental Impacts Section (Part II) and the Discussion of Environmental Evaluation (Part III) of the Initial Study.

ITEM #	RESPONSE

SUMMARY OF MITIGATION MEASURES

(Address - Centered)

ITEM #	RESPONSE

APPENDIX 10-3

APPENDIX 10-3

GUIDELINES FOR PROPONENT'S ENVIRONMENTAL ASSESSMENT

1.0 SUMMARY

1.2 Project Purpose And Need

All PEAs shall contain an explanation of the objective or objectives of the project. This shall be accompanied by an analysis of the reason why attainment of these objectives is necessary or desirable. The analysis should normally not exceed a page or two in length except where significant or potentially significant project impacts have been identified in the Environmental Impact Assessment Summary required by Section V, 13. Where such impacts have been identified, the analysis of project purpose and need must be sufficiently detailed to permit the Commission to independently evaluate the project need and benefits in order to accurately consider them in light of the potential environmental costs. This requirement may be satisfied by reference to specific portions of the project application which address this issue.

1.3 Project Description

The description of the project shall contain the following information, but should not supply extensive detail beyond that needed for evaluation and review of the environmental impact.

a. The precise location and boundaries of the project shall be shown on a detailed map, preferably topographic. The location shall also be shown on a regional map.

b. A general description of the project's technical, economic, and environmental characteristics considering the principal engineering proposals and supporting public service facilities.

The requirements of this section may be satisfied by reference to specific portions of the project application which address these issues and include this information.

1.4 Environmental Setting

The PEA must include a description of the environment in the vicinity of the project and within the potential range of impact as it exists before commencement of the project. Both local (site-specific) and regional perspectives must be provided. The description should include some discussion of the topography, land use patterns, and general biological environment. Detailed descriptions should be limited to those elements of the environment which may be subject to a potentially significant impact. The setting must, however, be sufficiently described to permit an independent evaluation by the Commission of elements which could be impacted by the project.

All elements of the environmental setting necessary to fully understand impacts identified as significant or potentially significant in the Environmental Impact Assessment Summary required by Section V, 13 shall be described in detail.

b. Alternatives to the Proposed Action – Describe all reasonable alternatives to the project, or to the location of the project, which could feasibly attain the basic objectives of the project, and why they are rejected in favor of the ultimate choice. The specific alternative of "no project" must also always be evaluated, along with the impact. The discussion of alternatives shall include alternatives capable of substantially reducing or eliminating any significant environmental effects, even if these alternatives substantially impede the attainment of the project objectives, and are more costly.

c. The Growth-Inducing Impact of the Proposed Action – Discuss the ways in which the proposed project could foster economic or population growth, either directly or indirectly, in the surrounding environment. Included are projects which would remove obstacles to population growth (a major expansion of a waste water treatment plant might, for example, allow for more construction in service areas). Increases in the population may further tax existing community service facilities so consideration must be given to this impact. Also, discuss the characteristics of some projects which may encourage and facilitate other activities that could significantly affect the environment, either individually or cumulatively. It must not be assumed that growth in any area is necessarily beneficial, detrimental, or of little significance to the environment.

d. Organizations and Persons Consulted – The PEA shall include a list of persons, and their qualifications, responsible for compiling the detailed information for each area of environmental concern, and a discussion of the methods used to produce such information.

APPENDIX 11-1

APPENDIX 11-1

ENVIRONMENTAL ASSESSMENT COMMITTEE MEMBERS

Environmental Assessment Committee

Name	Organization
Mike Nazemi	SCAQMD
Chris Abe	SCAQMD
Marijke Bekken	ARB
Charles Chang	LADWP
Paul Clanon	CPUC
Dave Coel	SCAQMD
Mike Davis	RCTC/Bechtel
Bill Dennison	Dennison & Asso.
Myra Frank	Myra Frank & Asso.
Royce Green	Southern Pacific Rail
Andrew Hirsch	So. Cal. Gas Co.
Bob Huddy	SCAG
Tom Kardos	Morrison Knudsen Corp.
Ken Koss	CPUC
Lee Lisecki	Myra Frank & Asso.
Kirk Marckwald	Cal. Environnmental Asso.
Larry Marigold	AMI
Bryan Morrison	Santa Fe Railway
Calvin Naito	Myra Frank & Asso.
Deepak Nanda	SCE
Jim Ortner	LACTC
Mark Reimers	Union Pacific Railroad
David Rice	LADWP
Mike San Miguel	SCE
Joel Schwartz	Coalition for Clean Air
Celia Shih	SCAQMD
Robert Shipley	DeLeuw Cather & Co.
Glyn Short	ICI/AMI
Mark P. Stehly	Santa Fe Railway
John Tandy	SCRRA
Frank Turpin	Morrison Knudsen Corp.
Daniel Uhlar	Ventura County APCD
Greg Vlasek	So. Cal. Gas Co.
Bill West	Southern Ca. Edison
Wayne Williams	Morrison Knudsen Corp.

APPENDIX 11-2

APPENDIX 11-2

COMMUTER RAIL

TABLE B-1: COMMUTER RAIL ANALYSIS SERVICE LEVEL ASSUMPTIONS
(Number of Trains)

	Route	Start Up	Intermed.	Mature
1	Ventura to LA	4 (0)	8 (4)	9 (10)
2	Santa Clarita to LA	3 (0)	4 (0)	6 (6)
3	San Bernardino to LA	5 (0)	8 (6)	9 (10)
4	Riverside to LA (Ontario)	3 (0)	5 (2)	6 (6)
5	Oceanside to LA	8 (0)	8 (4)	10 (10)
6	Riverside to LA (Fullerton)	2 (0)	4 (3)	5 (14)
7	San Bern./Riverside to Irvine	4 (0)	8 (3)	10 (14)
8	Hemet to Riverside	2 (0)	4 (0)	5 (0)
9	Redlands to San Bernardino	2 (0)	4 (2)	5 (5)

Notes:

1. Off peak levels of service are in parentheses.
2. Unless noted otherwise, service levels included in this analysis are referenced from the Southern California Commuter Rail 1991 Regional System Plan.
3. Start up peak service levels for routes 4 and 9 and intermediate peak level service levels for routes 4, 5, and 9 have been supplied by Jim Ortner, LACTC, in December 1991.
4. Start up off-peak service levels for routes 4, 5, 7, and 9 are assumed to be 0. This is consistent with levels for the other routes, as specified in the Regional System Plan.
5. Intermediate off-peak service levels for routes 4, 5, and 9 have been estimated by District staff by adding intermediate off-peak levels for routes 1, 2, 3, 6, 7, and 8 and dividing the sum by the intermediate peak total for these routes. This factor has been multiplied by the intermediate peak levels for these routes.
6. High peak service levels for routes 4, 5, and 9 have been estimated by District staff by adding peak high levels for routes 1, 2, 3, 6, 7, and 8 and dividing the sum by the intermediate peak total for these routes. This factor has been multiplied by the intermediate peak levels for these routes.
7. High off-peak service levels for routes 4, 5, and 9 have been estimated by District staff by adding high off-peak levels for routes 1, 2, 3, 6, 7, and 8 and dividing the sum by the high peak total for these routes. This factor has been multiplied by the intermediate peak levels for these routes.

TABLE B-2

TIME IN THROTTLE NOTCH BY ROUTE

	Route	Minutes in Throttle Notch Starting Point to Destination									Minutes in Throttle Notch Destination to Starting Point								
		Idle	1	2	3	4	5	6	7	8	Idle	1	2	3	4	5	6	7	8
1	Ventura to LA	15.5	6.1	12.2	7.1	2.3	2.7	6	3.2	16.9	12.3	5.4	4.8	6.6	12.2	4.4	6.4	3.5	17.4
2	Santa Clarita to LA	15.2	5.8	5.7	7	3.7	2.8	2.6	1.6	13.6	9.4	2.1	2.5	6	5.3	6.1	5	3.9	21.7
3	SB to LA	20.6	8.1	6.5	9	11.9	4.4	6.4	1.3	23.8	18.8	3.7	6.4	5.7	6.1	9	1.7	6.7	30.9
4	Riverside to LA (Ontario)	21.4	8.4	6.8	9.4	12.4	4.6	6.7	1.4	24.8	19.6	3.9	6.7	5.9	6.3	9.4	1.8	7.0	32.2
5	Oceanside to LA	32.3	12.6	15.4	14.5	11.3	6.2	9.4	3.8	34.2	25.5	7.1	8.6	11.5	14.9	12.3	8.2	8.9	44.1
6	Riverside to LA (Fullerton)	22.9	9.0	7.2	10.0	13.2	4.9	7.1	1.4	26.5	20.9	4.1	7.1	6.3	6.8	10.0	1.9	7.4	34.3
7	SB/Riverside to Irvine	21.5	8.5	6.8	9.4	12.4	4.6	6.7	1.4	24.9	19.6	3.9	6.7	6.0	6.4	9.4	1.8	7.0	32.3
8	Hemet to Riverside	14.4	5.7	4.6	6.3	8.3	3.1	4.5	0.9	16.7	13.2	2.6	4.5	4.0	4.3	6.3	1.2	4.7	21.7
9	Redlands to SB	4.4	1.7	1.4	1.9	2.5	0.9	1.4	0.3	5.1	4.0	0.8	1.4	1.2	1.3	1.9	0.4	1.4	6.6

Note: Minutes in throttle notch data available only for routes 1 through 3.
Values for routes 4, 6, 7, 8, and 9 are based on those for route 3, weighted by mileage.
Route 5 time in throttle notch data is based on a composite of the values for routes 1 through 3, weighted by mileage.

TABLE B-3

HORSEPOWER BY THROTTLE NOTCH - DIESEL LOCOMOTIVE ENGINE MODEL EMD 12-710G3A

	Route	Diesel Prime Mover Horsepower by Throttle Notch								
		Idle	1	2	3	4	5	6	7	8
1	Ventura to LA	7.8	209.4	372.2	716.9	1052.8	1401.5	1695.9	2533.7	3195.5
2	Santa Clarita to LA	7.8	209.4	372.2	716.9	1052.8	1401.5	1695.9	2533.7	3195.5
3	SB to LA	7.8	209.4	372.2	716.9	1052.8	1401.5	1695.9	2533.7	3195.5
4	Riverside to LA (Ontario)	7.8	209.4	372.2	716.9	1052.8	1401.5	1695.9	2533.7	3195.5
5	Oceanside to LA	7.8	209.4	372.2	716.9	1052.8	1401.5	1695.9	2533.7	3195.5
6	Riverside to LA (Fullerton)	7.8	209.4	372.2	716.9	1052.8	1401.5	1695.9	2533.7	3195.5
7	SB/Riverside to Irvine	7.8	209.4	372.2	716.9	1052.8	1401.5	1695.9	2533.7	3195.5
8	Hemet to Riverside	7.8	209.4	372.2	716.9	1052.8	1401.5	1695.9	2533.7	3195.5
9	Redlands to SB	7.8	209.4	372.2	716.9	1052.8	1401.5	1695.9	2533.7	3195.5

TABLE B-4

COMMUTER RAIL DIESEL SCENARIO – PEAK SERVICE – NOx

	Route	Line Start Year	Miles	Number of Trains Start	Inter.	Mature	Diesel Prime Mover NOx Emissions per Throttle Notch (g/hr) Idle	1	2	3	4	5	6	7	8	1992 Loco Emission Factor	Emission Conversion Factor (7 to 4 car)	Start to Destination Emissions (grams)	Destination to Start Emissions (grams)	Total Emissions (ton/yr) Start	Inter.	Mature
1	Ventura to LA	1992	47	4	8	9	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	11774.61	13389.72	28.19	56.38	63.42
2	Santa Clarita to LA	1992	35	3	4	6	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	9032.13	13653.32	19 06	25 41	38.12
3	SB to LA	1992	56.5	5	8	9	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	15743.64	18317.37	47.69	76.31	85.84
4	Riverside to LA (Ontario)	1993	58.8	3	5	6	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	16384.53	19063.04	29.78	49.63	59.56
5	Oceanside to LA	1993	87.2	8	8	10	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	23012.22	26559.04	115.53	115.53	144.42
6	Riverside to LA (Fullerton)	1995	62.8	2	4	5	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	17499.12	20359.84	21.20	42.41	53.01
7	SB/Riverside to Irvine	1995	59	4	8	10	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	16440.26	19127.88	39.84	79.68	99 60
8	Hemet to Riverside	1995	39.6	2	4	5	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	11034.48	12838 37	13 37	26.74	33.43
9	Redlands to SB	1995	12	2	4	5	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	3343.78	3890.42	4.05	8.10	10.13

Notes: 1. Emission factors are for EMD engine model 12-710-G3A with seven passenger compartments.
2. This scenario assumes the use of locomotives with 25 percent less NOx than current commuter rail locomotives. Improvements are due to retarded injection timing, 0.02 percent sulfur fuel, and operational improvements.
3. The start-up level of service will consist of four passenger cars per train.
4. The intermediate and mature levels of service will consist of trains with seven passenger cars per train.
5. Trains are assumed to operate five days per week, less six holidays per year.

TABLE B-5

COMMUTER RAIL DIESEL SCENARIO – PEAK SERVICE – PM

	Route	Line Start Year	Miles	Number of Trains: Start	Inter.	Mature	Diesel Prime Mover PM Emissions per Throttle Notch (g/hr): Idle	1	2	3	4	5	6	7	8	Emission Conversion Factor (7 to 4 car)	Start to Destination Emissions (grams)	Destination to Start Emissions (grams)	Total Emissions (ton/yr): Start	Inter.	Mature
1	Ventura to LA	1992	47	4	8	9	20	33	133	290	305	384	653	747	944	1.00	469.89	526.78	1.12	2.23	2.61
2	Santa Clarita to LA	1992	35	3	4	6	20	33	133	290	305	384	653	747	944	1.00	353.64	549.20	0.76	1.01	1.52
3	SB to LA	1992	56.5	5	8	9	20	33	133	290	305	384	653	747	944	1.00	618.17	726.72	1.88	3.01	3.39
4	Riverside to LA (Ontario)	1993	58.8	3	5	6	20	33	133	290	305	384	653	747	944	1.00	643.34	756.31	1.18	1.96	2.35
5	Oceanside to LA	1993	87.2	8	8	10	20	33	133	290	305	384	653	747	944	1.00	907.70	1134.98	4.58	4.58	5.72
6	Riverside to LA (Fullerton)	1995	62.8	2	4	5	20	33	133	290	305	384	653	747	944	1.00	687.10	807.76	0.84	1.67	2.09
7	SB/Riverside to Irvine	1995	59	4	8	10	20	33	133	290	305	384	653	747	944	1.00	645.53	758.88	1.57	3.15	3.93
8	Hemet to Riverside	1995	39.6	2	4	5	20	33	133	290	305	384	653	747	944	1.00	433.27	509.35	0.53	1.06	1.32
9	Redlands to SB	1995	12	2	4	5	20	33	133	290	305	384	653	747	944	1 00	131.29	154.35	0.16	0.32	0.40

Notes: 1. PM emission factors for EMD engine model 12–710G3A with seven passenger compartments were not available. Instead, PM factors for EMD engine model 16–710G3 have been used.

2. This scenario assumes the use of locomotives incorporating retarded injection timing and .02 percent sulfur fuel. It is assumed that PM increases with injection retard. However, the use of low sulfur fuel will offset this factor to some extent. Also, it is assumed that the EMD 16–710G3 emission factors give higher PM than would be expected from the 12–710G3A.

3. The start–up level of service will consist of four passenger cars per train.

4. The intermediate and mature levels of service will consist of trains with seven passenger cars per train.

5. Trains are assumed to operate five days per week, less six holidays per year.

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TABLE B-6

COMMUTER RAIL DIESEL SCENARIO – PEAK SERVICE – HC

	Route	Line Start Year	Miles	Number of Trains Start	Number of Trains Inter.	Number of Trains Mature	Diesel Prime Mover HC Emissions per Throttle Notch (g/hr) Idle	1	2	3	4	5	6	7	8	Emission Conversion Factor (7 to 4 car)	Start to Destination Emissions (grams)	Destination to Start Emissions (grams)	Total Emissions (ton/yr) Start	Inter.	Mature
1	Ventura to LA	1992	47	4	8	9	55	84	82	122	137	168	187	228	352	1.00	196.68	214.32	0.46	0.92	1.04
2	Santa Clarita to LA	1992	35	3	4	6	55	84	82	122	137	168	187	228	352	1.00	154.34	214.07	0.31	0.41	0.62
3	SB to LA	1992	56.5	5	8	9	55	84	82	122	137	168	187	228	352	1.00	261.41	293.92	0.78	1.24	1.40
4	Riverside to LA (Ontario)	1993	58.8	3	5	6	55	84	82	122	137	168	187	228	352	1.00	272.05	305 88	0.49	0.81	0.97
5	Oceanside to LA	1993	87.2	8	8	10	55	84	82	122	137	168	187	228	352	1.00	385.58	454.76	1.88	1.88	2.35
6	Riverside to LA (Fullerton)	1995	62.8	2	4	5	55	84	82	122	137	168	187	228	352	1.00	290.56	326.69	0.35	0.69	0.86
7	SB/Riverside to Irvine	1995	59	4	8	10	55	84	82	122	137	168	187	228	352	1.00	272.98	306.92	0.65	1.30	1.62
8	Hemet to Riverside	1995	39.6	2	4	5	55	84	82	122	137	168	187	228	352	1.00	183.22	206 00	0.22	0.44	0.54
9	Redlands to SB	1995	12	2	4	5	55	84	82	122	137	168	187	228	352	1.00	55.52	62.42	0.07	0.13	0.17

Notes: 1. Emission factors are for EMD engine model 12–710G3A with seven passenger compartments.
2. The start–up level of service will consist of four passenger cars per train.
3. The intermediate and mature levels of service will consist of trains with seven passenger cars per train.
4. Trains are assumed to operate five days per week, less six holidays per year.

TABLE B-7

COMMUTER RAIL DIESEL SCENARIO - PEAK SERVICE - CO

	Route	Line Start Year	Miles	Number of Trains Start	Number of Trains Inter.	Number of Trains Mature	Diesel Prime Mover CO Emissions per Throttle Notch (g/hr) Idle	1	2	3	4	5	6	7	8	Emission Conversion Factor (7 to 4 car)	Start to Destination Emissions (grams)	Destination to Start Emissions (grams)	Total Emissions (ton/yr) Start	Inter.	Mature
1	Ventura to LA	1992	47	4	8	9	54	113	127	179	305	855	1408	4333	3930	1.00	1601.45	1718.45	3.72	7.44	8.37
2	Santa Clarita to LA	1992	35	3	4	6	54	113	127	179	305	855	1408	4333	3930	1.00	1183.62	1969.80	2.65	3.53	5.30
3	SB to LA	1992	56.5	5	8	9	54	113	127	179	305	855	1408	4333	3930	1.00	2000.56	2761.39	6.67	10.67	12.00
4	Riverside to LA (Ontario)	1993	58.8	3	5	6	54	113	127	179	305	855	1408	4333	3930	1.00	2082.00	2873.80	4.16	6.94	8.33
5	Oceanside to LA	1993	87.2	8	8	10	54	113	127	179	305	855	1408	4333	3930	1.00	3013.05	4060.72	15.85	15.85	19.81
6	Riverside to LA (Fullerton)	1995	62.8	2	4	5	54	113	127	179	305	855	1408	4333	3930	1.00	2223.63	3069.30	2.96	5.93	7.41
7	SB/Riverside to Irvine	1995	59	4	8	10	54	113	127	179	305	855	1408	4333	3930	1.00	2089.08	2883.58	5.57	11.14	13.93
8	Hemet to Riverside	1995	39 6	2	4	5	54	113	127	179	305	855	1408	4333	3930	1.00	1402.16	1935.42	1.87	3.74	4.67
9	Redlands to SB	1995	12	2	4	5	54	113	127	179	305	855	1408	4333	3930	1.00	424.90	586.49	0.57	1.13	1.42

Notes: 1. Emission factors are for EMD engine model 12-710G3A with seven passenger compartments.
2. The start-up level of service will consist of four passenger cars per train.
3. The intermediate and mature levels of service will consist of trains with seven passenger cars per train.
4. Trains are assumed to operate five days per week, less six holidays per year.

TABLE B-8

COMMUTER RAIL DIESEL SCENARIO – PEAK SERVICE – SOx

	Route	Line Start Year	Miles	Number of Trains Start	Number of Trains Inter.	Number of Trains Mature	Diesel Prime Mover SOx Emissions per Throttle Notch (g/hr) Idle	1	2	3	4	5	6	7	8	Emission Conversion Factor (7 to 4 car)	Start to Destination Emissions (grams)	Destination to Start Emissions (grams)	Total Emissions (ton/yr) Start	Inter.	Mature
1	Ventura to LA	1992	47	4	8	9	34	165	253	466	674	897	1068	1546	1949	1.00	936.57	1065.46	2.24	4.49	5.05
2	Santa Clarita to LA	1992	35	3	4	6	34	165	253	466	674	897	1068	1546	1949	1.00	715.67	1113.35	1.54	2.05	3.07
3	SB to LA	1992	56.5	5	8	9	34	165	253	466	674	897	1068	1546	1949	1.00	1251.23	1501.79	3.85	6.17	6.94
4	Riverside to LA (Ontario)	1993	58.8	3	5	6	34	165	253	466	674	897	1068	1546	1949	1.00	1302.17	1562.92	2.41	4.01	4.81
5	Oceanside to LA	1993	87.2	8	8	10	34	165	253	466	674	897	1068	1546	1949	1.00	1828.03	2317.32	9.29	9.29	11.61
6	Riverside to LA (Fullerton)	1995	62.8	2	4	5	34	165	253	466	674	897	1068	1546	1949	1.00	1390.75	1669.25	1.71	3 43	4.28
7	SB/Riverside to Irvine	1995	59	4	8	10	34	165	253	466	674	897	1068	1546	1949	1.00	1306.60	1568.24	3.22	6.44	8.05
8	Hemet to Riverside	1995	39.6	2	4	5	34	165	253	466	674	897	1068	1546	1949	1.00	876.97	1052.58	1.08	2.16	2.70
9	Redlands to SB	1995	12	2	4	5	34	165	253	466	674	897	1068	1546	1949	1.00	265.75	318.96	0.33	0.65	0.82

Notes: 1. Emission factors are for EMD engine model 12–710G3A with seven passenger compartments.
2. The start–up level of service will consist of four passenger cars per train.
3. The intermediate and mature levels of service will consist of trains with seven passenger cars per train.
4. Trains are assumed to operate five days per week, less six holidays per year.

TABLE B-9

COMMUTER RAIL ELECTRIFICATION SCENARIO – PEAK SERVICE – START UP LEVEL – NOx

	Route	Line Start Year	Miles	# of Trains	Start/ Dest. Power (KW-HR)	Dest./ Start Power (KW-HR)	Train Pwr Req (MW-HR/ day)	Total Pwr Req (MW-HR/ day)	1992 NOx (t/yr) 100% Basin	1992 NOx (t/yr) 40% Basin	1993 NOx (t/yr) 100% Basin	1993 NOx (t/yr) 40% Basin	1994 NOx (t/yr) 100% Basin	1994 NOx (t/yr) 40% Basin	1995 NOx (t/yr) 100% Basin	1995 NOx (t/yr) 40% Basin	1996 NOx (t/yr) 100% Basin	1996 NOx (t/yr) 40% Basin	1997 NOx (t/yr) 100% Basin	1997 NOx (t/yr) 40% Basin	1998 NOx (t/yr) 100% Basin	1998 NOx (t/yr) 40% Basin	1999 NOx (t/yr) 100% Basin	1999 NOx (t/yr) 40% Basin	2000+ NOx (t/yr) 100% Basin	2000+ NOx (t/yr) 40% Basin
1	Ventura to LA	1992	47	4	1112.61	1268.67	9.53	12.34	1.43	0.57	1.29	0 51	1.13	0.45	0 99	0.39	0.83	0.33	0.69	0 28	0.53	0.21	0.39	0.16	0.24	0.09
2	Santa Clarita to LA	1992	35	3	847.79	1337.01	6.55	8.49	0.98	0.39	0.88	0.35	0.78	0.31	0.68	0.27	0.57	0.23	0.47	0.19	0.37	0.15	0.27	0.11	0.16	0.06
3	SB to LA	1992	56.5	5	1486.72	1802.42	16.45	21.31	2.46	0.98	2.22	0.89	1.95	0.78	1.70	0.68	1.43	0.57	1.19	0.48	0.92	0 37	0.68	0.27	0.41	0 16
4	Riverside to LA (Ontario)	1993	58.8	3	1547.24	1875.79	10.27	13.30	1.54	0.62	1.39	0.55	1.22	0.49	1.06	0.43	0.90	0.36	0.74	0.30	0.57	0.23	0.42	0.17	0.25	0.10
5	Oceanside to LA	1993	87.2	8	2170.32	2775.35	39.57	51.26	5.92	2.37	5.34	2.14	4 69	1.87	4.10	1.64	3.45	1.38	2.86	1.15	2.21	0.89	1.63	0.65	0 98	0 39
6	Riverside to LA (Fullerton)	1995	62.8	2	1652.50	2003.40	7.31	9.47	1.09	0.44	0.99	0.39	0.87	0.35	0.76	0.30	0.64	0 26	0.53	0.21	0.41	0.16	0.30	0.12	0.18	0.07
7	SB/Riverside to Irvine	1995	59	4	1552.51	1882.17	13.74	17.80	2.06	0.82	1.85	0.74	1.63	0.65	1.42	0.57	1.20	0 48	0.99	0.40	0.77	0.31	0.57	0.23	0.34	0.14
8	Hemet to Riverside	1995	39.6	2	1042.02	1263.29	4.61	5.97	0.69	0.28	0.62	0.25	0.55	0.22	0.48	0.19	0.40	0.16	0.33	0.13	0.26	0.10	0.19	0.08	0.11	0.05
9	Redlands to SB	1995	12	2	315.76	382.82	1.40	1.81	0.21	0.08	0.19	0.08	0.17	0 07	0.14	0.06	0.12	0.05	0.10	0.04	0.08	0.03	0.06	0.02	0.03	0.01

Notes: 1. First year of electric service is assumed to be 1996. Thus, system start up for all routes assumed to be diesel operation.
2. The start-up level of service will consist of four passenger cars per train.
3. Line losses of seven percent and catenary efficiency of 83 percent assumed
4. Trains are assumed to operate five days per week, less six holidays per year.
5. Horsepower by throttle notch is for EMD engine model 12-710G3A with seven passenger cars.
6. Two scenarios are assumed for this analysis—100 percent and 40 percent in-Basin power generation.

COMMUTER RAIL ELECTRIFICATION SCENARIO – PEAK SERVICE – INTERMEDIATE LEVEL – NOx

	Route	Line Start Year	Miles	# of Trains	Start/ Dest. Power (KW-HR)	Dest./ Start Power (KW-HR)	Train Pwr Req (MW-HR/ day)	Total Pwr Req (MW-HR/ day)	1992 NOx (t/yr) 100% Basin	1992 NOx (t/yr) 40% Basin	1993 NOx (t/yr) 100% Basin	1993 NOx (t/yr) 40% Basin	1994 NOx (t/yr) 100% Basin	1994 NOx (t/yr) 40% Basin	1995 NOx (t/yr) 100% Basin	1995 NOx (t/yr) 40% Basin	1996 NOx (t/yr) 100% Basin	1996 NOx (t/yr) 40% Basin	1997 NOx (t/yr) 100% Basin	1997 NOx (t/yr) 40% Basin	1998 NOx (t/yr) 100% Basin	1998 NOx (t/yr) 40% Basin	1999 NOx (t/yr) 100% Basin	1999 NOx (t/yr) 40% Basin	2000+ NOx (t/yr) 100% Basin	2000+ NOx (t/yr) 40% Basin
1	Ventura to LA	1992	47	8	1112.61	1268.67	19.05	24.68	2.85	1.14	2.57	1.03	2.26	0.90	1.97	0.79	1.66	0.66	1.38	0.55	1.07	0.43	0.78	0.31	0.47	0.19
2	Santa Clarita to LA	1992	35	4	847.79	1337.01	8.74	11.32	1.31	0.52	1.18	0.47	1.04	0.41	0.91	0.36	0.76	0.30	0.63	0.25	0.49	0.20	0.36	0.14	0.22	0.09
3	SB to LA	1992	56.5	8	1486.72	1802.42	26.31	34.09	3.94	1.58	3.55	1.42	3.12	1.25	2.73	1.09	2.29	0.92	1.90	0.76	1.47	0.59	1.08	0.43	0.65	0.26
4	Riverside to LA (Ontario)	1993	58.8	5	1547.24	1875.79	17.12	22.17	2.56	1.03	2.31	0.92	2.03	0.81	1.77	0.71	1.49	0.60	1.24	0.50	0.96	0.38	0.70	0.28	0.42	0 17
5	Oceanside to LA	1993	87.2	8	2170.32	2775.35	39.57	51.26	5.92	2.37	5.34	2.14	4.69	1.87	4.10	1.64	3.45	1.38	2.86	1.15	2.21	0.89	1.63	0.65	0.98	0 39
6	Riverside to LA (Fullerton)	1995	62.8	4	1652.50	2003.40	14.62	18.94	2.19	0.88	1.97	0.79	1.73	0 69	1.52	0.61	1.28	0.51	1.06	0.42	0.82	0.33	0.60	0.24	0.36	0.14
7	SB/Riverside to Irvine	1995	59	8	1552.51	1882.17	27.48	35.60	4.11	1.65	3.71	1.48	3.26	1.30	2.85	1.14	2.40	0.96	1.99	0.80	1.54	0.61	1.13	0.45	0.68	0 27
8	Hemet to Riverside	1995	39.6	4	1042.02	1263.29	9 22	11.95	1.38	0.55	1.24	0.50	1.09	0.44	0.96	0.38	0.80	0.32	0.67	0.27	0.52	0.21	0.38	0.15	0.23	0.09
9	Redlands to SB	1995	12	4	315.76	382.82	2.79	3.62	0.42	0.17	0.38	0.15	0 33	0.13	0.29	0.12	0.24	0.10	0.20	0.08	0.16	0.06	0.11	0.05	0 07	0 03

Notes: 1. The intermediate level of service will consist of seven passenger cars per train.
2. Line losses of seven percent and catenary efficiency of 83 percent assumed.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Horsepower by throttle notch is for EMD engine model 12-710G3A with seven passenger cars.
5. Two scenarios are assumed for this analysis—100 percent and 40 percent in-Basin power generation.

TABLE B-9 (Continued)

COMMUTER RAIL ELECTRIFICATION SCENARIO – PEAK SERVICE – MATURE LEVEL – NOx

	Route	Line Start Year	Miles	# of Trains	Start/ Dest. Power (KW-HR)	Dest./ Start Power (KW-HR)	Train Pwr Req (MW-HR/ day)	Total Pwr Req (MW-HR/ day)	1992 NOx (t/yr)		1993 NOx (t/yr)		1994 NOx (t/yr)		1995 NOx (t/yr)		1996 NOx (t/yr)		1997 NOx (t/yr)		1998 NOx (t/yr)		1999 NOx (t/yr)		2000+ NOx (t/yr)	
									100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin
1	Ventura to LA	1992	47	9	1112.61	1268.67	21.43	27.76	3.21	1.26	2.89	1.16	2.54	1.02	2 22	0 89	1.87	0.75	1.55	0.62	1.20	0.48	0.88	0.35	0.53	0 21
2	Santa Clarita to LA	1992	35	6	847.79	1337.01	13.11	16.98	1.96	0.79	1.77	0.71	1.55	0.62	1.36	0.54	1.14	0.46	0.95	0.38	0.73	0.29	0 54	0 22	0.32	0 13
3	SB to LA	1992	56.5	9	1486.72	1802.42	29.60	38.35	4.43	1.77	3.99	1.60	3.51	1.40	3.07	1.23	2.58	1.03	2.14	0.86	1.66	0.66	1.22	0.49	0.73	0.29
4	Riverside to LA (Ontario)	1993	58.6	6	1547.24	1876.79	20.54	26.61	3.06	1.23	2.77	1.11	2 43	0.97	2.13	0.85	1.79	0.72	1.49	0 59	1.16	0.46	0.84	0.34	0.51	0 20
5	Oceanside to LA	1993	87.2	10	2170.32	2775.35	49.46	64.07	7.40	2.96	6.67	2.67	5.86	2 34	5.13	2.05	4 31	1.73	3.58	1 43	2.77	1.11	2.03	0.81	1.22	0 49
6	Riverside to LA (Fullerton)	1995	62.8	5	1652.50	2003.40	18.28	23.68	2.74	1.09	2.47	0.99	2 17	0.87	1.89	0.76	1.59	0.64	1.32	0.53	1.02	0.41	0.75	0.30	0.45	0.18
7	SB/Riverside to Irvine	1995	59	10	1552.51	1882.17	34.35	44.50	5.14	2.06	4.63	1.85	4.07	1.63	3.56	1.42	3 00	1.20	2.49	0.99	1.92	0.77	1.41	0.57	0.85	0.34
8	Hemet to Riverside	1995	39.6	5	1042.02	1263.29	11.53	14.93	1.73	0.69	1.56	0.62	1.37	0.55	1.19	0.48	1.01	0.40	0.83	0.33	0.64	0.26	0.47	0.19	0.28	0.11
9	Redlands to SB	1995	12	5	315.76	382.82	3.49	4.53	0.52	0.21	0.47	0.19	0.41	0.17	0 36	0.14	0.30	0.12	0.25	0.10	0.20	0.08	0.14	0.06	0.09	0 03

Notes: 1. The mature level of service will consist of seven passenger cars per train.
2. Line losses of seven percent and catenary efficiency of 83 percent assumed.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Horsepower by throttle notch is for EMD engine model 12-710G3A with seven passenger cars.
5. Two scenarios are assumed for this analysis—100 percent and 40 percent in-Basin power generation.

TABLE B-11

COMMUTER RAIL ELECTRIFICATION SCENARIO – PEAK SERVICE – HC

	Route	Line Start Year	Miles	Number of Trains Start	Number of Trains Inter.	Number of Trains Mature	Start/ Dest. Power (KW-HR)	Dest./ Start Power (KW-HR)	Train Pwr Req (MW-HR/day) Start	Train Pwr Req (MW-HR/day) Inter.	Train Pwr Req (MW-HR/day) Mature	Total Pwr Req (MW-HR/day) Start	Total Pwr Req (MW-HR/day) Inter	Total Pwr Req (MW-HR/day) Mature	Pwr.Plnt HC Emiss. Factor	Start HC (t/yr) 100% Basin	Start HC (t/yr) 40% Basin	Inter. HC (t/yr) 100% Basin	Inter. HC (t/yr) 40% Basin	Mature HC (t/yr) 100% Basin	Mature HC (t/yr) 40% Basin
1	Ventura to LA	1992	47	4	8	9	1112.61	1268.67	9.53	19.05	21.43	12.34	24.68	27.76	0.084	0.13	0.05	0.26	0.11	0.30	0.12
2	Santa Clarita to LA	1992	35	3	4	6	847.79	1337.01	6.55	8.74	13.11	8.49	11.32	16.98	0.084	0.09	0.04	0.12	0.05	0.18	0.07
3	SB to LA	1992	56.5	5	8	9	1486.72	1602.42	16.45	26.31	29.60	21.31	34.09	38.35	0.084	0.23	0.09	0.36	0.15	0.41	0 16
4	Riverside to LA (Ontario)	1993	58.8	3	5	6	1547.24	1675.79	10.27	17.12	20.54	13.30	22.17	26.61	0.084	0.14	0.06	0.24	0.09	0.28	0.11
5	Oceanside to LA	1993	87.2	8	8	10	2170.32	2775.35	39.57	39.57	49.46	51.26	51.26	64.07	0.084	0.55	0.22	0.55	0.22	0.68	0.27
6	Riverside to LA (Fullerton)	1995	62.8	2	4	5	1652.50	2003.40	7.31	14.62	18.28	9.47	18.94	23.68	0.084	0.10	0.04	0.20	0.08	0.25	0.10
7	SB/Riverside to Irvine	1995	59	4	8	10	1552.51	1882.17	13.74	27.48	34.35	17.80	35.60	44.50	0.084	0.19	0.08	0.38	0.15	0.47	0.19
8	Hemet to Riverside	1995	39.6	2	4	5	1042.02	1263.29	4.61	9.22	11.53	5.97	11.95	14.93	0.084	0.06	0.03	0.13	0.05	0.16	0.06
9	Redlands to SB	1995	12	2	4	5	315.76	382.62	1.40	2.79	3.49	1.81	3.62	4.53	0.084	0.02	0.01	0.04	0.02	0.05	0 02

Notes: 1. First year of electric service is assumed to be 1996. Thus, system start up for all routes assumed to be diesel operation.
2. The start–up level of service will consist of four passenger cars per train.
3. The intermediate and mature levels of service will consist of seven passenger cars.
4. Line losses of seven percent and catenary efficiency of 83 percent assumed
5. Trains are assumed to operate five days per week, less six holidays per year.
6. Horsepower by throttle notch is for EMD engine model 12–710G3A with seven passenger cars.
7. Two scenarios are assumed for this analysis—100 percent and 40 percent in–Basin power generation.
8. Powerplant HC emission levels are from Joe Whittaker and Marty Kay of SCAQMD's Engineering Division and Office of Planning and Rules, respectively.

TABLE B-12

COMMUTER RAIL ELECTRIFICATION SCENARIO - PEAK SERVICE - CO

	Route	Line Start Year	Miles	Number of Trains			Start/ Dest. Power (KW-HR)	Dest./ Start Power (KW-HR)	Train Pwr Req (MW-HR/day)			Total Pwr Req (MW-HR/day)			Pwr.Plnt CO Emiss. Factor	Start CO (t/yr)		Inter. CO (t/yr)		Mature CO (t/yr)	
				Start	Inter.	Mature			Start	Inter.	Mature	Start	Inter	Mature		100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin
1	Ventura to LA	1992	47	4	8	9	1112.61	1268.67	9.53	19.05	21.43	12.34	24.68	27.76	0.143	0.22	0.09	0.45	0.18	0.50	0.20
2	Santa Clarita to LA	1992	35	3	4	6	847.79	1337.01	6.55	8.74	13.11	8.49	11.32	16.98	0.143	0.15	0.06	0.21	0.08	0.31	0.12
3	SB to LA	1992	56.5	5	8	9	1486.72	1802.42	16.45	26.31	29.60	21.31	34.09	38.35	0.143	0.39	0.15	0.62	0.25	0.70	0.28
4	Riverside to LA (Ontario)	1993	58.8	3	5	6	1647.24	1875.79	10.27	17.12	20.54	13.30	22.17	26.61	0.143	0.24	0.10	0.40	0.16	0.48	0.19
5	Oceanside to LA	1993	87.2	8	8	10	2170.32	2775.35	39.57	39.57	49.46	51.26	51.26	64.07	0.143	0.93	0.37	0.93	0.37	1.16	0.47
6	Riverside to LA (Fullerton)	1995	62.8	2	4	5	1652.50	2003 40	7.31	14.62	18.28	9.47	18.94	23.68	0.143	0.17	0.07	0.34	0.14	0.43	0 17
7	SB/Riverside to Irvine	1995	59	4	8	10	1552.51	1882.17	13 74	27.48	34.36	17.80	35.60	44.50	0.143	0.32	0.13	0.65	0.26	0.81	0.32
8	Hemet to Riverside	1995	39.6	2	4	5	1042.02	1263.29	4.61	9.22	11.53	5.97	11.95	14.93	0.143	0 11	0 04	0 22	0.09	0.27	0.11
9	Redlands to SB	1995	12	2	4	5	315.76	382.82	1.40	2.79	3.49	1.81	3.62	4.53	0.143	0.03	0.01	0.07	0.03	0.08	0.03

Notes: 1. First year of electric service is assumed to be 1996. Thus, system start up for all routes assumed to be diesel operation.
2. The start-up level of service will consist of four passenger cars per train.
3. The intermediate and mature levels of service will consist of seven passenger cars.
4. Line losses of seven percent and catenary efficiency of 83 percent assumed
5. Trains are assumed to operate five days per week, less six holidays per year.
6. Horsepower by throttle notch is for EMD engine model 12-710G3A with seven passenger cars.
7. Two scenarios are assumed for this analysis—100 percent and 40 percent in-Basin power generation.
8. Powerplant CO emission levels are from Joe Whittaker and Marty Kay of SCAQMD's Engineering Division and Office of Planning and Rules, respectively.

TABLE B-13

COMMUTER RAIL ELECTRIFICATION SCENARIO - PEAK SERVICE - SOx

	Route	Line Start Year	Miles	Number of Trains			Start/ Dest. Power (KW-HR)	Dest./ Start Power (KW-HR)	Train Pwr Req (MW-HR/day)			Total Pwr Req (MW-HR/day)			Pwr.Plnt SOx Emiss. Factor	Start SOx (t/yr)		Inter. SOx (t/yr)		Mature SOx (t/yr	
				Start	Inter.	Mature			Start	Inter.	Mature	Start	Inter	Mature		100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin
1	Ventura to LA	1992	47	4	8	9	1112.61	1268.67	9.53	19.05	21.43	12.34	24.68	27.76	0.008	0.01	0.01	0.03	0.01	0.03	0.01
2	Santa Clarita to LA	1992	35	3	4	6	847.79	1337.01	6.56	8.74	13.11	8.49	11.32	16 98	0.008	0.01	0 00	0.01	0.00	0.02	0.01
3	SB to LA	1992	56.5	5	8	9	1486.72	1802.42	16.45	26.31	29 60	21.31	34.09	38.35	0.008	0.02	0.01	0.03	0.01	0.04	0.02
4	Riverside to LA (Ontario)	1993	58.8	3	5	6	1647.24	1876.79	10.27	17.12	20.54	13.30	22.17	26.61	0 008	0.01	0 01	0.02	0.01	0.03	0 01
5	Oceanside to LA	1993	87.2	8	8	10	2170.32	2776.35	39.57	39.57	49.46	51.26	51.26	64.07	0.008	0.05	0.02	0.05	0.02	0.07	0.03
6	Riverside to LA (Fullerton)	1995	62.8	2	4	5	1652.50	2003.40	7.31	14 62	18.28	9.47	18.94	23.68	0.008	0.01	0.00	0.02	0 01	0.02	0.01
7	SB/Riverside to Irvine	1995	59	4	8	10	1552.51	1882.17	13.74	27.48	34.35	17.80	35.60	44.50	0.008	0.02	0.01	0.04	0.01	0.05	0.02
8	Hemet to Riverside	1995	39.6	2	4	5	1042.02	1263.29	4.61	9.22	11.53	5.97	11.95	14.93	0.008	0.01	0.00	0.01	0.00	0.02	0.01
9	Redlands to SB	1995	12	2	4	5	315.76	382.82	1.40	2.79	3.49	1.81	3.62	4 53	0.008	0.00	0.00	0.00	0.00	0.00	0.00

Notes: 1. First year of electric service is assumed to be 1996. Thus, system start up for all routes assumed to be diesel operation.
2. The start-up level of service will consist of four passenger cars per train.
3. The intermediate and mature levels of service will consist of seven passenger cars.
4. Line losses of seven percent and catenary efficiency of 83 percent assumed
5. Trains are assumed to operate five days per week, less six holidays per year.
6. Horsepower by throttle notch is for EMD engine model 12-710G3A with seven passenger cars.
7. Two scenarios are assumed for this analysis---100 percent and 40 percent in-Basin power generation.
8. Powerplant SOx emission levels are from Joe Whittaker and Marty Kay of SCAQMD's Engineering Division and Office of Planning and Rules, respectively.

TABLE B-16 (Continued)

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – PEAK SERVICE – MATURE LEVEL – ROG

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.
1	Ventura to LA	47	9	7	200	12600	17.09	430666.00
2	Santa Clarita to LA	35	6	7	200	8400	13.97	234696.00
3	SB to LA	56.5	9	7	200	12600	36.32	915264.00
4	Riverside to LA (Ontario)	58.5	6	7	200	8400	26.40	443455.69
5	Oceanside to LA	87.2	10	7	200	14000	33.94	950320.00
6	Riverside to LA (Fullerton)	62.8	5	7	200	7000	28.19	394685.62
7	SB/Riverside to Irvine	59	10	7	200	14000	26.49	741606.73
8	Hemet to Riverside	39.6	5	7	200	7000	17.78	248876.19
9	Redlands to SB	12	5	7	200	7000	5.39	75417.63

	Route	Predicted Basin Passenger Car ROG Emissions (lb/mile) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	0.0027	0.0025	0.0023	0 0021	0.0019	0.0017	0.0016	0.0014	0.0013	0.0004
2	Santa Clarita to LA	0.0027	0.0025	0.0023	0 0021	0.0019	0.0017	0.0016	0.0014	0.0013	0.0004
3	SB to LA	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0 0004
4	Riverside to LA (Ontario)	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0.0004
5	Oceanside to LA	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0 0004
6	Riverside to LA (Fullerton)	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0.0004
7	SB/Riverside to Irvine	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0 0004
8	Hemet to Riverside	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0.0004
9	Redlands to SB	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0 0004

	Route	ROG Emissions Avoided (tons/yr) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	147.22	134.92	123.34	112.55	103.32	94.82	86.28	77.53	69.42	22 55
2	Santa Clarita to LA	80.23	73.53	67.22	61.33	56.30	51.68	47.02	42 25	37.83	12.29
3	SB to LA	312.87	286.74	262.13	239.19	219.57	201.52	183.37	164.76	147.54	47.91
4	Riverside to LA (Ontario)	151.59	138.93	127.00	115.89	106.39	97.64	88.86	79.83	71.49	23.22
5	Oceanside to LA	324.86	297.72	272.17	248.35	227.96	209.24	190.39	171.07	153.19	49.75
6	Riverside to LA (Fullerton)	134.92	123.65	113.04	103.14	94.69	86.90	79.07	71.05	63.62	20 66
7	SB/Riverside to Irvine	253.51	232.33	212.39	193.81	177.91	163.29	148.58	133.60	119.55	38 82
8	Hemet to Riverside	85.07	77.97	71.28	65.04	59.71	54.80	49.86	44.80	40.12	13.03
9	Redlands to SB	25.78	23.63	21.60	19.71	18.09	16.61	15.11	13.58	12.16	3.95

Notes:
1. It is assumed that each car is filled to capacity (200 passengers).
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on SCAG data and the length of routes 1, 2, 3, and 5 has been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.
Emission factors for 1994 and subsequent years have been adjusted to account for ARB vehicle regulations.

TABLE B-17

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – PEAK SERVICE – START UP LEVEL – CO

	Route	Route engt	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car CO Emissions (lb/mile)										CO Emissions Avoided (tons/yr)									
									1992	1993	1994	1995	1996	1997	1998	1999	2000	2010	1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	4	4	119 2	1907	17.09	65188.10	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	161.16	170.25	158.76	147.02	135.95	125 72	115.96	107.13	96.84	49.46
2	Santa Clarita to LA	35	3	4	119.2	1430	13.97	39965.38	0.0219	0.0206	0.0192	0 0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	111.08	104.38	97.34	90.14	83.35	77.07	71.09	65.68	60.59	30.32
3	SB to LA	56.5	5	4	119.2	2384	36.32	173173.76	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	481.31	452.28	421.79	390.57	361.15	333.97	308.04	284.69	262.56	131.39
4	Riverside to LA (Ontario)	58.8	3	4	119.2	1430	26.40	75514.17	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	209.88	197.22	183 93	170.31	157.48	145.63	134.32	124.10	114.49	57.29
5	Oceanside to LA	87.2	8	4	119.2	3814	33.94	258921.47	0.0219	0 0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	719.63	676.23	630.65	583.97	539.98	499.34	460.56	425.51	392.57	196.45
6	Riverside to LA (Fullerton)	62.8	2	4	119.2	954	28.19	53767.46	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0 0119	0.0060	149.44	140.43	130.96	121.27	112.13	103.69	95.64	88.36	81.52	40.79
7	SB/Riverside to Irvine	59	4	4	119.2	1907	26.49	101028.03	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0 0129	0.0119	0.0060	280.79	263.86	246.07	227.86	210 69	194.84	179.71	166.03	153.18	76 65
8	Hemet to Riverside	39.6	2	4	119.2	954	17.78	33904.32	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	94.23	88.55	82.58	76.47	70.71	65.39	60 31	55.72	51.40	25 72
9	Redlands to SB	12	2	4	119.2	954	5.39	10274.04	0.0219	0 0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	28.56	26.83	25.02	23.17	21.43	19.81	18.28	16.88	15.58	7.80

Notes: 1. It is assumed that 119.2 passengers are in each car. This value is a composite of estimated ridership data from SCAG.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the length of routes 1, 2, 3, and 5 has been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.
Emission factors for 1994 and subsequent years have been adjusted to account for ARB vehicle regulations.

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – PEAK SERVICE – INTERMEDIATE LEVEL – CO

	Route	Route engt	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car CO Emissions (lb/mile)										CO Emissions Avoided (tons/yr)									
									1992	1993	1994	1995	1996	1997	1998	1999	2000	2010	1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	8	7	119.2	6675	17.09	228158.34	0.0219	0 0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	634.13	595.89	555.72	514.69	475.82	440.01	405.84	374.95	345.93	173 11
2	Santa Clarita to LA	35	4	7	119.2	3338	13.97	93252.54	0.0219	0.0206	0.0192	0.0178	0.0164	0 0152	0.0140	0.0129	0.0119	0 0060	259.18	243.55	227.13	210 32	194.48	179 84	165.88	153.25	141.39	70.75
3	SB to LA	56.5	8	7	119.2	6675	36.32	484886.53	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	1347.67	1266.39	1181 02	1093 61	1011.22	935.12	862.51	796.65	735.17	367.89
4	Riverside to LA (Ontario)	58 8	5	7	119.2	4172	26.40	220249.66	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0 0060	612.15	575.23	536.46	496.75	459.33	424.76	391.78	361.95	333 93	167.11
5	Oceanside to LA	87.2	8	7	119.2	6675	33.94	453112.58	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	1259.36	1183.41	1103 63	1021.94	944 96	873 84	805 99	744.64	686.99	343.79
6	Riverside to LA (Fullerton)	62 8	4	7	119.2	3338	28.19	188186.10	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	523.04	491.49	458.36	424.43	392.46	362.92	334.74	309.26	285.32	142.78
7	SB/Riverside to Irvine	59	8	7	119.2	6675	26.49	353598 09	0.0219	0.0206	0.0192	0 0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	982.77	923 50	861.25	797.50	737.42	681.93	628.97	581.10	536.11	268.28
8	Hemet to Riverside	39.6	4	7	119.2	3338	17.78	118665.12	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	329 81	309 92	289 03	267.64	247.47	228.86	211.08	195.01	179.92	90.03
9	Redlands to SB	12	4	7	119.2	3338	5.39	35959 13	0 0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	99.94	93.92	87.58	81.10	74 99	69.35	63.96	59.09	54.52	27.28

Notes: 1. It is assumed that 119.2 passengers are in each car. This value is a composite of estimated ridership data from SCAG.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the length of routes 1, 2, 3, and 5 has been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.
Emission factors for 1994 and subsequent years have been adjusted to account for ARB vehicle regulations.

TABLE B-17 (Continued)

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – PEAK SERVICE – MATURE LEVEL – CO

	Route	Route engt	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car CO Emissions (lb/mile) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	9	7	200	12600	17.09	430668.00	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060
2	Santa Clarita to LA	35	6	7	200	8400	13.97	234696.00	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060
3	SB to LA	56.5	9	7	200	12600	36.32	915264.00	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060
4	Riverside to LA (Ontario)	58.8	6	7	200	8400	26.40	443455.69	0.0219	0.0206	0.0192	0.0178	0.0164	0 0152	0.0140	0.0129	0.0119	0.0060
5	Oceanside to LA	E7.2	10	7	200	14000	33.94	950320.00	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060
6	Riverside to LA (Fullerton)	62.8	5	7	200	7000	28.19	394665.62	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060
7	SB/Riverside to Irvine	59	10	7	200	14000	26.49	741606.73	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060
8	Hemet to Riverside	39.6	5	7	200	7000	17.78	248878.19	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060
9	Redlands to SB	12	5	7	200	7000	5.39	75417.63	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060

	Route	CO Emissions Avoided (tons/yr) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	1196.98	1124.79	1048.97	971.32	898.15	830.56	766.06	707.76	652.96	326.76
2	Santa Clarita to LA	652.30	612.96	571.64	529.33	489.45	452.62	417.47	385.70	355.84	178.07
3	SB to LA	2543.84	2390.42	2229.28	2064.27	1908.77	1765.12	1628.05	1504.13	1387.69	694.43
4	Riverside to LA (Ontario)	1232.52	1158.18	1080.11	1000.16	924.82	855.22	788.81	728.77	672.35	336.46
5	Oceanside to LA	2641.27	2481.97	2314.67	2143.34	1981.88	1832.72	1690.41	1561.74	1440.84	721.03
6	Riverside to LA (Fullerton)	1096.97	1030.81	961.33	890.17	823.11	761.16	702.06	648.62	598.41	299.46
7	SB/Riverside to Irvine	2061.19	1936.87	1806.31	1672.61	1546.61	1430.21	1319.15	1218.74	1124.40	562.67
8	Hemet to Riverside	691.72	650.00	606.19	561.32	519.03	479 97	442.70	409.00	377.34	188.83
9	Redlands to SB	209.61	196.97	183.69	170.10	157.28	145.45	134.15	123.94	114.35	57.22

Notes: 1. It is assumed that each car is filled to capacity (200 passengers).
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the length of routes 1, 2, 3, and 5 has been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.
Emission factors for 1994 and subsequent years have been adjusted to account for ARB vehicle regulations.

TABLE B-18

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – PEAK SERVICE – START UP LEVEL – SOx

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car SOx Emissions (lb/mile) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	4	4	119.2	1907	17.09	65188.10	0.0001	0 0001	0.0001	0.0001	0.0001	0 0001	0.0001	0.0001	0 0001	0 0001
2	Santa Clarita to LA	35	3	4	119.2	1430	13.97	39965.38	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3	SB to LA	56.5	5	4	119.2	2384	36.32	173173.76	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
4	Riverside to LA (Ontario)	58.8	3	4	119.2	1430	26.40	75514.17	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0 0001
5	Oceanside to LA	87.2	8	4	119.2	3814	33.94	258921.47	0.0001	0 0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
6	Riverside to LA (Fullerton)	62.8	2	4	119.2	954	28.19	53767.46	0.0001	0.0001	0.0001	0 0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
7	SB/Riverside to Irvine	59	4	4	119.2	1907	26.49	101028.03	0.0001	0.0001	0.0001	0.0001	0 0001	0.0001	0.0001	0.0001	0.0001	0.0001
8	Hemet to Riverside	39.6	2	4	119.2	954	17.78	33904.32	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
9	Redlands to SB	12	2	4	119 2	954	5.39	10274.04	0.0001	0.0001	0.0001	0.0001	0 0001	0.0001	0.0001	0.0001	0.0001	0.0001

	Route	SOx Emissions Avoided (tons/yr) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	1.07	1.04	1.00	0.96	0.93	0.91	0 88	0.86	0.85	0.77
2	Santa Clarita to LA	0.66	0.63	0.61	0.59	0.57	0.56	0.54	0.53	0.52	0 47
3	SB to LA	2.86	2.75	2.66	2.55	2.46	2.41	2.35	2.29	2.25	2.06
4	Riverside to LA (Ontario)	1.24	1.20	1.16	1.11	1.08	1.05	1.02	1.00	0.98	0.90
5	Oceanside to LA	4.27	4.11	3 97	3.81	3.71	3.61	3.51	3.42	3.36	3 08
6	Riverside to LA (Fullerton)	0.89	0.85	0.83	0.79	0.77	0.75	0.73	0.71	0 70	0 64
7	SB/Riverside to Irvine	1.67	1.60	1.55	1.49	1.45	1.41	1.37	1.34	1.31	1.20
8	Hemet to Riverside	0.56	0.54	0.52	0.50	0.49	0.47	0.46	0.45	0.44	0.40
9	Redlands to SB	0.17	0.16	0.16	0.15	0 15	0.14	0.14	0.14	0.13	0.12

Notes: 1. It is assumed that 119.2 passengers are in each car. This value is a composite of estimated ridership data from SCAG.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the lengths of routes 1, 2, 3, and 5 have been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – PEAK SERVICE – INTERMEDIATE LEVEL – SOx

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car SOx Emissions (lb/mile) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	8	7	119.2	6675	17.09	228158.34	0.0001	0.0001	0.0001	0.0001	0.0001	0 0001	0 0001	0.0001	0.0001	0.0001
2	Santa Clarita to LA	35	4	7	119.2	3338	13.97	93252.54	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0 0001	0.0001	0.0001	0.0001
3	SB to LA	56.5	8	7	119.2	6675	36.32	484886 53	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
4	Riverside to LA (Ontario)	58.8	5	7	119.2	4172	26.40	220249.66	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
5	Oceanside to LA	87.2	8	7	119.2	6675	33.94	453112 58	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0 0001	0.0001	0.0001	0.0001
6	Riverside to LA (Fullerton)	62.8	4	7	119.2	3338	28.19	188186.10	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0 0001	0.0001	0.0001	0.0001
7	SB/Riverside to Irvine	59	8	7	119.2	6675	26.49	353598.09	0.0001	0.0001	0.0001	0.0001	0.0001	0 0001	0.0001	0 0001	0.0001	0.0001
8	Hemet to Riverside	39.6	4	7	119.2	3338	17.78	118665.12	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0 0001	0.0001	0.0001
9	Redlands to SB	12	4	7	119.2	3338	5.39	35959.13	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

	Route	SOx Emissions Avoided (tons/yr) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	3 76	3 62	3.50	3.36	3.27	3.18	3.10	3.02	2.96	2.71
2	Santa Clarita to LA	1.54	1.48	1.43	1.37	1.33	1.30	1.27	1.23	1.21	1.11
3	SB to LA	7 99	7 70	7.44	7.14	6 94	6 75	6.58	6.41	6.29	5.76
4	Riverside to LA (Ontario)	3.63	3.50	3.36	3.24	3.15	3.07	2 99	2.91	2.86	2 62
5	Oceanside to LA	7.47	7.19	6.95	6.67	6 48	6.31	6.15	5.99	5.88	5.39
6	Riverside to LA (Fullerton)	3.10	2.99	2.89	2.77	2.69	2.62	2 55	2.49	2.44	2.24
7	SB/Riverside to Irvine	5.83	5.61	5.43	5.21	5.06	4.93	4 80	4.67	4.59	4.20
8	Hemet to Riverside	1.96	1.88	1.82	1.75	1.70	1.65	1.61	1.57	1.54	1.41
9	Redlands to SB	0.59	0 57	0.55	0.53	0.51	0.50	0.49	0.48	0.47	0.43

Notes: 1. It is assumed that 119.2 passengers are in each car. This value is a composite of estimated ridership data from SCAG.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the lengths of routes 1, 2, 3, and 5 have been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.

TABLE B-18 (Continued)

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – PEAK SERVICE – MATURE LEVEL – SOx

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car SOx Emissions (lb/mile) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	9	7	200	12600	17.09	430668.00	0.0001	0.0001	0.0001	0.0001	0.0001	0 0001	0.0001	0.0001	0.0001	0.0001
2	Santa Clarita to LA	35	6	7	200	8400	13.97	234696 00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3	SB to LA	56.5	9	7	200	12600	36.32	915264.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
4	Riverside to LA (Ontario)	58.8	6	7	200	8400	26.40	443455.69	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
5	Oceanside to LA	87.2	10	7	200	14000	33.94	950320.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0 0001
6	Riverside to LA (Fullerton)	62.6	5	7	200	7000	28.19	394685.62	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
7	SB/Riverside to Irvine	59	10	7	200	14000	26.49	741606.73	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
8	Hemet to Riverside	39.6	5	7	200	7000	17.78	248878.19	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0 0001
9	Redlands to SB	12	5	7	200	7000	5.39	75417.63	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

	Route	SOx Emissions Avoided (tons/yr) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	7.10	6.84	6.61	6.34	6.16	6.00	5.85	5.69	5.59	5.12
2	Santa Clarita to LA	3.87	3.73	3.60	3.46	3 36	3.27	3.19	3.10	3.05	2.79
3	SB to LA	15.09	14.53	14.04	13.48	13.10	12.75	12 42	12.10	11.88	10.86
4	Riverside to LA (Ontario)	7.31	7.04	6.80	6.53	6.35	6.18	6.02	5.86	5.75	5.27
5	Oceanside to LA	15.67	15.09	14.58	13.99	13.60	13.24	12.90	12.56	12.33	11.29
6	Riverside to LA (Fullerton)	6.51	6.27	6.06	5.81	5.65	5.50	5.36	5.22	5.12	4.69
7	SB/Riverside to Irvine	12.23	11.76	11.38	10.92	10.61	10.33	10.07	9.80	9.62	8.81
8	Hemet to Riverside	4.10	3.95	3.82	3.66	3.56	3.47	3.38	3.29	3.23	2.96
9	Redlands to SB	1.24	1.20	1.16	1.11	1.08	1.05	1.02	1.00	0.98	0.90

Notes: 1. It is assumed that each car is filled to capacity (200 passengers).
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the lengths of routes 1, 2, 3, and 5 have been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.

TABLE B-19

COMMUTER RAIL DIESEL SCENARIO – OFF-PEAK SERVICE – NOx

	Route	Line Start Year	Miles	Number of Trains Start	Number of Trains Inter.	Number of Trains Mature	Diesel Prime Mover NOx Emissions per Throttle Notch (g/hr) Idle	1	2	3	4	5	6	7	8	1992 Loco Emission Factor	Emission Conversion Factor (7 to 4 car)	Start to Destination Emissions (grams)	Destination to Start Emissions (grams)	Total Emissions (ton/yr) Start	Inter.	Mature
1	Ventura to LA	1992	47	0	4	10	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	11774.61	13389.72	0.00	28.19	70.47
2	Santa Clarita to LA	1992	35	0	0	6	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	9032.13	13653.32	0.00	0.00	38.12
3	SB to LA	1992	56.5	0	6	10	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	15743.64	18317.37	0.00	57.23	95.38
4	Riverside to LA (Ontario)	1993	58.8	0	2	6	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	16384.53	19063.04	0.00	19.85	59.56
5	Oceanside to LA	1993	87.2	0	4	10	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	23012.22	28559.04	0.00	57.77	144.42
6	Riverside to LA (Fullerton)	1995	62.8	0	3	14	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	17499.12	20359.84	0.00	31.81	148.43
7	SB/Riverside to Irvine	1995	59	0	3	14	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	16440.26	19127.88	0.00	29.88	139.44
8	Hemet to Riverside	1995	39.6	0	0	0	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	11034.48	12838.37	0.00	0.00	0.00
9	Redlands to SB	1995	12	0	2	5	889	3338	5598	9951	12644	15318	18163	23715	30389	0.75	1.00	3343.78	3890.42	0.00	4.05	10.13

Notes: 1. Emission factors are for EMD engine model 12-710-G3A with seven passenger compartments.
2. This scenario assumes the use of locomotives with 25 percent less NOx than current commuter rail locomotives. Improvements are due to retarded injection timing, 0.02 percent sulfur fuel, and operational improvements.
3. The start-up level of service will consist of four passenger cars per train.
4. The intermediate and mature levels of service will consist of trains with seven passenger cars per train.
5. Trains are assumed to operate five days per week, less six holidays per year.

TABLE B-20

COMMUTER RAIL DIESEL SCENARIO – OFF-PEAK SERVICE – PM

	Route	Line Start Year	Miles	Number of Trains Start	Inter.	Mature	Diesel Prime Mover PM Emissions per Throttle Notch (g/hr) Idle	1	2	3	4	5	6	7	8	Emission Conversion Factor (7 to 4 car)	Start to Destination Emissions (grams)	Destination to Start Emissions (grams)	Total Emissions (ton/yr) Start	Inter.	Mature
1	Ventura to LA	1992	47	0	4	10	20	33	133	290	305	384	653	747	944	1.00	469.89	526.78	0.00	1.12	2.79
2	Santa Clarita to LA	1992	35	0	0	6	20	33	133	290	305	384	653	747	944	1.00	353.64	549.20	0 00	0.00	1.52
3	SB to LA	1992	56.5	0	6	10	20	33	133	290	305	384	653	747	944	1.00	618.17	726.72	0.00	2.26	3.77
4	Riverside to LA (Ontario)	1993	58.8	0	2	6	20	33	133	290	305	384	653	747	944	1.00	643.34	756.31	0.00	0.78	2.35
5	Oceanside to LA	1993	87.2	0	4	10	20	33	133	290	305	384	653	747	944	1.00	907.70	1134.98	0.00	2.29	5.72
6	Riverside to LA (Fullerton)	1995	62.8	0	3	14	20	33	133	290	305	384	653	747	944	1.00	687.10	807.76	0.00	1.26	5.86
7	SB/Riverside to Irvine	1995	59	0	3	14	20	33	133	290	305	384	653	747	944	1.00	645.53	758.88	0.00	1.18	5.51
8	Hemet to Riverside	1995	39.6	0	0	0	20	33	133	290	305	384	653	747	944	1.00	433.27	509.35	0.00	0.00	0.00
9	Redlands to SB	1995	12	0	2	5	20	33	133	290	305	384	653	747	944	1.00	131.29	154.35	0.00	0.16	0.40

Notes: 1. PM emission factors for EMD engine model 12–710G3A with seven passenger compartments were not available. Instead, PM factors for EMD engine model 16–710G3 have been used.

2. This scenario assumes the use of locomotives incorporating retarded injection timing and .02 percent sulfur fuel. It is assumed that PM increases with injection retard. However, the use of low sulfur fuel will offset this factor to some extent. Also, it is assumed that the EMD 16–710G3 emission factors give higher PM than would be expected from the 12–710G3A.

3. The start–up level of service will consist of four passenger cars per train.

4. The intermediate and mature levels of service will consist of trains with seven passenger cars per train.

5. Trains are assumed to operate five days per week, less six holidays per year.

TABLE B-21

COMMUTER RAIL DIESEL SCENARIO – OFF-PEAK SERVICE – HC

	Route	Line Start Year	Miles	Number of Trains			Diesel Prime Mover HC Emissions per Throttle Notch (g/hr)									Emission Conversion Factor (7 to 4 car)	Start to Destination Emissions (grams)	Destination to Start Emissions (grams)	Total Emissions (ton/yr)		
				Start	Inter.	Mature	Idle	1	2	3	4	5	6	7	8				Start	Inter.	Mature
1	Ventura to LA	1992	47	0	4	10	55	84	82	122	137	168	187	228	352	1.00	196.68	214.32	0.00	0.46	1.15
2	Santa Clarita to LA	1992	35	0	0	6	55	84	82	122	137	168	187	228	352	1.00	154.34	214.07	0.00	0.00	0.62
3	SB to LA	1992	56.5	0	6	10	55	84	82	122	137	168	187	228	352	1.00	261.41	293.92	0.00	0.93	1.56
4	Riverside to LA (Ontario)	1993	58.8	0	2	6	55	84	82	122	137	168	187	228	352	1.00	272.05	305.88	0.00	0.32	0.97
5	Oceanside to LA	1993	87.2	0	4	10	55	84	82	122	137	168	187	228	352	1.00	385.58	454.76	0.00	0.94	2.35
6	Riverside to LA (Fullerton)	1995	62.8	0	3	14	55	84	82	122	137	168	187	228	352	1.00	290.56	326.69	0.00	0.52	2.42
7	SB/Riverside to Irvine	1995	59	0	3	14	55	84	82	122	137	168	187	228	352	1.00	272.98	306.92	0.00	0.49	2.27
8	Hemet to Riverside	1995	39.6	0	0	0	55	84	82	122	137	168	187	228	352	1.00	183.22	206.00	0 00	0.00	0.00
9	Redlands to SB	1995	12	0	2	5	55	84	82	122	137	168	187	228	352	1.00	55.52	62.42	0.00	0.07	0.17

Notes: 1. Emission factors are for EMD engine model 12–710G3A with seven passenger compartments.

2. The start–up level of service will consist of four passenger cars per train.

3. The intermediate and mature levels of service will consist of trains with seven passenger cars per train.

4. Trains are assumed to operate five days per week, less six holidays per year.

TABLE B-22

COMMUTER RAIL DIESEL SCENARIO – OFF-PEAK SERVICE – CO

	Route	Line Start Year	Miles	Number of Trains Start	Number of Trains Inter.	Number of Trains Mature	Diesel Prime Mover CO Emissions per Throttle Notch (g/hr) Idle	1	2	3	4	5	6	7	8	Emission Conversion Factor (7 to 4 car)	Start to Destination Emissions (grams)	Destination to Start Emissions (grams)	Total Emissions (ton/yr) Start	Inter.	Mature
1	Ventura to LA	1992	47	0	4	10	54	113	127	179	305	855	1408	4333	3930	1.00	1601.45	1718.45	0.00	3.72	9.30
2	Santa Clarita to LA	1992	35	0	0	6	54	113	127	179	305	855	1408	4333	3930	1.00	1183.62	1969.80	0.00	0.00	5.30
3	SB to LA	1992	56.5	0	6	10	54	113	127	179	305	855	1408	4333	3930	1.00	2000.56	2761.39	0.00	8.00	13.34
4	Riverside to LA (Ontario)	1993	58.8	0	2	6	54	113	127	179	305	855	1408	4333	3930	1.00	2082.00	2873.80	0.00	2.78	8.33
5	Oceanside to LA	1993	87.2	0	4	10	54	113	127	179	305	855	1408	4333	3930	1.00	3013.05	4060.72	0.00	7.92	19.81
6	Riverside to LA (Fullerton)	1995	62.8	0	3	14	54	113	127	179	305	855	1408	4333	3930	1.00	2223.63	3069.30	0.00	4.45	20.75
7	SB/Riverside to Irvine	1995	59	0	3	14	54	113	127	179	305	855	1408	4333	3930	1.00	2089.08	2883.58	0.00	4.18	19.50
8	Hemet to Riverside	1995	39.6	0	0	0	54	113	127	179	305	855	1408	4333	3930	1.00	1402.16	1935.42	0.00	0.00	0.00
9	Redlands to SB	1995	12	0	2	5	54	113	127	179	305	855	1408	4333	3930	1.00	424.90	586.49	0.00	0 57	1.42

Notes:
1. Emission factors are for EMD engine model 12–710G3A with seven passenger compartments.
2. The start–up level of service will consist of four passenger cars per train.
3. The intermediate and mature levels of service will consist of trains with seven passenger cars per train.
4. Trains are assumed to operate five days per week, less six holidays per year.

TABLE B-23

COMMUTER RAIL DIESEL SCENARIO – OFF-PEAK SERVICE – SOx

	Route	Line Start Year	Miles	Number of Trains Start	Inter.	Mature	Diesel Prime Mover SOx Emissions per Throttle Notch (g/hr) Idle	1	2	3	4	5	6	7	8	Emission Conversion Factor (7 to 4 car)	Start to Destination Emissions (grams)	Destination to Start Emissions (grams)	Total Emissions (ton/yr) Start	Inter.	Mature
1	Ventura to LA	1992	47	0	4	10	34	165	253	466	674	897	1068	1546	1949	1.00	936.57	1065.46	0.00	2.24	5.61
2	Santa Clarita to LA	1992	35	0	0	6	34	165	253	466	674	897	1068	1546	1949	1.00	715.67	1113.35	0.00	0.00	3 07
3	SB to LA	1992	56.5	0	6	10	34	165	253	466	674	897	1068	1546	1949	1.00	1251.23	1501.79	0.00	4.63	7.71
4	Riverside to LA (Ontario)	1993	58.8	0	2	6	34	165	253	466	674	897	1068	1546	1949	1.00	1302.17	1562.92	0.00	1.60	4.81
5	Oceanside to LA	1993	87.2	0	4	10	34	165	253	466	674	897	1068	1546	1949	1.00	1828.03	2317.32	0.00	4.64	11.61
6	Riverside to LA (Fullerton)	1995	62.8	0	3	14	34	165	253	466	674	897	1068	1546	1949	1.00	1390.75	1669.25	0.00	2.57	12.00
7	SB/Riverside to Irvine	1995	59	0	3	14	34	165	253	466	674	897	1068	1546	1949	1.00	1306.60	1568.24	0.00	2.42	11.27
8	Hemet to Riverside	1995	39.6	0	0	0	34	165	253	466	674	897	1068	1546	1949	1.00	876.97	1052.58	0.00	0.00	0 00
9	Redlands to SB	1995	12	0	2	5	34	165	253	466	674	897	1068	1546	1949	1.00	265.75	318.96	0.00	0.33	0.82

Notes: 1. Emission factors are for EMD engine model 12–710G3A with seven passenger compartments.
2. The start–up level of service will consist of four passenger cars per train.
3. The intermediate and mature levels of service will consist of trains with seven passenger cars per train.
4. Trains are assumed to operate five days per week, less six holidays per year.

TABLE B-24

COMMUTER RAIL ELECTRIFICATION SCENARIO – OFF-PEAK SERVICE – START UP LEVEL – NOx

	Route	Line Start Year	Miles	# of Trains	Start/ Dest. Power (KW-HR)	Dest./ Start Power (KW-HR)	Train Pwr Req (MW-HR/ day)	Total Pwr Req (MW-HR/ day)	1992 NOx (t/yr) 100% Basin	1992 NOx (t/yr) 40% Basin	1993 NOx (t/yr) 100% Basin	1993 NOx (t/yr) 40% Basin	1994 NOx (t/yr) 100% Basin	1994 NOx (t/yr) 40% Basin	1995 NOx (t/yr) 100% Basin	1995 NOx (t/yr) 40% Basin	1996 NOx (t/yr) 100% Basin	1996 NOx (t/yr) 40% Basin	1997 NOx (t/yr) 100% Basin	1997 NOx (t/yr) 40% Basin	1998 NOx (t/yr) 100% Basin	1998 NOx (t/yr) 40% Basin	1999 NOx (t/yr) 100% Basin	1999 NOx (t/yr) 40% Basin	2000+ NOx (t/yr) 100% Basin	2000+ NOx (t/yr) 40% Basin
1	Ventura to LA	1992	47	0	1112.61	1268.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
2	Santa Clarita to LA	1992	35	0	847.79	1337.01	0.00	0.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
3	SB to LA	1992	56.5	0	1486.72	1802.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Riverside to LA (Ontario)	1993	58.8	0	1547.24	1875.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Oceanside to LA	1993	87.2	0	2170.32	2775.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
6	Riverside to LA (Fullerton)	1995	62.8	0	1652.50	2003.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	SB/Riverside to Irvine	1995	59	0	1552.51	1882.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
8	Hemet to Riverside	1995	39.6	0	1042.02	1263.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	1995	12	0	315.76	382.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: 1. First year of electric service is assumed to be 1996. Thus, system start up for all routes assumed to be diesel operation.
2. The start-up level of service will consist of four passenger cars per train.
3. Line losses of seven percent and catenary efficiency of 83 percent assumed
4. Trains are assumed to operate five days per week, less six holidays per year.
5. Horsepower by throttle notch is for EMD engine model 12-710G3A with seven passenger cars.
6. Two scenarios are assumed for this analysis—100 percent and 40 percent In-Basin power generation.

COMMUTER RAIL ELECTRIFICATION SCENARIO – OFF-PEAK SERVICE – INTERMEDIATE LEVEL – NOx

	Route	Line Start Year	Miles	# of Trains	Start/ Dest. Power (KW-HR)	Dest./ Start Power (KW-HR)	Train Pwr Req (MW-HR/ day)	Total Pwr Req (MW-HR/ day)	1992 NOx (t/yr) 100% Basin	1992 NOx (t/yr) 40% Basin	1993 NOx (t/yr) 100% Basin	1993 NOx (t/yr) 40% Basin	1994 NOx (t/yr) 100% Basin	1994 NOx (t/yr) 40% Basin	1995 NOx (t/yr) 100% Basin	1995 NOx (t/yr) 40% Basin	1996 NOx (t/yr) 100% Basin	1996 NOx (t/yr) 40% Basin	1997 NOx (t/yr) 100% Basin	1997 NOx (t/yr) 40% Basin	1998 NOx (t/yr) 100% Basin	1998 NOx (t/yr) 40% Basin	1999 NOx (t/yr) 100% Basin	1999 NOx (t/yr) 40% Basin	2000+ NOx (t/yr) 100% Basin	2000+ NOx (t/yr) 40% Basin
1	Ventura to LA	1992	47	4	1112.61	1268.67	9.53	12.34	1.43	0.57	1.29	0.51	1.13	0.45	0.99	0.39	0.83	0.33	0.69	0.28	0.53	0.21	0 39	0.16	0.24	0 09
2	Santa Clarita to LA	1992	35	0	847.79	1337.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
3	SB to LA	1992	56.5	6	1486.72	1802.42	19.73	25.57	2.95	1.18	2.66	1.07	2.34	0.94	2.05	0.82	1.72	0.69	1.43	0.57	1.10	0.44	0.81	0.32	0.49	0.19
4	Riverside to LA (Ontario)	1993	58.8	2	1547.24	1875.79	6.85	8.87	1.03	0.41	0.92	0.37	0.81	0.32	[illegible]	0.28	0 60	0.24	0.50	0.20	0.38	0.15	0 28	0.11	0.17	0.07
5	Oceanside to LA	1993	87.2	4	2170.32	2775 35	19.78	25.63	2.96	1.18	2.67	1.07	2.34	0.94	2.06	0.82	1.73	0.69	1.43	0.57	1.11	0.44	0.81	0.33	0.49	0.20
6	Riverside to LA (Fullerton)	1995	62.8	3	1652.50	2003.40	10.97	14.21	1.64	0.66	1.48	0 59	1.30	0.52	1.14	0.45	0.96	0.38	0.79	0.32	0.61	0.25	0.45	0.18	0.27	0.11
7	SB/Riverside to Irvine	1995	59	3	1552.51	1882.17	10.30	13.35	1.54	0.62	1.39	0.56	1.22	0.49	1.07	0.43	0.90	0.36	0.75	0.30	0.58	0.23	0.42	0.17	0.25	0.10
8	Hemet to Riverside	1995	39.6	0	1042.02	1263.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
9	Redlands to SB	1995	12	2	315.76	382.82	1.40	1.81	0.21	0.08	0.19	0.08	0.17	0.07	0.14	0.06	0.12	0.05	0.10	0.04	0.08	0.03	0.06	0.02	0.03	0 01

Notes: 1. The intermediate level of service will consist of seven passenger cars per train.
2. Line losses of seven percent and catenary efficiency of 83 percent assumed.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Horsepower by throttle notch is for EMD engine model 12-710G3A with seven passenger cars.
5. Two scenarios are assumed for this analysis—100 percent and 40 percent In-Basin power generation.

TABLE B-24 (Continued)

COMMUTER RAIL ELECTRIFICATION SCENARIO – OFF–PEAK SERVICE – MATURE LEVEL – NOx

	Route	Line Start Year	Miles	# of Trains	Start/ Dest. Power (KW–HR)	Dest./ Start Power (KW–HR)	Train Pwr Req (MW–HR/ day)	Total Pwr Req (MW–HR/ day)	1992 NOx (t/yr)		1993 NOx (t/yr)		1994 NOx (t/yr)		1995 NOx (t/yr)		1996 NOx (t/yr)		1997 NOx (t/yr)		1998 NOx (t/yr)		1999 NOx (t/yr)		2000+ NOx (t/yr)	
									100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin
1	Ventura to LA	1992	47	10	1112.61	1268.67	23.61	30.85	3.57	1.43	3.21	1.29	2.82	1.13	2.47	0.99	2.08	0.83	1.72	0.69	1.33	0.53	0.98	0.39	0.59	0 24
2	Santa Clarita to LA	1992	35	6	847.79	1337.01	13.11	16.98	1.98	0.79	1.77	0.71	1.55	0.62	1.38	0.54	1.14	0.46	0.95	0.38	0.73	0.29	0.54	0 22	0.32	0.13
3	SB to LA	1992	56.5	10	1486.72	1602.42	32.89	42.61	4.92	1.97	4.44	1.76	3.90	1.56	3 41	1.36	2.87	1.15	2.38	0.95	1.84	0.74	1.35	0.54	0.81	0.32
4	Riverside to LA (Ontario)	1993	56.8	6	1547.24	1675.79	20.54	26.61	3.08	1.23	2.77	1.11	2.43	0.97	2.13	0.85	1.79	0.72	1.49	0.59	1.15	0.46	0.84	0.34	0.51	0 20
5	Oceanside to LA	1993	87.2	10	2170.32	2775.35	49.46	64.07	7.40	2.96	6.67	2.67	5.88	2.34	5.13	2.05	4.31	1.73	3.58	1.43	2.77	1.11	2.03	0.81	1.22	0.49
6	Riverside to LA (Fullerton)	1995	62.8	14	1652.50	2003.40	51.18	66.31	7.66	3.07	6.91	2.76	6.08	2.43	5.31	2.12	4.46	1.79	3.71	1.48	2.86	1.15	2.11	0.84	1.26	0.51
7	SB/Riverside to Irvine	1995	59	14	1652.51	1882.17	48.09	62.30	7.20	2.88	6.49	2.59	5.70	2.28	4.98	1.99	4.19	1.68	3.48	1.39	2.69	1.08	1.98	0.79	1.19	0.47
8	Hemet to Riverside	1995	39.6	0	1042.02	1263.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	1995	12	5	315.76	382.82	3.49	4.53	0.52	0.21	0.47	0.19	0 41	0.17	0.38	0 14	0 30	0.12	0.25	0.10	0.20	0.08	0.14	0.06	0.09	0.03

Notes: 1. The mature level of service will consist of seven passenger cars per train.
2. Line losses of seven percent and catenary efficiency of 83 percent assumed.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Horsepower by throttle notch is for EMD engine model 12-710G3A with seven passenger cars.
5. Two scenarios are assumed for this analysis—100 percent and 40 percent in-Basin power generation.

TABLE B-25

COMMUTER RAIL ELECTRIFICATION SCENARIO – OFF-PEAK SERVICE – PM

	Route	Line Start Year	Miles	Number of Trains			Start/ Dest. Power (KW-HR)	Dest./ Start Power (KW-HR)	Train Pwr Req (MW-HR/day)			Total Pwr Req (MW-HR/day)			Pwr.Plnt CO Emiss. Factor	Start PM (t/yr) [8]		Inter. PM (t/yr)		Mature PM (t/yr)	
				Start	Inter.	Mature			Start	Inter.	Mature	Start	Inter	Mature		100% Basin	40% Basin	100% Basin	40% Basin	100% Basin	40% Basin
1	Ventura to LA	1992	47	0	4	10	1112.61	1268.67	0.00	9.53	23.81	0.00	12.34	30.85	0.024	0.00	0.00	0.04	0.02	0.09	0 04
2	Santa Clarita to LA	1992	35	0	0	6	847.79	1337.01	0.00	0.00	13.11	0.00	0.00	16.98	0.024	0.00	0.00	0.00	0.00	0.05	0.02
3	SB to LA	1992	56.5	0	6	10	1486.72	1802.42	0.00	19.73	32.89	0.00	25.57	42.61	0.024	0.00	0.00	0.08	0.03	0.13	0.05
4	Riverside to LA (Ontario)	1993	58.8	0	2	6	1547.24	1875.79	0.00	6.85	20.54	0.00	8.87	26.61	0.024	0.00	0.00	0.03	0.01	0.08	0.03
5	Oceanside to LA	1993	87.2	0	4	10	2170.32	2776.35	0.00	19.78	49.46	0.00	25.63	64.07	0.024	0.00	0.00	0.08	0.03	0.20	0.08
6	Riverside to LA (Fullerton)	1995	62.8	0	3	14	1652.50	2003.40	0.00	10.97	51.18	0.00	14.21	66.31	0.024	0.00	0.00	0.04	0 02	0.20	0.08
7	SB/Riverside to Irvine	1995	59	0	3	14	1552.51	1882.17	0.00	10.30	48.09	0.00	13.35	62.30	0.024	0.00	0.00	0.04	0.02	0.19	0.08
8	Hemet to Riverside	1995	39.6	0	0	0	1042.02	1263.29	0.00	0.00	0.00	0.00	0.00	0.00	0.024	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	1995	12	0	2	5	315.76	382.82	0.00	1.40	3.49	0.00	1.81	4.53	0.024	0.00	0 00	0.01	0.00	0.01	0 01

Notes: 1. First year of electric service is assumed to be 1996. Thus, system start up for all routes assumed to be diesel operation.
2. The start-up level of service will consist of four passenger cars per train.
3. The intermediate and mature levels of service will consist of seven passenger cars.
4. Line losses of seven percent and catenary efficiency of 83 percent assumed
5. Trains are assumed to operate five days per week, less six holidays per year.
6. Horsepower by throttle notch is for EMD engine model 12-710G3A with seven passenger cars.
7. Two scenarios are assumed for this analysis—100 percent and 40 percent In-Basin power generation.
8. Powerplant PM emission levels are from Joe Whittaker and Marty Kay of SCAQMD's Engineering Division and Office of Planning and Rules, respectively.

TABLE B-26

COMMUTER RAIL ELECTRIFICATION SCENARIO – OFF-PEAK SERVICE – HC

	Route	Line Start Year	Miles	Number of Trains Start	Number of Trains Inter.	Number of Trains Mature	Start/ Dest. Power (KW-HR)	Dest./ Start Power (KW-HR)	Train Pwr Req (MW-HR/day) Start	Train Pwr Req (MW-HR/day) Inter.	Train Pwr Req (MW-HR/day) Mature	Total Pwr Req (MW-HR/day) Start	Total Pwr Req (MW-HR/day) Inter	Total Pwr Req (MW-HR/day) Mature	Pwr.Plnt CO Emiss. Factor	Start HC (t/yr) 100% Basin	Start HC (t/yr) 40% Basin	Inter. HC (t/yr) 100% Basin	Inter. HC (t/yr) 40% Basin	Mature HC (t/yr) 100% Basin	Mature HC (t/yr) 40% Basin
1	Ventura to LA	1992	47	0	4	10	1112.61	1268.67	0.00	9.53	23.81	0.00	12.34	30.85	0.084	0.00	0.00	0.13	0.05	0.33	0.13
2	Santa Clarita to LA	1992	35	0	0	6	847.79	1337.01	0.00	0.00	13.11	0.00	0.00	16.98	0.084	0.00	0.00	0.00	0.00	0.18	0.07
3	SB to LA	1992	56.5	0	6	10	1486.72	1602.42	0.00	19.73	32.89	0.00	25.57	42.61	0.084	0.00	0.00	0.27	0.11	0.45	0.18
4	Riverside to LA (Ontario)	1993	58.8	0	2	6	1547.24	1875.79	0.00	6.85	20.54	0.00	8.87	26 61	0.084	0.00	0.00	0.09	0.04	0.28	0.11
5	Oceanside to LA	1993	87.2	0	4	10	2170.32	2775.35	0.00	19.78	49.46	0.00	25.63	64.07	0.084	0.00	0.00	0.27	0.11	0.68	0.27
6	Riverside to LA (Fullerton)	1995	62.8	0	3	14	1652.50	2003.40	0.00	10.97	51.16	0.00	14.21	66.31	0.084	0.00	0.00	0.15	0.06	0.71	0.28
7	SB/Riverside to Irvine	1995	59	0	3	14	1552.51	1882.17	0.00	10.30	48.09	0.00	13.35	62.30	0.084	0.00	0.00	0.14	0.06	0.66	0.27
8	Hemet to Riverside	1995	39.6	0	0	0	1042.02	1263.29	0.00	0.00	0.00	0.00	0.00	0.00	0.084	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	1995	12	0	2	5	315.76	382.82	0.00	1.40	3.49	0.00	1.81	4.53	0.084	0.00	0.00	0.02	0.01	0.05	0.02

Notes: 1. First year of electric service is assumed to be 1996. Thus, system start up for all routes assumed to be diesel operation.

2. The start-up level of service will consist of four passenger cars per train.

3. The intermediate and mature levels of service will consist of seven passenger cars.

4. Line losses of seven percent and catenary efficiency of 83 percent assumed

5. Trains are assumed to operate five days per week, less six holidays per year.

6. Horsepower by throttle notch is for EMD engine model 12-710G3A with seven passenger cars.

7. Two scenarios are assumed for this analysis—100 percent and 40 percent in-Basin power generation.

8. Powerplant HC emission levels are from Joe Whittaker and Marty Kay of SCAQMD's Engineering Division and Office of Planning and Rules, respectively.

TABLE B-27

COMMUTER RAIL ELECTRIFICATION SCENARIO - OFF-PEAK SERVICE - CO

	Route	Line Start Year	Miles	Number of Trains Start	Number of Trains Inter.	Number of Trains Mature	Start/ Dest. Power (KW-HR)	Dest./ Start Power (KW-HR)	Train Pwr Req (MW-HR/day) Start	Train Pwr Req (MW-HR/day) Inter.	Train Pwr Req (MW-HR/day) Mature	Total Pwr Req (MW-HR/day) Start	Total Pwr Req (MW-HR/day) Inter	Total Pwr Req (MW-HR/day) Mature	Pwr Plnt CO Emiss. Factor	Start CO (t/yr) 100% Basin	Start CO (t/yr) 40% Basin	Inter. CO (t/yr) 100% Basin	Inter. CO (t/yr) 40% Basin	Mature CO (t/yr) 100% Basin	Mature CO (t/yr) 40% Basin
1	Ventura to LA	1992	47	0	4	10	1112.61	1268.67	0.00	9.53	23.81	0.00	12.34	30.85	0.143	0.00	0.00	0.22	0.09	0.56	0 22
2	Santa Clarita to LA	1992	35	0	0	6	847.79	1337.01	0.00	0.00	13.11	0.00	0.00	16.98	0.143	0.00	0.00	0.00	0.00	0.31	0.12
3	SB to LA	1992	56.5	0	6	10	1466.72	1802.42	0.00	19.73	32.89	0.00	25.57	42.61	0.143	0.00	0.00	0.46	0.19	0.77	0.31
4	Riverside to LA (Ontario)	1993	58.8	0	2	6	1547.24	1875.79	0.00	6.85	20.54	0.00	8.87	26 61	0.143	0.00	0.00	0.16	0.06	0.48	0.19
5	Oceanside to LA	1993	87.2	0	4	10	2170.32	2775.35	0.00	19.78	49.46	0.00	25 63	64.07	0.143	0.00	0.00	0 47	0.19	1.16	0.47
6	Riverside to LA (Fullerton)	1995	62.8	0	3	14	1652.50	2003.40	0.00	10.97	51.18	0.00	14.21	66.31	0.143	0.00	0.00	0.26	0.10	1.20	0 48
7	SB/Riverside to Irvine	1995	59	0	3	14	1552.51	1882.17	0.00	10.30	48.09	0.00	13.35	62.30	0.143	0.00	0.00	0.24	0.10	1.13	0.45
8	Hemet to Riverside	1995	39.6	0	0	0	1042.02	1263.29	0.00	0.00	0.00	0.00	0.00	0.00	0.143	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	1995	12	0	2	5	315.76	382.62	0.00	1.40	3 49	0 00	1.81	4.53	0.143	0.00	0.00	0.03	0.01	0.08	0.03

Notes: 1. First year of electric service is assumed to be 1996. Thus, system start up for all routes assumed to be diesel operation.
2. The start-up level of service will consist of four passenger cars per train.
3. The intermediate and mature levels of service will consist of seven passenger cars.
4. Line losses of seven percent and catenary efficiency of 83 percent assumed
5. Trains are assumed to operate five days per week, less six holidays per year.
6. Horsepower by throttle notch is for EMD engine model 12-710G3A with seven passenger cars.
7. Two scenarios are assumed for this analysis—100 percent and 40 percent in-Basin power generation.
8. Powerplant CO emission levels are from Joe Whittaker and Marty Kay of SCAQMD's Engineering Division and Office of Planning and Rules, respectively.

TABLE B-28

COMMUTER RAIL ELECTRIFICATION SCENARIO – OFF-PEAK SERVICE – SOx

	Route	Line Start Year	Miles	Number of Trains Start	Number of Trains Inter.	Number of Trains Mature	Start/ Dest. Power (KW-HR)	Dest./ Start Power (KW-HR)	Train Pwr Req (MW-HR/day) Start	Train Pwr Req (MW-HR/day) Inter.	Train Pwr Req (MW-HR/day) Mature	Total Pwr Req (MW-HR/day) Start	Total Pwr Req (MW-HR/day) Inter	Total Pwr Req (MW-HR/day) Mature	Pwr.Plnt CO Emiss. Factor	Start SOx (t/yr) 100% Basin	Start SOx (t/yr) 40% Basin	Inter. SOx (t/yr) 100% Basin	Inter. SOx (t/yr) 40% Basin	Mature SOx (t/yr 100% Basin	Mature SOx (t/yr 40% Basin
1	Ventura to LA	1992	47	0	4	10	1112.61	1268.67	0.00	9.53	23.81	0.00	12.34	30.85	0.008	0.00	0.00	0.01	0.01	0.03	0.01
2	Santa Clarita to LA	1992	36	0	0	6	847.79	1337.01	0.00	0.00	13.11	0.00	0.00	16.98	0 008	0.00	0.00	0.00	0.00	0.02	0.01
3	SB to LA	1992	56.5	0	6	10	1486.72	1802.42	0.00	19.73	32.89	0.00	25.57	42.61	0.008	0.00	0.00	0.03	0.01	0.04	0.02
4	Riverside to LA (Ontario)	1993	58.6	0	2	6	1547.24	1875.79	0.00	6.85	20.54	0.00	8.87	26.61	0.008	0.00	0.00	0.01	0.00	0.03	0.01
5	Oceanside to LA	1993	87.2	0	4	10	2170.32	2775.35	0.00	19.78	49.46	0.00	25.63	64.07	0.008	0.00	0.00	0.03	0.01	0.07	0.03
6	Riverside to LA (Fullerton)	1995	62.8	0	3	14	1652.50	2003.40	0.00	10.97	51.18	0.00	14.21	66.31	0.008	0.00	0.00	0.01	0.01	0.07	0.03
7	SB/Riverside to Irvine	1995	59	0	3	14	1552.51	1882.17	0.00	10.30	48.09	0.00	13.35	62.30	0.008	0.00	0.00	0.01	0.01	0 06	0.03
8	Hemet to Riverside	1995	39.6	0	0	0	1042.02	1263.29	0.00	0.00	0.00	0.00	0.00	0.00	0.008	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	1995	12	0	2	5	315.76	382.82	0.00	1.40	3.49	0.00	1.81	4.53	0.008	0.00	0.00	0.00	0.00	0.00	0.00

Notes: 1. First year of electric service is assumed to be 1996. Thus, system start up for all routes assumed to be diesel operation.
2. The start-up level of service will consist of four passenger cars per train.
3. The intermediate and mature levels of service will consist of seven passenger cars.
4. Line losses of seven percent and catenary efficiency of 83 percent assumed
5. Trains are assumed to operate five days per week, less six holidays per year.
6. Horsepower by throttle notch is for EMD engine model 12-710G3A with seven passenger cars.
7. Two scenarios are assumed for this analysis—100 percent and 40 percent in-Basin power generation.
8. Powerplant SOx emission levels are from Joe Whittaker and Marty Kay of SCAQMD's Engineering Division and Office of Planning and Rules, respectively.

TABLE B-29

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – OFF-PEAK SERVICE – START UP LEVEL – NOx

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car NOx Emissions (lb/mile) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010	NOx Emissions Avoided (tons/yr) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	0	4	35	0	17.09	0.00	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Santa Clarita to LA	35	0	4	35	0	13.97	0.00	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	SB to LA	56.5	0	4	35	0	36.32	0.00	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Riverside to LA (Ontario)	58.8	0	4	35	0	26.40	0.00	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Oceanside to LA	87.2	0	4	35	0	33.94	0.00	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Riverside to LA (Fullerton)	62.8	0	4	35	0	28.19	0.00	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	SB/Riverside to Irvine	59	0	4	35	0	26.49	0.00	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Hemet to Riverside	39.6	0	4	35	0	17.78	0.00	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	12	0	4	35	0	5.39	0.00	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: 1. It is assumed that 35 passengers are in each car.

2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the length of routes 1, 2, 3, and 5, has been used.

3. Trains are assumed to operate five days per week, less six holidays per year.

4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.
Emission factors for 1994 and subsequent years have been adjusted to account for ARB vehicle regulations.

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – OFF-PEAK SERVICE – INTERMEDIATE LEVEL – NOx

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car NOx Emissions (lb/mile) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010	NOx Emissions Avoided (tons/yr) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	4	7	35	980	17.09	33496.40	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	10.47	9.61	8.65	8.16	7.54	6.99	6.47	5.95	5.43	2.57
2	Santa Clarita to LA	35	0	7	35	0	13.97	0.00	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	SB to LA	56.5	6	7	35	1470	36.32	106780.80	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	33.39	30.62	28.22	26.01	24.03	22.29	20.62	18.98	17.32	8.21
4	Riverside to LA (Ontario)	58.8	2	7	35	490	26.40	25868.25	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	8.09	7.42	6.84	6.30	5.82	5.40	5.00	4.60	4.20	1.99
5	Oceanside to LA	87.2	4	7	35	980	33.94	66522.40	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	20.80	19.08	17.58	16.20	14.97	13.88	12.85	11.62	10.79	5.11
6	Riverside to LA (Fullerton)	62.8	3	7	35	735	28.19	41441.99	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	12.96	11.88	10.95	10.09	9.33	8.65	8.00	7.37	6.72	3.19
7	SB/Riverside to Irvine	59	3	7	35	735	26.49	38934.35	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	12.17	11.16	10.29	9.48	8.76	8.13	7.52	6.92	6.32	2.99
8	Hemet to Riverside	39.6	0	7	35	0	17.78	0.00	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	12	2	7	35	490	5.39	5279.23	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006	1.65	1.51	1.40	1.29	1.19	1.10	1.02	0.94	0.86	0.41

Notes: 1. It is assumed that 35 passengers are in each car.

2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the length of routes 1, 2, 3, and 5, has been used.

3. Trains are assumed to operate five days per week, less six holidays per year.

4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.
Emission factors for 1994 and subsequent years have been adjusted to account for ARB vehicle regulations

TABLE B-29 (Continued)

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – OFF-PEAK SERVICE – MATURE LEVEL – NOx

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.
1	Ventura to LA	47	10	7	35	2450	17.09	83741.00
2	Santa Clarita to LA	35	6	7	35	1470	13.97	41071.80
3	SB to LA	56.5	10	7	35	2450	36.32	177968.00
4	Riverside to LA (Ontario)	58.8	6	7	35	1470	26.40	77604.75
5	Oceanside to LA	87.2	10	7	35	2450	33.94	166306.00
6	Riverside to LA (Fullerton)	62.8	14	7	35	3430	28.19	193395.95
7	SB/Riverside to Irvine	59	14	7	35	3430	26.49	181693.65
8	Hemet to Riverside	39.6	0	7	35	0	17.78	0.00
9	Redlands to SB	12	5	7	35	1225	5.39	13196.09

	Route	Predicted Basin Passenger Car NOx Emissions (lb/mile)									
		1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0 0015	0.0014	0.0013	0.0006
2	Santa Clarita to LA	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006
3	SB to LA	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006
4	Riverside to LA (Ontario)	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006
5	Oceanside to LA	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006
6	Riverside to LA (Fullerton)	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006
7	SB/Riverside to Irvine	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006
8	Hemet to Riverside	0.0025	0 0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006
9	Redlands to SB	0.0025	0.0023	0.0021	0.0019	0.0018	0.0016	0.0015	0.0014	0.0013	0.0006

	Route	NOx Emissions Avoided (tons/yr)									
		1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	26.18	24.01	22.13	20.39	18.84	17.48	16.17	14.89	13.59	6.44
2	Santa Clarita to LA	12.84	11.78	10.86	10.00	9.24	8.57	7.93	7.30	6.66	3.16
3	SB to LA	55.65	51.03	47.04	43.34	40.05	37.14	34.37	31.63	28.87	13.68
4	Riverside to LA (Ontario)	24.26	22.25	20.51	18.90	17.46	16.20	14.99	13.79	12.59	5.97
5	Oceanside to LA	52.00	47.69	43.96	40.50	37.42	34.71	32.12	29.56	26.98	12.78
6	Riverside to LA (Fullerton)	60.47	55.46	51.12	47.10	43.52	40.36	37.35	34.38	31.38	14.87
7	SB/Riverside to Irvine	56.81	52.10	48.02	44.25	40.89	37.92	35.09	32.30	29.48	13.97
8	Hemet to Riverside	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	4.13	3.78	3.49	3.21	2 97	2.75	2 55	2.35	2.14	1.01

Notes:
1. It is assumed that 35 passengers are in each car.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
   For the other routes, a mileage weighted composite based on the SCAG data and the length of routes 1, 2, 3, and 5, has been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.
   Emission factors for 1994 and subsequent years have been adjusted to account for ARB vehicle regulations.

TABLE B-30

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED - OFF-PEAK SERVICE - START UP LEVEL - PM

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car PM Emissions (lb/mile)										PM Emissions Avoided (tons/yr)									
									1992	1993	1994	1995	1996	1997	1998	1999	2000	2010	1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	0	4	35	0	17.09	0.00	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Santa Clarita to LA	35	0	4	35	0	13.97	0.00	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	SB to LA	56.5	0	4	35	0	36.32	0.00	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Riverside to LA (Ontario)	58.8	0	4	35	0	26.40	0.00	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Oceanside to LA	87.2	0	4	35	0	33.94	0.00	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Riverside to LA (Fullerton)	62.8	0	4	35	0	28.19	0.00	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	SB/Riverside to Irvine	59	0	4	35	0	26.49	0.00	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Hemet to Riverside	39.6	0	4	35	0	17.78	0.00	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	12	0	4	35	0	5.39	0.00	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: 1. It is assumed that 35 passengers are in each car.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the lengths of routes 1, 2, 3, and 5 has been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED - OFF-PEAK SERVICE - INTERMEDIATE LEVEL - PM

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car PM Emissions (lb/mile)										PM Emissions Avoided (tons/yr)									
									1992	1993	1994	1995	1996	1997	1998	1999	2000	2010	1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	4	7	35	980	17.09	51736.50	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	3.16	3.14	3.13	3.11	3.10	3.08	3.07	3.06	3.06	3.04
2	Santa Clarita to LA	35	0	7	35	0	13.97	0.00	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	SB to LA	56.5	6	7	35	1470	36.32	106780.80	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	6.53	6.49	6.45	6.42	6.39	6.36	6.34	6.32	6.31	6.27
4	Riverside to LA (Ontario)	58.8	2	7	35	490	26.40	25868.25	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	1.58	1.57	1.56	1.56	1.55	1.54	1.54	1.53	1.53	1.52
5	Oceanside to LA	87.2	4	7	35	980	33.94	66522.40	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	4.07	4.04	4.02	4.00	3.98	3.97	3.95	3.94	3.93	3.91
6	Riverside to LA (Fullerton)	62.8	3	7	35	735	28.19	41441.99	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	2.53	2.52	2.50	2.49	2.48	2.47	2.46	2.45	2.45	2.44
7	SB/Riverside to Irvine	59	3	7	35	735	26.49	38934.35	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	2.38	2.37	2.35	2.34	2.33	2.32	2.31	2.31	2.30	2.29
8	Hemet to Riverside	39.6	0	7	35	0	17.78	0.00	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	12	2	7	35	490	5.39	5279.23	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.32	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31	0.31

Notes: 1. It is assumed that 35 passengers are in each car.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the lengths of routes 1, 2, 3, and 5 has been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – OFF-PEAK SERVICE – MATURE LEVEL – PM

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car PM Emissions (lb/mile) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	10	7	35	2450	17.09	129341.24	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
2	Santa Clarita to LA	35	6	7	35	1470	13.97	41071.80	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
3	SB to LA	56.5	10	7	35	2450	36.32	177968.00	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
4	Riverside to LA (Ontario)	58.8	6	7	35	1470	26.40	77604.75	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
5	Oceanside to LA	87.2	10	7	35	2450	33.94	166306.00	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
6	Riverside to LA (Fullerton)	62.8	14	7	35	3430	28.19	193395.95	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
7	SB/Riverside to Irvine	59	14	7	35	3430	26.49	181693.65	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
8	Hemet to Riverside	39.6	0	7	35	0	17.78	0.00	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
9	Redlands to SB	12	5	7	35	1225	5.39	13196.09	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005

	Route	PM Emissions Avoided (tons/yr) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	7.91	7.86	7.82	7.78	7.74	7.71	7.68	7.66	7.64	7.60
2	Santa Clarita to LA	2.51	2.50	2.48	2.47	2.46	2.45	2.44	2.43	2.43	2.41
3	SB to LA	10.88	10.82	10.76	10.70	10.65	10.61	10.57	10.54	10.52	10.46
4	Riverside to LA (Ontario)	4.75	4.72	4.69	4.67	4.65	4.63	4.61	4.60	4.59	4.56
5	Oceanside to LA	10.17	10.11	10.05	10.00	9.96	9.91	9.88	9.85	9.83	9.77
6	Riverside to LA (Fullerton)	11.83	11.76	11.69	11.63	11.58	11.53	11.49	11.45	11.43	11.36
7	SB/Riverside to Irvine	11.11	11.04	10.98	10.93	10.88	10.83	10.79	10.76	10.74	10.68
8	Hemet to Riverside	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	0.81	0.80	0.80	0.79	0.79	0.79	0.78	0.78	0.78	0.78

Notes: 1. It is assumed that 35 passengers are in each car.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the lengths of routes 1, 2, 3, and 5 has been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.

TABLE B-31

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – OFF-PEAK SERVICE – START UP LEVEL – ROG

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car ROG Emissions (lb/mile)										ROG Emissions Avoided (tons/yr)									
									1992	1993	1994	1995	1996	1997	1998	1999	2000	2010	1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	0	4	35	0	17.09	0.00	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0.0004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Santa Clarita to LA	35	0	4	35	0	13.97	0.00	0 0027	0.0025	0.0023	0 0021	0.0019	0.0017	0.0016	0.0014	0.0013	0.0004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	SB to LA	56.5	0	4	35	0	36.32	0.00	0.0027	0.0025	0 0023	0.0021	0.0019	0.0017	0.0016	0.0014	0 0013	0 0004	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Riverside to LA (Ontario)	58.8	0	4	35	0	26.40	0.00	0.0027	0.0025	0.0023	0.0021	0 0019	0.0017	0.0016	0.0014	0.0013	0.0004	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0 00	0.00
5	Oceanside to LA	87.2	0	4	35	0	33.94	0.00	0.0027	0.0025	0.0023	0 0021	0.0019	0.0017	0.0016	0.0014	0.0013	0.0004	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0.00
6	Riverside to LA (Fullerton)	62.8	0	4	35	0	28.19	0.00	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0 0004	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0.00	0 00
7	SB/Riverside to Irvine	59	0	4	35	0	26.49	0.00	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0.0004	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Hemet to Riverside	39.6	0	4	35	0	17.78	0.00	0.0027	0.0025	0.0023	0 0021	0.0019	0.0017	0.0016	0.0014	0 0013	0.0004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	12	0	4	35	0	5.39	0.00	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0 0004	0.00	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0 00	0.00

Notes: 1. It is assumed that 35 passengers are in each car.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on SCAG data and the length of routes 1, 2, 3, and 5 has been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.
Emission factors for 1994 and subsequent years have been adjusted to account for ARB vehicle regulations.

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – OFF-PEAK SERVICE – INTERMEDIATE LEVEL – ROG

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car ROG Emissions (lb/mile)										ROG Emissions Avoided (tons/yr)									
									1992	1993	1994	1995	1996	1997	1998	1999	2000	2010	1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	4	7	35	980	17.09	33496.40	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0 0014	0 0013	0.0004	11.45	10 49	9.59	8.75	8.04	7.38	6.71	6.03	5.40	1.75
2	Santa Clarita to LA	35	0	7	35	0	13.97	0.00	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0.0004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	SB to LA	56.5	6	7	35	1470	36.32	106760.80	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0 0014	0.0013	0.0004	36.50	33 45	30.58	27.91	25.62	23.61	21 39	19.22	17.21	5 59
4	Riverside to LA (Ontario)	58.8	2	7	35	490	26.40	25868.25	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0.0004	8.84	8.10	7.41	6.76	6.21	5.70	5.18	4.66	4.17	1.35
5	Oceanside to LA	87.2	4	7	35	980	33.94	66522.40	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0 0014	0 0013	0.0004	22 74	20 84	19.05	17.38	16.96	14.65	13.33	11.98	10.72	3.48
6	Riverside to LA (Fullerton)	62.8	3	7	35	735	28.19	41441.99	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0 0013	0.0004	14.17	12.98	11.87	10.83	9.94	9 12	8 30	7.48	6.68	2.17
7	SB/Riverside to Irvine	59	3	7	35	735	26 49	38934.35	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0 0004	13.31	12.20	11.16	10.17	9.34	8.57	7 60	7 01	6 26	2.04
8	Hemet to Riverside	39.6	0	7	35	0	17.78	0 00	0.0027	0.0025	0.0023	0.0021	0.0019	0.0017	0.0016	0.0014	0.0013	0.0004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	12	2	7	35	490	5.39	5279.23	0 0027	0.0025	0.0023	0 0021	0.0019	0.0017	0.0016	0 0014	0.0013	0.0004	1.80	1.65	1.51	1.38	1.27	1.16	1.06	0.95	0 85	0 28

Notes: 1. It is assumed that 35 passengers are in each car.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on SCAG data and the length of routes 1, 2, 3, and 5 has been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.
Emission factors for 1994 and subsequent years have been adjusted to account for ARB vehicle regulations.

TABLE B-32

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED - OFF-PEAK SERVICE - START UP LEVEL - CO

	Route	Route engt	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car CO Emissions (lb/mile) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010	CO Emissions Avoided (tons/yr) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	0	4	35	0	17.09	0.00	0 0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	0.00	0.00	0 00	0 00	0.00	0.00	0.00	0 00	0.00	0.00
2	Santa Clarita to LA	35	0	4	35	0	13.97	0.00	0 0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0 0119	0.0060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	SB to LA	56.5	0	4	35	0	36.32	0.00	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Riverside to LA (Ontario)	58.8	0	4	35	0	26.40	0.00	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Oceanside to LA	87.2	0	4	35	0	33.94	0.00	0 0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Riverside to LA (Fullerton)	62.8	0	4	35	0	28.19	0.00	0.0219	0.0206	0.0192	0.0178	0 0164	0 0152	0.0140	0.0129	0.0119	0.0060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	SB/Riverside to Irvine	59	0	4	35	0	26.49	0.00	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00
8	Hemet to Riverside	39.6	0	4	35	0	17.78	0.00	0.0219	0.0206	0.0192	0.0178	0.0164	0 0152	0.0140	0.0129	0.0119	0.0060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00
9	Redlands to SB	12	0	4	35	0	5.39	0.00	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0 0129	0.0119	0.0060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00

Notes: 1. It is assumed that 35 passengers are in each car.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the length of routes 1, 2, 3, and 5 has been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.
Emission factors for 1994 and subsequent years have been adjusted to account for ARB vehicle regulations.

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED - OFF-PEAK SERVICE - INTERMEDIATE LEVEL - CO

	Route	Route engt	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car CO Emissions (lb/mile) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010	CO Emissions Avoided (tons/yr) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	4	7	35	980	17.09	33496.40	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0 0129	0.0119	0 0060	93.10	87.48	81.59	75 55	69.86	64.60	59.58	55.05	50.79	25.41
2	Santa Clarita to LA	35	0	7	35	0	13.97	0.00	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0 0060	0.00	0.00	0 00	0 00	0.00	0.00	0.00	0.00	0.00	0.00
3	SB to LA	56.5	6	7	35	1470	36.32	106780.80	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0 0060	296.78	278.88	260.08	240.83	222.69	205.93	189.94	175.48	161 90	81.02
4	Riverside to LA (Ontario)	58.8	2	7	35	490	26.40	25868.25	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	71.90	67.56	63.01	58.34	53.96	49.89	46.01	42.51	39.22	19.63
5	Oceanside to LA	87.2	4	7	35	980	33.94	66522.40	0 0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	184.89	173.74	162.03	150.03	138.73	128.29	118.33	109 32	100.86	50.47
6	Riverside to LA (Fullerton)	62.8	3	7	35	735	28.19	41441.99	0 0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	115.18	108.24	100.94	93.47	86.43	79.92	73.72	68.11	62.83	31.44
7	SB/Riverside to Irvine	59	3	7	35	735	26.49	38934.35	0.0219	0 0206	0.0192	0.0178	0.0164	0.0152	0.0140	0 0129	0.0119	0.0060	108 21	101.69	94.83	87.81	81 20	75.09	69.26	63.98	59.03	29.54
8	Hemet to Riverside	39.6	0	7	35	0	17.78	0.00	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	0.00	0.00	0 00	0.00	0.00	0 00	0.00	0.00	0.00	0.00
9	Redlands to SB	12	2	7	35	490	5.39	5279 23	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0 0060	14.67	13.79	12.86	11.91	11.01	10.18	9.39	8 68	8.00	4.01

Notes: 1. It is assumed that 35 passengers are in each car.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the length of routes 1, 2, 3, and 5 has been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.
Emission factors for 1994 and subsequent years have been adjusted to account for ARB vehicle regulations.

TABLE B-32 (Continued)

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – OFF-PEAK SERVICE – MATURE LEVEL – CO

	Route	Route engt	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car CO Emissions (lb/mile) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010	CO Emissions Avoided (tons/yr) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	10	7	35	2450	17.09	83741.00	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0 0129	0.0119	0.0060	232.75	216.71	203.97	188.87	174.64	161.50	148.96	137.62	126.97	63.54
2	Santa Clarita to LA	36	6	7	35	1470	13.97	41071.80	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	114.15	107.27	100.04	92.63	85.65	79 21	73.06	67.50	62.27	31.16
3	SB to LA	56.5	10	7	35	2450	36.32	177968.00	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	494.64	464.80	433.47	401.39	371.15	343.22	316.57	292.47	269.83	135.03
4	Riverside to LA (Ontario)	58.5	6	7	35	1470	26.40	77604.75	0.0219	0.0206	0.0192	0.0178	0.0164	0 0152	0.0140	0.0129	0.0119	0.0060	215 69	202.68	189.02	175.03	161.84	149.66	138.04	127.53	117.66	58.88
5	Oceanside to LA	87.2	10	7	35	2450	33.94	166306.00	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0 0140	0.0129	0.0119	0.0060	462.22	434.35	405.07	375.08	346.83	320.73	295.82	273.30	252.15	126.16
6	Riverside to LA (Fullerton)	62.8	14	7	35	3430	28.19	193395.95	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	537.52	505.10	471.05	436.18	403.32	372.97	344.01	317.82	293.22	146.73
7	SB/Riverside to Irvine	59	14	7	35	3430	26.49	181693.65	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	504.99	474.53	442.55	409.79	378.92	350 40	323.19	298.59	275.48	137.86
8	Hemet to Riverside	39.6	0	7	35	0	17.78	0.00	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	12	5	7	35	1225	5.39	13198.09	0.0219	0.0206	0.0192	0.0178	0.0164	0.0152	0.0140	0.0129	0.0119	0.0060	36.68	34.47	32.15	29.77	27.52	25.45	23.48	21.69	20.01	10.01

Notes: 1. It is assumed that 35 passengers are in each car.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the length of routes 1, 2, 3, and 5 has been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.
Emission factors for 1994 and subsequent years have been adjusted to account for ARB vehicle regulations.

TABLE B-33

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – OFF-PEAK SERVICE – START UP LEVEL – SOx

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car SOx Emissions (lb/mile) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010	SOx Emissions Avoided (tons/yr) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	0	4	35	0	17.09	0.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Santa Clarita to LA	35	0	4	35	0	13.97	0.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	SB to LA	56.5	0	4	35	0	36.32	0.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Riverside to LA (Ontario)	58.8	0	4	35	0	26.40	0.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Oceanside to LA	87.2	0	4	35	0	33.94	0.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Riverside to LA (Fullerton)	62.8	0	4	35	0	28.19	0.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	SB/Riverside to Irvine	59	0	4	35	0	26.49	0.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Hemet to Riverside	39.6	0	4	35	0	17.78	0.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	12	0	4	35	0	6.39	0.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: 1. It is assumed that 35 passengers are in each car.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the lengths of routes 1, 2, 3, and 5 have been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – OFF-PEAK SERVICE – INTERMEDIATE LEVEL – SOx

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car SOx Emissions (lb/mile) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010	SOx Emissions Avoided (tons/yr) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	4	7	35	980	17.09	33496.40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.55	0.53	0.51	0.49	0.48	0.47	0.45	0.44	0.43	0.40
2	Santa Clarita to LA	35	0	7	35	0	13.97	0.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	SB to LA	56.5	6	7	35	1470	36.32	106780.80	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	1.76	1.70	1.64	1.57	1.53	1.49	1.45	1.41	1.39	1.27
4	Riverside to LA (Ontario)	58.8	2	7	35	490	26.40	25868.25	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.43	0.41	0.40	0.38	0.37	0.36	0.35	0.34	0.34	0.31
5	Oceanside to LA	87.2	4	7	35	980	33.94	66522.40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	1.10	1.06	1.02	0.98	0.95	0.93	0.90	0.88	0.86	0.79
6	Riverside to LA (Fullerton)	62.8	3	7	35	735	28.19	41441.99	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.68	0.66	0.64	0.61	0.59	0.58	0.56	0.55	0.54	0.49
7	SB/Riverside to Irvine	59	3	7	35	735	26.49	38934.35	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.64	0.62	0.60	0.57	0.56	0.54	0.53	0.51	0.51	0.46
8	Hemet to Riverside	39.6	0	7	35	0	17.78	0.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	12	2	7	35	490	5.39	5279.23	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.09	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.06

Notes: 1. It is assumed that 35 passengers are in each car.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the lengths of routes 1, 2, 3, and 5 have been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.

TABLE B-33 (Continued)

COMMUTER RAIL VEHICLE EMISSIONS AVOIDED – OFF-PEAK SERVICE – MATURE LEVEL – SOx

	Route	Route Length	# of Trains	# of Cars	Pass. Per Car	Round Trip Pass.	1-Way VMT Avoid.	Daily VMT Avoid.	Predicted Basin Passenger Car SOx Emissions (lb/mile) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	47	10	7	·35	2450	17.09	83741.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
2	Santa Clarita to LA	35	6	7	35	1470	13.97	41071.80	0.0001	0.0001	0.0001	0 0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3	SB to LA	56.5	10	7	35	2450	36.32	177968.00	0.0001	0.0001	0.0001	0.0001	0.0001	0 0001	0.0001	0.0001	0.0001	0.0001
4	Riverside to LA (Ontario)	58.8	6	7	35	1470	26.40	77604.75	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
5	Oceanside to LA	87.2	10	7	35	2450	33.94	166306 00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
6	Riverside to LA (Fullerton)	62.8	14	7	35	3430	28.19	193395.95	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
7	SB/Riverside to Irvine	59	14	7	35	3430	26.49	181693.65	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
8	Hemet to Riverside	39.6	0	7	35	0	17.78	0.00	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
9	Redlands to SB	12	5	7	35	1225	5.39	13198.09	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0 0001

	Route	SOx Emissions Avoided (tons/yr) 1992	1993	1994	1995	1996	1997	1998	1999	2000	2010
1	Ventura to LA	1.38	1.33	1.28	1.23	1.20	1 17	1.14	1.11	1.09	1.00
2	Santa Clarita to LA	0.68	0.65	0.63	0.60	0.59	0.57	0.56	0.54	0.53	0.49
3	SB to LA	2.93	2.83	2.73	2.62	2.55	2.48	2.42	2.35	2.31	2.12
4	Riverside to LA (Ontario)	1.28	1.23	1.19	1.14	1.11	1.08	1.05	1.03	1.01	0.92
5	Oceanside to LA	2.74	2.64	2.55	2.45	2.38	2.32	2.26	2.20	2.16	1.98
6	Riverside to LA (Fullerton)	3.19	3.07	2.97	2.85	2.77	2.69	2.62	2.56	2.51	2.30
7	SB/Riverside to Irvine	3.00	2.88	2.79	2.68	2.60	2.53	2.47	2.40	2 36	2.16
8	Hemet to Riverside	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Redlands to SB	0 22	0.21	0.20	0.19	0.19	0.18	0.18	0.17	0.17	0.16

Notes: 1. It is assumed that 35 passengers are in each car.
2. One-way VMT avoided for routes 1, 2, 3, and 5 is based on data supplied by SCAG.
For the other routes, a mileage weighted composite based on the SCAG data and the lengths of routes 1, 2, 3, and 5 have been used.
3. Trains are assumed to operate five days per week, less six holidays per year.
4. Vehicle emissions avoided are based on passenger car emission factors as contained in the ARB's EMFAC7E/BURDEN7C emission inventory.

APPENDIX 11-3

APPENDIX 11-3

FREIGHT RAIL AND AMTRAK

TABLE C-1

Emission Factors & HP Data used for AEP (Based on 50% 16-710 and 50% 16-645E3 Engines)

Category	Source	Notch 8	Notch 7	Notch 6	Notch 5	Notch 4	Notch 3	Notch 2	Notch 1	Idle	Brake
HP	710	4035	3496	2637	1817	1351	975	430	198	5	23
	645E3	3159	2661	1971	1461	1034	686	395	105	17	69
	Combined	3597	3079	2304	1639	1193	831	413	152	11	46
NOx	710	41686	38661	27684	18466	14657	11079	6486	3732	1064	3810
	645E3	36933	31188	25568	20899	15416	10179	6040	2810	1635	4104
	Combined	39310	34925	26626	19683	15037	10629	6263	3271	1350	3957
PM	710	944	747	653	384	305	290	133	33	20	93
	645E3	837	648	545	336	258	227	133	24	34	80
	Combined	891	698	599	360	282	259	133	29	27	87
HC	710	1332	1049	738	509	405	302	172	113	63	369
	645E3	1169	878	611	424	321	247	201	156	185	293
	Combined	1251	964	675	467	363	275	187	135	124	331
CO	710	1574	1678	2531	1127	513	312	129	103	80	330
	645E3	5908	5029	1912	760	435	329	292	267	564	655
	Combined	3741	3354	2222	944	474	321	211	185	322	493
SO2	710	3228	2796	2162	1563	1175	857	408	216	56	330
	645E3	2528	2129	1597	1198	869	590	359	137	86	285
	Combined	2878	2463	1880	1381	1022	724	384	177	71	308

(EFHPAEP.WK1)

TABLE C-2: FREIGHT RAIL -- BASELINE BASIN CASE (Year 1991)

# of Trains	# of Loco	Proposed Route	Seg-ment	Dir	Current Rail Systems From	To	Miles	-- Diesel Emissions (Tons/Year) -- NOx	PM	HC	CO	SO2	Power (MWhr/Yr)	-Elect Emissions (Tons/Year)- NOx	PM	HC	CO	SO2
24	3.60	Coast Line	L	E	LA/Chatsworth	Beaumont	110	4.63	0.10	0.17	0.42	0.32	304.33	0.138	0.004	0.013	0.022	0.001
60	4.50		L	W	Beaumont	LA/Chatswort	110	20.46	0.43	0.72	1.76	1.42	1348.58	0.614	0.016	0.057	0.096	0.005
84							220	25.09	0.53	0.89	2.18	1.74	1652.9	0.752	0.020	0.069	0.118	0.007
832	4.05	Saugus Line	E	E	Acton	LA	51	116.67	2.55	6.11	14.02	8.25	6076.72	2.765	0.073	0.255	0.434	0.024
456	3.60		E	E	Acton	LA	51	59.24	1.30	3.05	7.06	4.19	3152.77	1.435	0.038	0.132	0.225	0.013
12	5.39		E	E	Acton	LA	51	2.34	0.05	0.12	0.28	0.17	124.45	0.057	0.001	0.005	0.009	0.000
408	3.60		E	W	LA	Acton	51	87.93	1.86	2.96	8.07	6.10	6093.28	2.772	0.073	0.256	0.436	0.024
960	3.82		E	W	LA	Acton	51	219.83	4.64	7.41	20.18	15.25	15233.20	6.931	0.183	0.640	1.089	0.061
2668							255	486.01	10.39	19.65	49.60	33.96	30680.4	13.960	0.368	1.289	2.194	0.123
1,648	3.78	Alhambra/Yuma	D	E	Long Beach	West Colton	68	330.55	7.14	12.39	31.94	23.11	22337.18	10.163	0.268	0.938	1.597	0.089
180	5.39	/Barstow Line	D	E	Long Beach	West Colton	68	51.58	1.11	1.93	4.98	3.61	3485.34	1.586	0.042	0.146	0.249	0.014
24	2.25		D	W	West Colton	Long Beach	68	2.31	0.05	0.10	0.24	0.16	131.64	0.060	0.002	0.006	0.009	0.001
1,236	4.50		D	W	West Colton	Long Beach	68	237.54	5.01	10.54	24.40	16.46	13558.64	6.169	0.163	0.569	0.969	0.054
96	2.70		D	W	West Colton	Long Beach	68	11.07	0.23	0.49	1.14	0.77	631.86	0.287	0.008	0.027	0.045	0.003
892	3.96		A	E	Beaumont	West Colton	25	108.60	2.37	4.53	12.36	7.51	7129.46	3.244	0.086	0.299	0.510	0.029
484	3.37		A	W	West Colton	Beaumont	25	23.16	0.47	1.30	3.06	1.47	982.08	0.447	0.012	0.041	0.070	0.004
288	4.50		B	E	West Colton	LA	52	71.26	1.56	2.66	7.29	5.03	5031.95	2.290	0.060	0.211	0.360	0.020
216	4.05		C	E	Summit	West Colton	24	9.58	0.20	0.78	1.63	0.62	140.31	0.064	0.002	0.006	0.010	0.001
2,356	3.60		C	E	Summit	West Colton	24	92.85	1.93	7.58	15.80	6.02	1360.41	0.619	0.016	0.057	0.097	0.005
1,720	3.93		C	W	West Colton	Summit	24	384.09	8.48	14.03	40.65	27.20	27941.27	12.713	0.335	1.174	1.998	0.112
636	1.35		G	W	LA	Long Beach	18	16.06	0.34	0.77	2.00	1.07	895.75	0.408	0.011	0.038	0.064	0.004
324	3.60		G	W	LA	Long Beach	18	21.82	0.46	1.05	2.72	1.45	1216.87	0.554	0.015	0.051	0.087	0.005
1,644	3.87		H	E	Long Beach	Beaumont	94	452.43	9.79	16.28	41.98	31.84	31328.96	14.255	0.376	1.316	2.240	0.125
1,860	4.12		H	W	Beaumont	Long Beach	94	437.00	9.23	18.74	42.93	30.53	25618.78	11.657	0.307	1.076	1.832	0.102
384	4.50		H	W	Beaumont	Long Beach	94	98.42	2.08	4.22	9.67	6.88	5769.86	2.625	0.069	0.242	0.413	0.023
480	3.15		I	E	Cajon	Beaumont	44	78.32	1.73	3.27	8.39	5.55	5078.61	2.311	0.061	0.213	0.363	0.020
336	1.80		I	E	Cajon	Beaumont	44	31.33	0.69	1.31	3.35	2.22	2031.44	0.924	0.024	0.085	0.145	0.008
324	4.50		I	W	Beaumont	Cajon	44	98.45	2.16	3.58	9.93	6.97	7044.12	3.205	0.085	0.296	0.504	0.028
264	3.60		I	W	Beaumont	Cajon	44	64.17	1.41	2.33	6.48	4.54	4591.72	2.089	0.055	0.193	0.328	0.018
1,824	3.90		J	E	Beaumont	LA	78	577.45	12.73	20.49	56.69	41.09	42076.45	19.145	0.505	1.767	3.008	0.168
196	3.60		J	E	Beaumont	LA	78	57.28	1.26	2.03	5.62	4.08	4173.57	1.899	0.050	0.175	0.298	0.017
96	1.80		J	W	LA	Beaumont	78	5.71	0.12	0.25	0.55	0.38	308.53	0.140	0.004	0.013	0.022	0.001
852	3.90		J	W	LA	Beaumont	78	109.77	2.28	4.89	10.65	7.38	5932.80	2.699	0.071	0.249	0.424	0.024
18360							1320	3370.79	72.83	135.58	344.46	235.92	218797.6	99.553	2.626	9.190	15.644	0.875
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21112		Year 1991 Total for SP:					1795	3881.9	83.7	156.1	396.2	271.6	251130.9	114.3	3.0	10.5	18.0	1.0
		Year 1991 40% of TOTAL:											100452.4	45.7	1.2	4.2	7.2	0.4
		Year 2000/2010 Total for SP:						2717.3	83.7	156.1	396.2	271.6	251130.9	18.8	3.0	10.5	18.0	1.0
		Year 2000/2010 40% of TOTAL:											100452.4	7.5	1.2	4.2	7.2	0.4

TABLE C-2 (Continued): FREIGHT RAIL -- BASELINE BASIN CASE (Year 1991)

# of Trains	# of Loco	Proposed Route	Seg-ment	Dir	Current Rail Systems From	To	Miles	-- Diesel Emissions (Tons/Year) -- NOx	PM	HC	CO	SO2	Power (MWhr/Yr)	-Elect Emissions (Tons/Year)- NOx	PM	HC	CO	SO2
1,564	3.60	San Bernardino	SFH	E	Hobart	S Bernardino	63	253.92	5.38	9.00	23.69	17.54	17348.66	7.894	0.208	0.729	1.240	0.069
2,202	4.44	Subdivision	SFI	E	Hobart	S Bernardino	63	413.57	8.77	14.91	39.16	28.55	28047.56	12.762	0.337	1.178	2.005	0.112
182	4.84		SFJ	E	Hobart	S Bernardino	63	29.20	0.61	1.10	2.70	1.98	1867.74	0.850	0.022	0.078	0.134	0.007
1,351	4.32		SFA	W	S Bernardino	Hobart	63	173.29	3.58	7.51	17.13	11.71	9784.65	4.452	0.117	0.411	0.700	0.039
756	3.96		SFB	W	S Bernardino	Hobart	63	77.89	1.61	3.52	8.03	5.24	4249.60	1.934	0.051	0.178	0.304	0.017
12	6.27		SFC	W	S Bernardino	Hobart	63	2.60	0.05	0.11	0.26	0.18	153.43	0.070	0.002	0.006	0.011	0.001
38	3.99		SFD	W	S Bernardino	Hobart	63	3.23	0.07	0.15	0.34	0.21	165.25	0.075	0.002	0.007	0.012	0.001
1,274	4.09		SFE	W	S Bernardino	Hobart	63	157.50	3.35	7.08	16.77	10.87	9084.80	4.134	0.109	0.382	0.650	0.036
1,361	3.91		SFF	W	S Bernardino	Hobart	63	147.03	3.13	6.74	16.09	10.12	8385.91	3.816	0.101	0.352	0.600	0.034
80	4.00		SFG	W	S Bernardino	Hobart	63	7.95	0.17	0.37	0.86	0.54	437.12	0.199	0.005	0.018	0.031	0.002
1,981	4.15		SFN	E	S Bernardino	Cajon	20	394.38	8.68	14.45	41.83	27.90	28595.80	13.011	0.343	1.201	2.045	0.114
3,845	4.20		SFO	E	S Bernardino	Cajon	20	668.39	14.62	24.97	72.07	46.99	47618.07	21.666	0.571	2.000	3.405	0.190
2	3.06		SFP	E	S Bernardino	Cajon	20	0.36	0.01	0.01	0.04	0.03	26.90	0.012	0.000	0.001	0.002	0.000
3,163	4.39		SFK	W	Cajon	S Bernardino	20	126.59	2.64	10.59	22.02	8.18	1588.45	0.723	0.019	0.067	0.114	0.006
2,165	3.89		SFL	W	Cajon	S Bernardino	20	74.08	1.54	6.18	12.98	4.74	950.98	0.433	0.011	0.040	0.068	0.004
13	6.39		SFM	W	Cajon	S Bernardino	20	0.71	0.01	0.06	0.12	0.05	9.64	0.004	0.000	0.000	0.001	0.000
19989							750	2530.70	54.22	106.75	274.09	174.84	158314.6	72.033	1.900	6.649	11.319	0.633
388	4.46	Watson Sub.	SFS	E	Watson	Hobart	19	33.22	0.68	1.61	3.05	2.10	1485.12	0.676	0.018	0.062	0.106	0.006
349	4.47		SFQ	W	Hobart	Watson	19	38.90	0.78	1.82	3.51	2.57	1872.28	0.852	0.022	0.079	0.134	0.007
4	4.04		SFR	W	Hobart	Watson	19	0.48	0.01	0.02	0.05	0.03	26.50	0.012	0.000	0.001	0.002	0.000
741							57	72.59	1.47	3.46	6.60	4.71	3383.9	1.540	0.041	0.142	0.242	0.014
431	4.08	San Diego Sub.	SFU	E	San Clemente	Hobart	42	30.28	0.62	1.37	3.31	1.96	1632.15	0.743	0.020	0.069	0.117	0.007
198	4.15		SFT	W	Hobart	San Clemente	42	14.15	0.29	0.64	1.54	0.91	762.59	0.347	0.009	0.032	0.055	0.003
629							84	44.42	0.91	2.02	4.85	2.87	2394.7	1.090	0.029	0.101	0.171	0.010
21359		Year 1991 Total for SF:					891	2647.7	56.6	112.2	285.5	182.4	164093.2	74.7	2.0	6.9	11.7	0.7
		Year 1991 40% of TOTAL:											65637.3	29.9	0.8	2.8	4.7	0.3
		Year 2000/2010 Total for SF:						1853.4	56.6	112.2	285.5	182.4	164093.2	12.3	2.0	6.9	11.7	0.7
		Year 2000/2010 40% of TOTAL:											65637.3	4.9	0.8	2.8	4.7	0.3

TABLE C-2 (Continued): FREIGHT RAIL -- BASELINE BASIN CASE (Year 1991)

# of Trains	# of Loco	Proposed Route	Seg-ment	Dir	Current Rail Systems From	To	Miles	-- Diesel Emissions (Tons/Year) -- NOx	PM	HC	CO	SO2	Power (MWhr/Yr)	-Elect Emissions (Tons/Year)- NOx	PM	HC	CO	SO2
82	2.31	Union Pacific	UAA	E	LA	Summit	80.3	7.22	0.16	0.35	0.83	0.52	412.90	0.188	0.005	0.017	0.030	0.002
533	3.12	Line	UAA	E	LA	Summit	80.3	120.52	2.68	4.29	12.09	8.61	8853.63	4.028	0.106	0.372	0.633	0.035
299	5.81		UAA	E	LA	Summit	80.3	158.85	3.55	5.51	15.70	11.40	11916.91	5.422	0.143	0.501	0.852	0.048
1,045	3.32		UAA	E	LA	Summit	80.3	255.27	5.60	8.94	25.40	18.16	18634.68	8.479	0.224	0.783	1.332	0.075
51	3.05		UBB	E	Long Beach	Summit	101	7.21	0.16	0.34	0.81	0.52	420.30	0.191	0.005	0.018	0.030	0.002
86	2.58		UBB	E	Long Beach	Summit	101	20.21	0.44	0.69	1.97	1.44	1491.70	0.679	0.018	0.063	0.107	0.006
53	1.64		UDD	W	Summit	LA	80.3	11.76	0.26	0.40	1.14	0.85	901.51	0.410	0.011	0.038	0.064	0.004
106	2.58		UDD	W	Summit	LA	80.3	9.89	0.22	0.50	1.14	0.70	540.31	0.246	0.006	0.023	0.039	0.002
105	1.81		UCC	W	Summit	LA	80.3	20.69	0.46	0.71	2.04	1.49	1575.15	0.717	0.019	0.066	0.113	0.006
557	3.45		UCC	W	Summit	LA	80.3	49.00	1.06	2.55	5.77	3.40	2471.45	1.125	0.030	0.104	0.177	0.010
272	5.20		UCC	W	Summit	LA	80.3	41.41	0.90	2.11	4.83	2.91	2197.77	1.000	0.026	0.092	0.157	0.009
867	3.56		UCC	W	Summit	LA	80.3	92.39	2.02	4.74	10.99	6.52	4926.06	2.241	0.059	0.207	0.352	0.020
4056							1005	794.43	17.52	31.12	82.72	56.53	54342.4	24.726	0.652	2.282	3.885	0.217
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4056		Year 1991 Total for UP:					1005.0	794.4	17.5	31.1	82.7	56.5	54342.4	24.7	0.7	2.3	3.9	0.2
		Year 1991 40% of TOTAL:											21736.9	9.9	0.3	0.9	1.6	0.1
		Year 2000/2010 Total for UP:					1005.0	556.1	17.5	31.1	82.7	56.5	54342.4	4.1	0.7	2.3	3.9	0.2
		Year 2000/2010 40% of TOTAL:											21736.9	1.6	0.3	0.9	1.6	0.1
46527		Year 1991 TOTAL:					3691	7324	158	299	765	511	469567	214	6	20	34	2
		Year 1991 40% of TOTAL:											187827	85	2	8	13	1
		Year 2000/2010 TOTAL:					3691	5127	158	299	765	511	469567	35	6	20	34	2
(base1.wk1)		Year 2000/2010 40% of TOTAL:											187827	14	2	8	13	1

TABLE C-3: SEGMENT CORRELATIONS

LEAC	ELECTRIFICATION TASK FORCE STUDY
Passenger Service	
AA	1,2,3,4,5,70,40,41,42,43,44(0.333)
AB	Reverse of AA
AC	1,17,18,19,20,26,27,71,52,53,54,55,56,57(0.7241)
AD	Reverse of AC
AI	1,2,10,12,14,15
AP	Reverse of AI
AQ	28,29,30,31,32,33,34,35,71,52,53,54,55,56,57
AR	Reverse of AQ
AS	1,17,18,19,20,21,22,23(0.333),72
AT	Reverse of AS
AY	1,2,10,12,14,15
AX	Reverse of AY
UP Freight	
UAA	31,32,33,34,35,71,52,53,54,55,56,57
UBB	28,29,30,31,32,33,34,35,71,52,53,54,55,56,57
UCC	Reverse of UAA
UDD	31,32,33,34,35,71,52,53,54,55,56,57
SP Freight	
A	43,44(0.333)
B	42,41,40,70,5,39,38
C	62,63,64
D	28,29,37, + 38,39,6,70,40,41,42
E	10,12,13
F	10,12,14,15
G	37,29,28
H	28,29,37,38,39,5,70,40,41,42,43,44(0.333)
I	64,63,62,43,44(0.333)
J	38,39,5,70,40,41,42,43,44(0.333)
K	38,39,5,70,40,41,42,62,63,64
L	44(0.333),43,42,41,40,70,5,39,38,10,12,14,15

TABLE C-3 (Continued): SEGMENT CORRELATIONS

SF Freight

SFA	55,54,53,52,71,27,26,20,19
SFB	55,54,53,52,71,27,26,20,19
SFC	55,54,53,52,71,27,26,20,19
SFE	55,54,53,52,71,27,26,20,19
SFF	55,54,53,52,71,27,26,20,19
SFG	55,54,53,52,71,27,26,20,19
SFH	19,20,26,27,71,52,53,54,55
SFI	19,20,26,27,71,52,53,54,55
SFJ	19,20,26,27,71,52,53,54,55
SFT	19,20,21,22,23(0.333)
SFU	19,20,21,22,23(0.333)
SFK	57,56
SFL	57,56
SFM	57,56
SFN	57,56
SFO	57,56
SFP	57,56
SFQ	18,36,28
SFR	18,36,28
SFS	18,36,28

TABLE C-4: AMTRAK Emissions by LEAC Segment

											DIESEL POLLUTANTS					ENERGY		ELECTRICITY POLLUTANTS				
		Notch, Time (in minutes per engine)									tpy=[S(Tn*g/h)]*(1h/60min)*(#Engines)/(g/ton)							tpy=[(MWh)*(lb/MWh)/(2000lb/ton)]				
Seg	# Engines	8	7	6	5	4	3	2	1	Brake	NOx	CO	CH2	SO2	PM	bhp-hr/yr	MWh/yr	NOx	CO	CH2	SO2	PM
AR	312	29	15	14	11	11	12	20	18	0	11.97	1.25	0.14	0.72	0.36	1,046,401	1,011	0.076	0.072	0.042	0.004	0.012
AP	416	10	4	5	5	6	3	3	4	5	5.47	0.55	0.07	0.33	0.16	472,316	456	0.034	0.033	0.019	0.002	0.005
AX	364	10	4	5	5	6	3	3	4	5	4.78	0.48	0.06	0.29	0.14	413,277	399	0.030	0.029	0.017	0.002	0.005
AY	364	8	4	6	10	8	5	5	4	0	5.29	0.47	0.06	0.31	0.15	452,541	437	0.033	0.031	0.018	0.002	0.005
AI	416	8	4	6	10	8	5	5	4	0	6.05	0.54	0.07	0.36	0.18	517,190	500	0.037	0.036	0.021	0.002	0.006
AT	2856	32	0	4	0	3	0	0	0	2	57.07	6.96	0.67	3.62	1.78	5,342,986	5,162	0.387	0.369	0.217	0.021	0.062
AA	312	18	4	1	1	7	12	14	15	33	6.32	0.60	0.11	0.37	0.18	498,648	482	0.036	0.034	0.020	0.002	0.006
AS	2856	30	2	1	2	3	6	0	0	0	57.96	6.90	0.66	3.63	1.78	5,373,616	5,191	0.389	0.371	0.218	0.021	0.062
AB	312	49	13	1	1	7	7	11	11	0	11.95	1.47	0.14	0.75	0.36	1,099,283	1,062	0.080	0.076	0.045	0.004	0.013
AC	520	12	3	2	2	8	7	12	12	59	9.03	0.81	0.20	0.52	0.26	641,550	620	0.046	0.044	0.026	0.002	0.007
AD	520	65	14	11	13	15	12	9	13	6	29.84	3.37	0.35	1.84	0.90	2,692,467	2,601	0.195	0.186	0.109	0.010	0.031
AQ	312	10	3	3	3	6	13	23	20	48	5.79	0.45	0.12	0.32	0.16	407,804	394	0.030	0.028	0.017	0.002	0.005
											211.52	23.87	2.64	13.05	6.415	18,958,078	18,315	1.374	1.309	0.769	0.073	0.220
																% Reductions:		99.4%	94.5%	70.9%	99.4%	96.6%
																Emission Reductions (tpy):		210	23	2	13	6
																						0.059

Throttle notch times per engine and number of engines for each segment are provided by the "CARB Locomotive Emission Study--Appendices", p B-15--for passenger trains in the South Coast Basin.

DIESEL EMISSIONS are calculated using grams-per-hour data from Engine Model 12-710G3A; and the diesel energy (bhp-hr/yr) for each segment is calculated using data from the same Engine Model. This input data, given on the next page, was obtained from LACTC on 12/18/91. The Engine Model used is the one recommended by Bob McCulloch of Booz, Allen, and Hamilton on 1/23/92.

The EXCEPTIONS are DIESEL PM EMISSIONS, which are calculated using Engine Model 16-710G3 from the "CARB Locomotive Emission Study--Appendices", p B-6 (for lack of data on other Engine Model). This input data also is given on the next page.

Equivalent electrical energy (MWh/yr) generation is calculated using a power distribution efficiency of 93% and a catenary efficiency of 83%, for a combined efficiency of 77.2%

ELECTRICITY-GENERATION EMISSIONS are calculated from equivalent electrical energy using the following rates:

Pollutant	lb/MWh
NOx	0.150
CO	0.143
CH2	0.084
SO2	0.008
PM	0.024

TABLE C-4 (Continued)

Engine Model 12–710G3A for Locomotive Models GP59, F59PH; 31–Oct–90.

Fuel sulfur content = 0.20%

		grams per brake horsepower–hour				------grams per hour------			
T/N	BHP	NOx	CO	CH2	SO2	NOx	CO	CH2	SO2
8	3195.5	9.51	1.23	0.11	0.61	30389	3930	352	1949
7	2533.7	9.36	1.71	0.09	0.61	23715	4333	228	1546
6	1695.9	10.71	0.83	0.11	0.63	18163	1408	187	1068
5	1401.5	10.93	0.61	0.12	0.64	15318	855	168	897
4	1052.8	12.01	0.29	0.13	0.64	12644	305	137	674
3	716.9	13.88	0.25	0.17	0.65	9951	179	122	466
2	372.2	15.04	0.34	0.22	0.68	5598	127	82	253
1	209.4	15.94	0.54	0.4	0.79	3338	113	84	165
Brk	24.8	112.96	9.21	7.69	6.21	2801	228	191	154

Engine Model 16–710G3 for Locomotive Models GP60, SD60.

Fuel sulfur content = 0.27%

T/N	BHP	g/hr PM
8	4035	944
7	3496	747
6	2637	653
5	1817	384
4	1351	305
3	975	290
2	430	133
1	198	33
Brk	23	93

TABLE C-5: DIESEL FREIGHT EMISSIONS BY ETF SEGMENT

ETF Segment	2010 ETF # Trains	LEAC # Trains	ETF Mileages	LEAC NOx	LEAC PM	LEAC HC	LEAC CO	LEAC SOx	ETF NOx w/o 30%	ETF NOx w/30%	ETF PM	ETF HC	ETF CO	ETF SOx
1	0	0	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0	0	0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0	0	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0	0	11.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	55	20	2.7	53.51	1.16	2.04	5.20	3.76	148.62	104.03	3.21	5.67	14.43	10.45
6	0	9	17.2	109.98	2.35	4.42	10.89	7.66	0.00	0.00	0.00	0.00	0.00	0.00
7	0	0	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0	0	19.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0	0	23.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	16	8	1.2	17.46	0.37	0.70	1.78	1.22	37.05	25.93	0.79	1.49	3.77	2.59
11	0	0	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	16	8	9.1	132.40	2.83	5.34	13.48	9.25	280.96	196.67	6.01	11.34	28.60	19.63
13	7	7	23.7	338.78	7.24	13.70	34.57	23.67	324.43	227.10	6.94	13.12	33.11	22.67
14	10	0	7.3	1.86	0.04	0.07	0.16	0.13	80.80	56.56	1.71	2.87	7.02	5.60
15	0	0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	8	0	56.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0	0	2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	16	2	1.3	3.59	0.07	0.17	0.33	0.23	28.28	19.80	0.57	1.34	2.58	1.83
19	38	26	7.6	150.88	3.18	6.06	14.98	10.33	222.37	155.66	4 69	8.92	22.07	15.23
20	38	26	12.9	256.10	5.40	10.28	25.42	17.53	377.45	264.21	7.96	15.15	37.46	25.84
21	0	2	7.9	7.92	0.16	0.36	0.86	0.51	0.00	0.00	0.00	0.00	0.00	0.00
22	4	2	6.2	6.22	0.13	0.28	0.68	0.40	14.43	10.10	0.30	0.65	1.58	0.93
23	4	2	9.7	9.76	0.20	0.44	1.07	0.63	22.66	15.86	0.46	1.02	2.47	1.46
24	4	0	41.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	4	0	5.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	38	24	5.4	101.79	2.15	4.06	10.05	6.99	160.76	112.53	3.39	6.41	15.87	11.04
27	40	24	30.0	565.50	11.93	22.54	55.83	38.83	940.14	658.10	19.84	37.47	92.82	64.56
28	73	24	24.4	481.38	10.21	19.98	47.25	33.21	1439.55	1007.69	30.52	59.74	141.30	99.32
29	36	22	1.5	25.46	0.54	1.03	2.53	1.77	40.94	28 66	0.87	1.66	4 07	2.85
30	0	0	1.0	0.24	0.01	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
31	37	11	8.4	71.44	1.58	2.75	7.38	5.09	237.86	166.50	5.25	9.16	24.58	16.93
32	37	11	6.4	54.43	1.20	2.10	5.63	3.87	181.23	126.86	4 00	6 98	18.73	12.90
33	37	11	11.7	99.50	2.19	3.83	10.28	7.08	331.30	231.91	7.31	12.76	34.24	23.59
34	37	11	7.2	61.23	1.35	2.36	6.33	4.36	203.88	142.72	4.50	7.86	21.07	14.51
35	37	11	19.8	168.39	3.71	6.49	17.40	11.99	560.67	392.47	12.37	21.60	57.96	39.92
36	16	2	0.6	1.66	0.03	0.08	0.15	0.11	13.05	9.14	0.26	0.62	1.19	0.85
37	36	22	2.8	46.84	1.00	1.90	4.65	3.26	76.62	53.64	1.64	3.11	7.61	5.34
38	55	29	5.8	152.03	3.28	5.88	14.83	10.67	293.13	205.19	6.32	11.34	28.60	20.57
39	55	29	6.9	180.87	3.90	6.99	17.85	12.69	348.73	244.11	7.52	13.49	34.03	24.47
40	63	29	13.3	348.63	7.52	13.48	34.02	24.46	769.95	538.97	16.60	29.78	75.13	54.03
41	63	29	3.5	91.74	1.98	3.55	8.95	6.44	202.62	141.83	4.37	7.84	19.77	14.22
42	63	29	19.9	521.63	11.25	20.17	50.90	36.61	1152.03	806.42	24.84	44.56	112.41	80.84
43	53	27	1.0	28.77	0.62	1.13	2.92	2.01	57.26	40.08	1.24	2.25	5.82	4.01
44	53	27	24.1	692.28	15.00	27.27	70.33	48.47	1377.60	964.46	29.84	54.26	139.98	96.46
45	53	0	124.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	0	0	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	0	0	3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	4	0	5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	0	0	1.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	0	0	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	0	0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	77	35	3.1	84.80	1.81	3.34	8.49	5.89	185.64	129.95	3.97	7.32	18.60	12 89
53	77	35	3.5	95.74	2.05	3.78	9.59	6.65	209.60	146.72	4.49	8.27	20.99	14.56
54	79	35	2.7	73.86	1.58	2.91	7.40	5.13	165.89	116.12	3.55	6.54	16.62	11.52
55	79	35	1.0	27.35	0.59	1.08	2.74	1.90	61.44	43.01	1.31	2.42	6.15	4.27
56	83	42	11.9	772.97	16.64	33.79	89.65	53.90	1538.08	1076.65	33.51	67.23	178.38	107.24
57	73	42	10.5	682.00	14.66	29.81	79.10	47.56	1193.56	835.49	26.01	52.17	138.43	83.22
58	73	0	19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	73	0	36.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	39	0	7.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
61	39	0	5.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62	0	16	5.8	124.20	2.71	5.50	14.37	8.68	0.00	0.00	0.00	0.00	0.00	0.00
63	0	16	7.8	167.03	3.65	7.40	19.32	11.67	0.00	0.00	0.00	0.00	0.00	0.00
64	0	16	16.0	342.62	7.49	15.17	39.63	23.93	0.00	0.00	0.00	0.00	0.00	0.00
65	0	0	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66	0	0	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67	0	0	2.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
68	0	0	12.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69	0	0	36.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	55	29	3.7	96.99	2.09	3.75	9.46	6.81	187.00	130.90	4.03	7.23	18.25	13.12
71	77	35	0.8	21.88	0.47	0.86	2.19	1.52	47.91	33.54	1.03	1.89	4.80	3.33
72	4	0	18.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total (tons/year)				7271.72	156.72	296.84	756.46	506.90	13513.68	9459.57	291.20	545.52	1390.47	942.81

TABLE C-5 (Continued): DIESEL FREIGHT EMISSIONS BY LEAC SEGMENT

LEAC Segments	Number of Trains (Yearly) Mixed	Inter.	Bulk	Total	Daily # Trains	NOx Emissions	PM Emissions	HC Emissions	CO Emissions	SOx Emissions	LEAC Mileage
AA	0	0	0	0	0.00	0	0	0	0	0	0
AB	0	0	0	0	0.00	0	0	0	0	0	0
AC	0	0	0	0	0.00	0	0	0	0	0	0
AD	0	0	0	0	0.00	0	0	0	0	0	0
AI	0	0	0	0	0.00	0	0	0	0	0	0
AP	0	0	0	0	0.00	0	0	0	0	0	0
AQ	0	0	0	0	0.00	0	0	0	0	0	0
AR	0	0	0	0	0.00	0	0	0	0	0	0
AS	0	0	0	0	0.00	0	0	0	0	0	0
AT	0	0	0	0	0.00	0	0	0	0	0	0
AY	0	0	0	0	0.00	0	0	0	0	0	0
AX	0	0	0	0	0.00	0	0	0	0	0	0
UAA	1045	832	82	1959	5.37	541.86	11.99	19.09	54.02	38.69	87
UBB	86	0	51	137	0.38	27.42	0.6	1.03	2.78	1.96	113.9
UCC	867	829	105	1801	4.93	203.49	4.44	10.11	23.63	14.32	113.9
UDD	106	0	53	159	0.44	21.65	0.48	0.9	2.28	1.55	87
A	1376	0	0	1376	3.77	131.76	2.84	5.83	15.42	8.96	25.1
B	288	0	0	288	0.79	71.26	1.56	2.66	7.29	5.03	55.8
C	4076	0	216	4292	11.76	486.52	10.61	22.39	58.08	33.84	29.6
D	2884	24	276	3184	8.72	633.05	13.54	25.45	62.7	44.11	99
E	12	1416	1240	2668	7.31	486.01	10.39	19.65	49.6	33.96	34
F	0	0	0	0	0.00	0	0	0	0	0	17.6
G	324	636	0	960	2.63	37.88	0.8	1.82	4.72	2.52	28.7
H	384	3504	0	3888	10.65	987.85	21.1	39.24	94.58	69.26	109.6
I	660	744	0	1404	3.85	272.27	5.99	10.49	28.15	19.28	54.7
J	292	2676	0	2968	8.13	750.21	16.39	27.66	73.51	52.93	80.9
K	0	0	0	0	0.00	0	0	0	0	0	85.4
L	24	60	0	84	0.23	25.09	0.53	0.89	2.18	1.74	98.5
SFA	1351	0	0	1351	3.70	173.29	3.58	7.51	17.13	11.71	67
SFB	0	756	0	756	2.07	77.89	1.61	3.52	8.03	5.24	67
SFC	0	0	12	12	0.03	2.6	0.05	0.11	0.26	0.18	67
SFE	1274	0	0	1274	3.49	157.5	3.35	7.08	16.77	10.87	67
SFF	0	1361	0	1361	3.73	147.03	3.13	6.74	16.09	10.12	67
SFG	0	80	0	80	0.22	7.95	0.17	0.37	0.86	0.54	67
SFH	1564	0	0	1564	4.28	253.92	5.38	9	23.69	17.54	67
SFI	0	2202	0	2202	6.03	413.67	8.77	14.91	39.16	28.55	67
SFJ	0	182	0	182	0.50	29.2	0.61	1.1	2.7	1.98	67
SFT	198	0	0	198	0.54	14.15	0.29	0.64	1.54	0.91	44.3
SFU	431	0	0	431	1.18	30.28	0.62	1.37	3.31	1.96	44.3
SFK	3163	0	0	3163	8.67	126.59	2.64	10.59	22.02	8.18	22.4
SFL	0	2165	0	2165	5.93	74.06	1.54	6.18	12.98	4.74	22.4
SFM	0	0	13	13	0.04	0.71	0.01	0.06	0.12	0.05	22.4
SFN	1981	0	0	1981	5.43	394.38	8.68	14.46	41.83	27.9	22.4
SFO	0	3845	0	3845	10.53	668.39	14.62	24.97	72.07	46.99	22.4
SFP	0	0	2	2	0.01	0.36	0.01	0.01	0.04	0.03	22.4
SFQ	349	0	0	349	0.96	38.9	0.78	1.82	3.51	2.57	26.3
SFR	0	0	4	4	0.01	0.48	0.01	0.02	0.05	0.03	26.3
SFS	388	0	0	388	1.06	33.22	0.68	1.61	3.05	2.1	26.3
Total (tons/year)						7320.81	157.79	299.27	764.15	510.36	

TABLE C–6: DIESEL AMTRAK EMISSIONS BY ETF SEGMENT

ETF Segment	2010 ETF # Trains	LEAC # Trains	ETF Mileages	LEAC NOx	LEAC PM	LEAC HC	LEAC CO	LEAC SOx	ETF NOx w/o 30%	ETF NOx w/30%	ETF PM	ETF HC	ETF CO	ETF SOx
1	48	21	0.8	2.12	0.05	0.03	0.23	0.13	4.82	3.38	0.11	0.06	0.53	0.30
2	14	4	0.3	0.42	0.01	0.01	0.04	0.03	1.47	1.03	0.04	0.02	0.14	0.09
3	0	1	0.2	0.05	0.00	0.00	0.01	0 00	0.00	0.00	0.00	0.00	0.00	0.00
4	0	1	11.4	2.58	0.08	0.04	0.29	0.16	0.00	0.00	0.00	0.00	0.00	0.00
5	4	1	2.7	0.61	0.02	0.01	0.07	0.04	2.86	2.00	0.09	0.04	0.32	0.18
6	0	0	17.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0	0	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0	0	19.6	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00
9	0	0	23.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	12	3	1.2	1.40	0.04	0.02	0.13	0.08	5.36	3.75	0.16	0.06	0.51	0.32
11	0	0	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	12	3	9.1	10.62	0.31	0.13	1.00	0.63	40.66	28.46	1.20	0.49	3 84	2.43
13	0	0	23.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	12	3	7.3	8.52	0.25	0.10	0.80	0.51	32.62	22.83	0.96	0.39	3.08	1.95
15	0	0	29.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
16	12	0	56.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	34	17	2.6	5.55	0.11	0.07	0.65	0.35	11.05	7.73	0.22	0.13	1.30	0.69
18	34	17	1.3	2.77	0.05	0.03	0.33	0.17	5.52	3.87	0 11	0.07	0.65	0.35
19	34	17	7.6	16.21	0.32	0.20	1.91	1.01	32.29	22.60	0.63	0.39	3.81	2.02
20	34	17	12.9	27.52	0.54	0.33	3.25	1.72	54.80	38.36	1.07	0.66	6.47	3.43
21	30	16	7.9	13.58	0.23	0.16	1.64	0.86	26 04	18.23	0.44	0.30	3.14	1.64
22	30	16	6.2	10.66	0.18	0.12	1.28	0.67	20.44	14.31	0.35	0.24	2.46	1.29
23	30	16	9.7	16.73	0.28	0.19	2.02	1.05	32.08	22.46	0.56	0.37	3.87	2.02
24	30	0	41.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0	0	5.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	2	1	5.4	2.24	0.07	0.03	0.24	0.14	3.14	2.20	0.09	0.04	0.34	0.19
27	2	1	30.0	12.42	0.37	0.18	1.34	0.75	17.43	12.20	0.52	0.25	1.87	1.06
28	0	1	24.4	3.80	0.11	0.06	0.36	0.22	0.00	0.00	0.00	0.00	0.00	0.00
29	0	1	1.5	0.23	0.01	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
30	0	1	1.0	0.16	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
31	0	1	8.4	1.31	0.04	0.02	0.13	0.08	0.00	0.00	0.00	0.00	0.00	0.00
32	0	1	6.4	1.00	0.03	0.01	0.10	0.06	0.00	0.00	0.00	0.00	0.00	0.00
33	0	1	11.7	1.82	0.05	0.03	0.17	0.11	0.00	0.00	0.00	0.00	0.00	0.00
34	0	1	7.2	1.12	0.03	0.02	0.11	0.07	0.00	0.00	0.00	0.00	0.00	0.00
35	0	1	19.8	3.09	0.09	0.05	0.30	0.18	0.00	0.00	0.00	0.00	0.00	0.00
36	0	0	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0	0	2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	4	0	5.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
39	4	0	6.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	4	1	13.3	3.01	0.09	0.04	0.34	0.18	14.09	9.86	0.42	0.19	1.60	0.86
41	4	1	3.5	0.79	0.02	0.01	0.09	0.05	3.71	2.60	0.11	0.05	0.42	0.23
42	4	1	19.9	4.51	0.13	0.06	0.51	0.28	21.08	14.76	0.63	0.29	2.39	1.29
43	4	1	1.0	0.23	0.01	0.00	0.03	0.01	1.06	0.74	0.03	0.01	0.12	0.06
44	2	1	24.1	5.45	0.16	0.07	0.62	0.33	12.75	8.92	0.38	0.17	1.44	0.78
45	2	0	124.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	0	0	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	0	0	3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	0	0	5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	0	0	1.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	0	0	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	0	0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	2	2	3.1	1.77	0.05	0.03	0.18	0.11	1.55	1.09	0.05	0.02	0.16	0.09
53	2	2	3.5	1.99	0.06	0.03	0.21	0.12	1.75	1.23	0.05	0.02	0.18	0.11
54	4	2	2.7	1.54	0.05	0.02	0.16	0.09	2.70	1.89	0.08	0.04	0.28	0.16
55	4	2	1.0	0.57	0.02	0.01	0.06	0.03	1.00	0.70	0.03	0.01	0.10	0.06
56	4	2	11.9	6.78	0.20	0.10	0.71	0.41	11.90	8.33	0.35	0.17	1.24	0.72
57	4	2	10.5	5.98	0.18	0.09	0.62	0.36	10.50	7.35	0.31	0.15	1.10	0.63
58	4	0	19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	4	0	36.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	4	0	7.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
61	2	0	5.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62	0	0	5.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
63	0	0	7.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
64	0	0	16.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65	0	0	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66	0	0	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67	0	0	2.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
68	0	0	12.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69	0	0	36.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	2	0	3.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
71	2	2	0.8	0.46	0.01	0.01	0.05	0.03	0.40	0.28	0.01	0.01	0.04	0.02
72	2	16	18.1	31.12	0.53	0.36	3.75	1.98	3.98	2.78	0.07	0.05	0.48	0.25
Total (tons/year)				210.73	4.79	2.64	23.76	13.01	377.04	263.93	9.05	4.71	41.89	23.22

TABLE C–6 (Continued): DIESEL AMTRAK EMISSIONS BY LEAC SEGMENT

LEAC Segments	Yearly # Trains	Daily # Trains	NOx Emissions	PM Emissions	HC Emissions	CO Emissions	SOx Emissions	LEAC Mileage
AA	156	0.43	6.32	0.18	0.11	0.60	0.37	80.7
AB	156	0.43	11.96	0.36	0.14	1.47	0.75	80.7
AC	260	0.71	9.03	0.26	0.20	0.81	0.52	93.9
AD	260	0.71	29.84	0.90	0.35	3.37	1.84	93.9
AI	208	0.57	6.05	0.18	0.07	0.54	0.36	18.5
AP	208	0.57	5.47	0.16	0.07	0.55	0.33	18.5
AQ	156	0.43	5.79	0.16	0.12	0.45	0.32	113.9
AR	156	0.43	11.97	0.36	0.14	1.25	0.72	113.9
AS	2856	7.82	57.96	1.78	0.66	6.90	3.63	66.9
AT	2856	7.82	57.07	0.18	0.67	6.96	3.62	66.9
AY	364	1.00	5.29	0.15	0.06	0.47	0.31	18.5
AX	364	1.00	4.78	0.14	0.06	0.48	0.29	18.5
UAA	0	0.00	0.00	0.00	0.00	0.00	0.00	0
UBB	0	0.00	0.00	0.00	0.00	0.00	0.00	0
UCC	0	0.00	0.00	0.00	0.00	0.00	0.00	0
UDD	0	0.00	0.00	0.00	0.00	0.00	0.00	0
A	0	0.00	0.00	0.00	0.00	0.00	0.00	0
B	0	0.00	0.00	0.00	0.00	0.00	0.00	0
C	0	0.00	0.00	0.00	0.00	0.00	0.00	0
D	0	0.00	0.00	0.00	0.00	0.00	0.00	0
E	0	0.00	0.00	0.00	0.00	0.00	0.00	0
F	0	0.00	0.00	0.00	0.00	0.00	0.00	0
G	0	0.00	0.00	0.00	0.00	0.00	0.00	0
H	0	0.00	0.00	0.00	0.00	0.00	0.00	0
I	0	0.00	0.00	0.00	0.00	0.00	0.00	0
J	0	0.00	0.00	0.00	0.00	0.00	0.00	0
K	0	0.00	0.00	0.00	0.00	0.00	0.00	0
L	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFA	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFB	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFC	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFE	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFF	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFG	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFH	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFI	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFJ	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFT	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFU	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFK	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFL	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFM	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFN	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFO	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFP	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFQ	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFR	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFS	0	0.00	0.00	0.00	0.00	0.00	0.00	0
Total (tons/year)			211.52	4.82	2.65	23.85	13.06	

TABLE C-7: ELECTRIFIED FREIGHT EMISSIONS BY ETF SEGMENT

ETF Segment	2010 ETF # Trains	LEAC # Trains	ETF Mileages	LEAC NOx	LEAC PM	LEAC HC	LEAC CO	LEAC SOx	ETF NOx w/o 30%	ETF NOx w/30%	ETF PM	ETF HC	ETF CO	ETF SOx
1	0	0	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0	0	0.3	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0	0	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0	0	11.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
5	55	20	2.7	1.63	0.04	0.15	0.26	0.01	4.53	3.17	0.12	0.42	0.71	0.04
6	0	9	17.2	3.17	0.08	0.29	0.50	0.03	0.00	0.00	0.00	0.00	0.00	0.00
7	0	0	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0	0	19.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0	0	23.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	16	8	1.2	0.50	0.01	0.05	0.08	0.00	1.06	0.75	0.03	0.10	0.17	0.01
11	0	0	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	16	8	9.1	3.81	0.10	0.35	0.60	0.03	8.08	5.65	0.21	0.75	1.27	0.07
13	7	7	23.7	9.73	0.26	0.90	1.53	0.08	9.32	6.52	0.25	0.86	1.46	0.08
14	10	0	7.3	0.06	0.00	0.01	0.01	0.00	2.42	1.69	0.06	0.23	0.39	0.03
15	0	[illegible]	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	8	0	56.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0	0	2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
18	16	2	1.3	0.08	0.00	0.01	0.01	0.00	0.60	0.42	0.02	0.05	0.09	0.01
19	38	26	7.6	4.28	0.11	0.40	0.67	0.04	6.31	4.42	0.17	0.58	0.99	0 06
20	38	26	12.9	7.27	0.19	0.67	1.14	0.06	10.71	7.50	0.29	0.99	1.69	0.10
21	0	2	7.9	0.19	0.01	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	4	2	6.2	0.15	0.00	0.01	0.03	0.00	0.35	0.25	0.01	0.03	0.06	0.00
23	4	2	9.7	0.24	0.01	0.02	0.04	0.00	0.56	0.39	0.02	0.05	0.09	0.01
24	4	0	41.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	4	0	5.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
26	38	24	5.4	2.91	0.08	0.27	0.46	0.03	4.60	3.22	0.12	0.43	0.72	0.04
27	40	24	30.0	16.16	0.43	1.50	2.54	0.14	26.87	18.81	0.71	2.49	4.22	0.24
28	73	24	24.4	13.29	0.35	1.23	2.09	0.12	39.74	27.82	1.05	3.67	6.24	0.37
29	36	22	1.5	0.73	0.02	0.07	0.11	0.01	1.17	0 82	0.03	0.11	0.18	0.01
30	0	0	1.0	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	37	11	8.4	2.25	0.06	0.21	0.35	0.02	7.50	5.25	0.20	0.69	1.18	0.07
32	37	11	6.4	1.72	0.05	0.16	0.27	0.02	5.71	4.00	0.15	0.53	0.90	0.05
33	37	11	11.7	3.14	0.08	0.29	0.49	0.03	10.44	7.31	0.28	0.96	1.64	0.10
34	37	11	7.2	1.93	0.05	0.18	0.30	0.02	6.43	4.50	0.17	0.59	1.01	0.06
35	37	11	19.8	5.31	0.14	0.49	0.83	0.05	17.68	12.37	0.47	1.63	2.78	0.16
36	16	2	0.6	0.04	0.00	0.00	0.01	0.00	0.28	0.19	0.01	0.03	0 04	0.00
37	36	22	2.8	1.34	0.04	0.12	0.21	0.01	2.19	1.53	0.06	0.20	0.34	0.02
38	65	29	5.8	4.57	0.12	0.42	0.72	0.04	8.82	6.17	0.23	0.81	1.39	0.08
39	65	29	6.9	5.44	0.14	0.50	0.86	0.05	10.49	7.35	0.28	0.97	1.65	0.09
40	63	29	13.3	10.49	0.28	0.97	1.65	0.09	23.17	16.22	0.61	2.14	3.64	0.20
41	63	29	3.5	2.76	0.07	0.25	0.43	0.02	6.10	4.27	0.16	0.56	0.96	0.05
42	63	29	19.9	15.70	0.41	1.45	2.47	0.14	34.67	24.27	0.91	3.20	5.45	0.31
43	53	27	1.0	0.91	0.02	0.08	0.14	0.01	1.82	1.27	0.05	0.16	0.27	0.01
44	53	27	24.1	22.00	0.55	1.92	3.28	0.18	43.78	30.64	1.10	3.83	6.52	0.36
45	53	0	124.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	0	0	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	0	0	3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	4	0	5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	0	0	1.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.00
50	0	0	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	0	0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	77	35	3.1	2.50	0.07	0.23	0.39	0.02	5.48	3.83	0.15	0.51	0.86	0.05
53	77	35	3.5	2.82	0.07	0.26	0.44	0.03	6.18	4.33	0.16	0.57	0.97	0.06
54	79	35	2.7	2.18	0.06	0.20	0.34	0.02	4.89	3.43	0.13	0.45	0.77	0.04
55	79	35	1.0	0.81	0.02	0.07	0.13	0.01	1.81	1.27	0.05	0.17	0.28	0.02
56	83	42	11.9	22.23	0.58	2.05	3.50	0.19	44.23	30.96	1.16	4.08	6.96	0.39
57	73	42	10.5	19.61	0.51	1.81	3.09	0.17	34.33	24.03	0.90	3.17	5.40	0.30
58	73	0	19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	73	0	36.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	39	0	7.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
61	39	0	5.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62	0	16	5.8	3.81	0.09	0.33	0.56	0.03	0.00	0.00	0.00	0.00	0.00	0.00
63	0	16	7.8	5.12	0.13	0.44	0.75	0.04	0.00	0.00	0.00	0.00	0.00	0.00
64	0	16	16.0	10.50	0.26	0.90	1.53	0.09	0.00	0.00	0.00	0.00	0.00	0.00
65	0	0	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66	0	0	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67	0	0	2.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
68	0	0	12.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69	0	0	36.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	65	29	3.7	2.92	0.08	0.27	0.46	0.03	5.63	3.94	0.15	0.52	0.88	0.05
71	77	35	0.8	0.65	0.02	0.06	0.10	0.01	1.41	0.99	0.04	0.13	0.22	0.01
72	4	0	18.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total (tons/year)				214.96	5.61	19.61	33.39	1.86	399.35	279.55	10.49	36.64	62.41	3.54

TABLE C-7 (Continued): ELECTRIFIED FREIGHT EMISSIONS BY LEAC SEGMENT

LEAC Segments	Number of Trains (Yearly) Mixed	Inter.	Bulk	Total	Daily # Trains	NOx Emissions	PM Emissions	HC Emissions	CO Emissions	SOx Emissions	LEAC Mileage
AA	0	0	0	0	0.00	0	0	0	0	0	0
AB	0	0	0	0	0.00	0	0	0	0	0	0
AC	0	0	0	0	0.00	0	0	0	0	0	0
AD	0	0	0	0	0.00	0	0	0	0	0	0
AI	0	0	0	0	0.00	0	0	0	0	0	0
AP	0	0	0	0	0.00	0	0	0	0	0	0
AQ	0	0	0	0	0.00	0	0	0	0	0	0
AR	0	0	0	0	0.00	0	0	0	0	0	0
AS	0	0	0	0	0.00	0	0	0	0	0	0
AT	0	0	0	0	0.00	0	0	0	0	0	0
AY	0	0	0	0	0.00	0	0	0	0	0	0
AX	0	0	0	0	0.00	0	0	0	0	0	0
UAA	1045	832	82	1959	5.37	18.12	0.48	1.67	2.85	0.16	87
UBB	86	0	51	137	0.38	0.87	0.02	0.08	0.14	0.01	113.9
UCC	867	829	105	1801	4.93	5.08	0.13	0.47	0.8	0.05	113.9
UDD	106	0	53	159	0.44	0.66	0.02	0.06	0.1	0.01	87
A	1376	0	0	1376	3.77	3.69	0.1	0.34	0.58	0.03	25.1
B	288	0	0	288	0.79	2.29	0.06	0.21	0.36	0.02	55.8
C	4076	0	216	4292	11.76	13.4	0.35	1.24	2.11	0.12	29.6
D	2884	24	276	3184	8.72	18.27	0.48	1.69	2.87	0.16	99
E	12	1416	1240	2668	7.31	13.96	0.37	1.29	2.19	0.12	34
F	0	0	0	0	0.00	0	0	0	0	0	17.6
G	324	636	0	960	2.63	0.96	0.03	0.09	0.15	0.01	28.7
H	384	3504	0	3888	10.65	28.54	0.75	2.63	4.49	0.25	109.6
I	660	744	0	1404	3.85	11.15	0.23	0.79	1.34	0.07	54.7
J	292	2676	0	2968	8.13	23.88	0.63	2.2	3.75	0.21	80.9
K	0	0	0	0	0.00	0	0	0	0	0	85.4
L	24	60	0	84	0.23	0.75	0.02	0.07	0.12	0.01	98.5
SFA	1351	0	0	1351	3.70	4.45	0.12	0.41	0.7	0.04	67
SFB	0	756	0	756	2.07	1.93	0.05	0.18	0.3	0.02	67
SFC	0	0	12	12	0.03	0.07	0	0.01	0.01	0	67
SFE	1274	0	0	1274	3.49	4.13	0.11	0.38	0.65	0.04	67
SFF	0	1361	0	1361	3.73	3.82	0.1	0.35	0.6	0.03	67
SFG	0	80	0	80	0.22	0.2	0.01	0.02	0.03	0	67
SFH	1564	0	0	1564	4.28	7.89	0.21	0.73	1.24	0.07	67
SFI	0	2202	0	2202	6.03	12.76	0.34	1.18	2.01	0.11	67
SFJ	0	182	0	182	0.50	0.85	0.02	0.08	0.13	0.01	67
SFT	198	0	0	198	0.54	0.35	0.01	0.03	0.06	0	44.3
SFU	431	0	0	431	1.18	0.74	0.02	0.07	0.12	0.01	44.3
SFK	3163	0	0	3163	8.67	0.72	0.02	0.07	0.11	0.01	22.4
SFL	0	2165	0	2165	5.93	0.43	0.01	0.04	0.07	0	22.4
SFM	0	0	13	13	0.04	0	0	0	0	0	22.4
SFN	1981	0	0	1981	5.43	13.01	0.34	1.2	2.05	0.11	22.4
SFO	0	3845	0	3845	10.53	21.67	0.57	2	3.41	0.19	22.4
SFP	0	0	2	2	0.01	0.01	0	0	0	0	22.4
SFQ	349	0	0	349	0.96	0.85	0.02	0.08	0.13	0.01	26.3
SFR	0	0	4	4	0.01	0.01	0	0	0	0	26.3
SFS	388	0	0	388	1.06	0.68	0.02	0.06	0.11	0.01	26.3
Total (tons/year)						216.19	5.64	19.72	33.58	1.89	

TABLE C-8: ELECTRIFIED AMTRAK EMISSIONS BY ETF SEGMENT

ETF Segment	2010 ETF # Trains	LEAC # Trains	ETF Mileages	LEAC NOx	LEAC PM	LEAC HC	LEAC CO	LEAC SOx	ETF NOx w/o 30%	ETF NOx w/30%	ETF PM	ETF HC	ETF CO	ETF SOx
1	48	21	0.6	0.01	0.00	0.01	0.01	0.00	0.03	0.02	0.00	0.02	0.03	0.00
2	14	4	0.3	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00
3	0	1	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0	1	11.4	0.02	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	4	1	2.7	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.01	0.02	0.00
6	0	0	17.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0	0	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0	0	19.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0	0	23.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	12	3	1.2	0.01	0.00	0.00	0.01	0.00	0.03	0.02	0.01	0.02	0.03	0.00
11	0	0	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	12	3	9.1	0.07	0.01	0.04	0.06	0.00	0.25	0.18	0.04	0.14	0.24	0.02
13	0	0	23.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	12	3	7.3	0.05	0.01	0.03	0.05	0.00	0.20	0.14	0.03	0.11	0.19	0.01
15	0	0	29.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	12	0	56.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	34	17	2.6	0.04	0.01	0.02	0.04	0.00	0.07	0.05	0.01	0.04	0.07	0.00
18	34	17	1.3	0.02	0.00	0.01	0.02	0.00	0.04	0.03	0.01	0.02	0.03	0.00
19	34	17	7.6	0.11	0.02	0.06	0.10	0.01	0.21	0.15	0.03	0.12	0.20	0.01
20	34	17	12.9	0.18	0.03	0.10	0.17	0.01	0.36	0.25	0.06	0.20	0.35	0.02
21	30	16	7.9	0.09	0.01	0.05	0.09	0.00	0.18	0.12	0.03	0.10	0.17	0.01
22	30	16	6.2	0.07	0.01	0.04	0.07	0.00	0.14	0.10	0.02	0.08	0.13	0.01
23	30	16	9.7	0.11	0.02	0.06	0.11	0.01	0.22	0.15	0.03	0.12	0.21	0.01
24	30	0	41.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0	0	5.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	2	1	5.4	0.01	0.00	0.01	0.01	0.00	0.02	0.01	0.00	0.01	0.02	0.00
27	2	1	30.0	0.08	0.01	0.04	0.07	0.00	0.11	0.08	0.02	0.06	0.10	0.01
28	0	1	24.4	0.02	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0	1	1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0	1	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0	1	8.4	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0	1	6.4	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0	1	11.7	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	0	1	7.2	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0	1	19.8	0.02	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	0	0	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0	0	2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	4	0	6.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	4	0	6.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	4	1	13.3	0.02	0.00	0.01	0.02	0.00	0.09	0.06	0.01	0.05	0.08	0.00
41	4	1	3.5	0.01	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.01	0.02	0.00
42	4	1	19.9	0.03	0.00	0.02	0.03	0.00	0.13	0.09	0.02	0.08	0.13	0.01
43	4	1	1.0	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00
44	2	1	24.1	0.03	0.01	0.02	0.03	0.00	0.08	0.06	0.01	0.05	0.08	0.00
45	2	0	124.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	0	0	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	0	0	3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	0	0	5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	0	0	1.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	0	0	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	0	0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	2	2	3.1	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00
53	2	2	3.5	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00
54	4	2	2.7	0.01	0.00	0.01	0.01	0.00	0.02	0.01	0.00	0.01	0.02	0.00
55	4	2	1.0	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00
56	4	2	11.9	0.04	0.01	0.02	0.04	0.00	0.07	0.05	0.01	0.04	0.07	0.00
57	4	2	10.5	0.04	0.01	0.02	0.03	0.00	0.06	0.05	0.01	0.04	0.06	0.00
58	4	0	19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	4	0	36.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	4	0	7.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
61	2	0	5.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62	0	0	5.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
63	0	0	7.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
64	0	0	16.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65	0	0	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66	0	0	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67	0	0	2.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
68	0	0	12.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69	0	0	36.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	2	0	3.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
71	2	2	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
72	2	16	18.1	0.21	0.03	0.12	0.20	0.01	0.03	0.02	0.00	0.02	0.03	0.00
Total (tons/year)				1.37	0.22	0.77	1.30	0.07	2.44	1.71	0.39	1.37	2.33	0.13

TABLE C-8 (Continued): ELECTRIFIED AMTRAK EMISSIONS BY LEAC SEGMENT

LEAC Segments	Yearly # Trains	Daily # Trains	NOx Emissions	PM Emissions	HC Emissions	CO Emissions	SOx Emissions	LEAC Mileage
AA	156	0.43	0.04	0.01	0.02	0.03	0.00	80.7
AB	156	0.43	0.08	0.01	0.05	0.08	0.00	80.7
AC	260	0.71	0.05	0.01	0.03	0.04	0.00	93.9
AD	260	0.71	0.20	0.03	0.11	0.19	0.01	93.9
AI	208	0.57	0.04	0.01	0.02	0.04	0.00	18.5
AP	208	0.57	0.03	0.01	0.02	0.03	0.00	18.5
AQ	156	0.43	0.03	0.01	0.02	0.03	0.00	113.9
AR	156	0.43	0.08	0.01	0.04	0.07	0.00	113.9
AS	2856	7.82	0.39	0.06	0.22	0.37	0.02	66.9
AT	2856	7.82	0.39	0.06	0.22	0.37	0.02	66.9
AY	364	1.00	0.03	0.01	0.02	0.03	0.00	18.5
AX	364	1.00	0.03	0.01	0.02	0.03	0.00	18.5
UAA	0	0.00	0.00	0.00	0.00	0.00	0.00	0
UBB	0	0.00	0.00	0.00	0.00	0.00	0.00	0
UCC	0	0.00	0.00	0.00	0.00	0.00	0.00	0
UDD	0	0.00	0.00	0.00	0.00	0.00	0.00	0
A	0	0.00	0.00	0.00	0.00	0.00	0.00	0
B	0	0.00	0.00	0.00	0.00	0.00	0.00	0
C	0	0.00	0.00	0.00	0.00	0.00	0.00	0
D	0	0.00	0.00	0.00	0.00	0.00	0.00	0
E	0	0.00	0.00	0.00	0.00	0.00	0.00	0
F	0	0.00	0.00	0.00	0.00	0.00	0.00	0
G	0	0.00	0.00	0.00	0.00	0.00	0.00	0
H	0	0.00	0.00	0.00	0.00	0.00	0.00	0
I	0	0.00	0.00	0.00	0.00	0.00	0.00	0
J	0	0.00	0.00	0.00	0.00	0.00	0.00	0
K	0	0.00	0.00	0.00	0.00	0.00	0.00	0
L	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFA	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFB	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFC	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFE	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFF	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFG	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFH	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFI	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFJ	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFT	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFU	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFK	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFL	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFM	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFN	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFO	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFP	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFQ	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFR	0	0.00	0.00	0.00	0.00	0.00	0.00	0
SFS	0	0.00	0.00	0.00	0.00	0.00	0.00	0
Total (tons/year)			1.37	0.22	0.77	1.31	0.07	

TABLE C-9: DIESEL FREIGHT AND AMTRAK EMISSIONS SUMMARY - TONS PER YEAR

ETF		NOx			PM			HC			CO			SOx	
Seg.	Freight	Amtrak	Total	Freight	Amtrak	Total	Freight	Amtrak	Total	Freight	Amtrak	Total	Freight	Amtrak	Total
1	0.00	3.38	3.38	0.00	0.11	0.11	0.00	0.06	0.06	0.00	0.53	0.53	0.00	0.30	0.30
2	0.00	1.03	1.03	0.00	0.04	0.04	0.00	0.02	0.02	0.00	0.14	0.14	0.00	0.09	0.09
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	104.03	2.00	106.03	3.21	0.09	3.30	5.67	0.04	5.71	14.43	0.32	14.75	10.45	0.18	10.63
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	25.93	3.75	29.69	0.79	0.16	0.95	1.49	0.06	1.56	3.77	0.51	4.28	2.59	0.32	2.91
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	196.67	28.46	225.13	6.01	1.20	7.20	11.34	0.49	11.82	28.60	3.84	32.44	19.63	2.43	22.06
13	227.10	0.00	227.10	6.94	0.00	6.94	13.12	0.00	13.12	33.11	0.00	33.11	22.67	0.00	22.67
14	56.56	22.83	79.39	1.71	0.96	2.67	2.87	0.39	3.26	7.02	3.08	10.10	5.60	1.96	7.55
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	7.73	7.73	0.00	0.22	0.22	0.00	0.13	0.13	0.00	1.30	1.30	0.00	0.69	0.69
18	19.80	3.87	23.66	0.57	0.11	0.68	1.34	0.07	1.41	2.58	0.65	3.23	1.83	0.35	2.18
19	155.66	22.60	178.26	4.69	0.63	5.31	8.92	0.39	9.31	22.07	3.81	25.88	15.23	2.02	17.25
20	264.21	38.36	302.57	7.95	1.07	9.02	15.15	0.66	15.81	37.46	6.47	43.93	25.84	3.43	29.27
21	0.00	18.23	18.23	0.00	0.44	0.44	0.00	0.30	0.30	0.00	3.14	3.14	0 00	1.64	1.64
22	10.10	14.31	24.41	0.30	0.35	0.64	0.65	0.24	0.89	1.58	2.46	4.04	0.93	1.29	2.22
23	15.86	22.46	38.32	0.46	0.55	1.01	1.02	0.37	1.40	2.47	3.87	6.34	1.46	2.02	3.49
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	112.53	2.20	114.73	3.39	0.09	3.49	6.41	0.04	6.45	15.87	0.34	16.21	11.04	0.19	11.23
27	658.10	12.20	670.30	19.84	0.52	20.36	37.47	0.25	37.72	92.82	1.87	94.69	64.56	1.06	65.62
28	1007.69	0.00	1007.69	30.52	0.00	30.52	59.74	0.00	59.74	141.30	0.00	141.30	99.32	0.00	99 32
29	28.66	0.00	28.66	0.87	0.00	0.87	1.66	0.00	1.66	4.07	0.00	4.07	2.85	0.00	2.85
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	166.50	0.00	166.50	5.25	0.00	5.25	9.16	0.00	9.16	24.58	0.00	24.58	16.93	0.00	16.93
32	126.86	0.00	126.86	4 00	0.00	4.00	6.98	0.00	6.98	18.73	0.00	18.73	12.90	0.00	12.90
33	231.91	0.00	231.91	7.31	0.00	7.31	12.76	0.00	12.76	34.24	0.00	34.24	23.59	0.00	23.59
34	142.72	0.00	142.72	4.50	0.00	4.50	7.85	0.00	7.85	21.07	0.00	21.07	14.51	0.00	14.51
35	392.47	0.00	392.47	12.37	0.00	12.37	21.60	0.00	21.60	57.95	0.00	57.95	39.92	0.00	39.92
36	9.14	0.00	9.14	0.26	0.00	0.26	0.62	0.00	0.62	1.19	0.00	1.19	0.85	0 00	0.85
37	53.64	0.00	53.64	1.64	0.00	1.64	3.11	0.00	3.11	7.61	0.00	7.61	5.34	0.00	5.34
38	205.19	0.00	205.19	6.32	0.00	6.32	11.34	0.00	11.34	28.60	0.00	28.60	20.57	0.00	20.57
39	244.11	0.00	244.11	7.52	0.00	7.52	13.49	0.00	13.49	34.03	0.00	34.03	24.47	0.00	24.47
40	538.97	9.86	548.83	16.60	0.42	17.02	29.78	0.19	29.97	75.13	1.60	76.72	54.03	0.86	54.89
41	141.83	2.60	144.43	4.37	0.11	4.48	7.84	0.05	7.89	19.77	0.42	20.19	14.22	0.23	14.45
42	806.42	14.76	821.18	24.84	0.63	25.47	44.55	0.29	44.84	112.41	2.39	114.80	80.84	1.29	82.14
43	40.08	0.74	40.82	1.24	0.03	1.27	2.25	0.01	2.27	5.82	0.12	5.94	4.01	0.06	4.07
44	964.46	8.92	973.39	29.84	0.38	30.22	54.26	0.17	54.44	139.98	1.44	141.42	96.46	0.78	97.24
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	129.95	1.09	131.03	3.97	0.05	4.02	7.32	0.02	7.34	18.60	0.16	18.76	12.89	0.09	12.99
53	146.72	1.23	147.94	4.49	0.05	4.54	8.27	0.02	8.29	20.99	0.18	21.18	14.56	0.11	14.66
54	116.12	1.89	118.01	3.55	0.08	3.63	6.54	0.04	6.58	16.62	0.28	16.90	11.52	0.16	11.68
55	43.01	0.70	43.71	1.31	0.03	1.34	2.42	0.01	2.44	6.15	0.10	6.26	4.27	0.06	4.33
56	1076.65	8.33	1084.98	33.51	0.35	33.87	67.23	0.17	67.40	178.38	1.24	179.62	107.24	0.72	107.96
57	835.49	7.35	842.84	26.01	0.31	26.32	52.17	0.15	52.32	138.43	1.10	139.52	83.22	0.63	83.85
58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00
59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	130.90	0.00	130.90	4.03	0.00	4.03	7.23	0.00	7.23	18.25	0.00	18.25	13.12	0.00	13.12
71	33.54	0.28	33.82	1.03	0.01	1.04	1.89	0.01	1.90	4.80	0.04	4.84	3.33	0.02	3.35
72	0.00	2.78	2.78	0.00	0.07	0.07	0.00	0.05	0.05	0.00	0.48	0.48	0.00	0.25	0.25
Total	9459.57	263.93	9723.50	291.20	9.05	300.25	545.52	4.71	550.23	1390.47	41.89	1432.37	942.81	23.22	966.02

TABLE C-10: ELECTRIFIED FREIGHT AND AMTRAK EMISSIONS SUMMARY - TONS PER YEAR

ETF		NOx			PM			HC			CO			SOx	
Seg.	Freight	Amtrak	Total	Freight	Amtrak	Total	Freight	Amtrak	Total	Freight	Amtrak	Total	Freight	Amtrak	Total
1	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.03	0.03	0.00	0.00	0.00
2	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	3.17	0.01	3.18	0.12	0.00	0.12	0.42	0.01	0.43	0.71	0.02	0.73	0.04	0.00	0.04
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.75	0.02	0.77	0.03	0.01	0.03	0.10	0.02	0.12	0.17	0.03	0.20	0.01	0.00	0.01
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	5.65	0.18	5.83	0.21	0.04	0.25	0.75	0.14	0.89	1.27	0.24	1.51	0.07	0.02	0.09
13	6.52	0.00	6.52	0.25	0.00	0.25	0.86	0.00	0.86	1.46	0.00	1.46	0.08	0.00	0.08
14	1.69	0.14	1.83	0.06	0.03	0.10	0.23	0.11	0.34	0.39	0.19	0.58	0.03	0.01	0.04
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.05	0.05	0.00	0.01	0.01	0.00	0.04	0.04	0.00	0.07	0.07	0.00	0.00	0.00
18	0.42	0.03	0.45	0.02	0.01	0.02	0.05	0.02	0.06	0.09	0.03	0.13	0.01	0.00	0.01
19	4.42	0.15	4.57	0.17	0.03	0.20	0.58	0.12	0.70	0.99	0.20	1.20	0.06	0.01	0.07
20	7.50	0.25	7.75	0.29	0.06	0.34	0.99	0.20	1.19	1.69	0.35	2.03	0.10	0.02	0.11
21	0.00	0.12	0.12	0.00	0.03	0.03	0.00	0.10	0.10	0.00	0.17	0.17	0.00	0.01	0.01
22	0.25	0.10	0.34	0.01	0.02	0.03	0.03	0 08	0.11	0.06	0.13	0.19	0.00	0.01	0.01
23	0.39	0.15	0.54	0.02	0.03	0.05	0.05	0.12	0.17	0.09	0.21	0.30	0.01	0.01	0.02
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	3.22	0.01	3.23	0.12	0.00	0.13	0.43	0.01	0.44	0.72	0.02	0.74	0.04	0.00	0.04
27	18.81	0.08	18.89	0.71	0.02	0.73	2.49	0.06	2.55	4.22	0.10	4.32	0.24	0.01	0.24
28	27.82	0.00	27.82	1.05	0.00	1.05	3.67	0.00	3.67	6.24	0.00	6.24	0.37	0.00	0.37
29	0.82	0.00	0.82	0.03	0.00	0.03	0.11	0.00	0.11	0.18	0.00	0.18	0.01	0.00	0.01
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	5.25	0.00	5.25	0.20	0.00	0.20	0.69	0.00	0.69	1.18	0.00	1.18	0.07	0.00	0.07
32	4.00	0.00	4.00	0.15	0.00	0.15	0.53	0.00	0.53	0.90	0.00	0.90	0.05	0.00	0.05
33	7.31	0.00	7.31	0.28	0.00	0.28	0.96	0.00	0.96	1.64	0.00	1.64	0.10	0.00	0.10
34	4.50	0.00	4.50	0.17	0.00	0.17	0.59	0.00	0.59	1.01	0.00	1.01	0.06	0.00	0.06
35	12.37	0.00	12.37	0.47	0.00	0.47	1.63	0.00	1.63	2.78	0.00	2.78	0.16	0.00	0.16
36	0.19	0.00	0.19	0.01	0.00	0.01	0.03	0.00	0.03	0.04	0.00	0.04	0.00	0.00	0.00
37	1.53	0.00	1.53	0.06	0.00	0.06	0.20	0.00	0.20	0.34	0.00	0.34	0.02	0.00	0.02
38	6.17	0.00	6.17	0.23	0.00	0.23	0.81	0.00	0.81	1.39	0.00	1.39	0.08	0.00	0.08
39	7.35	0.00	7.35	0.28	0.00	0.28	0.97	0.00	0.97	1.65	0.00	1.65	0.09	0.00	0.09
40	16.22	0.06	16.28	0.61	0.01	0.62	2.14	0.05	2.19	3.64	0.08	3.73	0.20	0.00	0.21
41	4.27	0.02	4.28	0.16	0.00	0.16	0.56	0.01	0.58	0.96	0.02	0.98	0.05	0.00	0.05
42	24.27	0.09	24.36	0.91	0.02	0.93	3.20	0.06	3.27	5.45	0.13	5.58	0.31	0.01	0.31
43	1.27	0.00	1.28	0.05	0.00	0.05	0.16	0.00	0.16	0.27	0.01	0.28	0.01	0.00	0.02
44	30.64	0.06	30.70	1.10	0.01	1.12	3.83	0.05	3.87	6.52	0.08	6.60	0.36	0.00	0.36
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	3.83	0.01	3.84	0.15	0.00	0.15	0.51	0.01	0.51	0.86	0.01	0.87	0.05	0.00	0.05
53	4.33	0.01	4.34	0.16	0.00	0.17	0.57	0.01	0.58	0.97	0.01	0.98	0.06	0.00	0.06
54	3.43	0.01	3.44	0.13	0.00	0.13	0.45	0.01	0.46	0.77	0.02	0.78	0.04	0.00	0.04
55	1.27	0.00	1.27	0.05	0.00	0.05	0.17	0.00	0.17	0.28	0.01	0.29	0.02	0.00	0.02
56	30.96	0.05	31.02	1.16	0.01	1.17	4.08	0.04	4.13	6.96	0.07	7.03	0.39	0.00	0.39
57	24.03	0.05	24.07	0.90	0.01	0.91	3.17	0.04	3.21	5.40	0.06	5.46	0.30	0.00	0.30
58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	3.94	0.00	3.94	0.15	0.00	0.15	0.52	0.00	0.52	0.88	0.00	0.88	0.05	0.00	0.05
71	0.99	0.00	0.99	0.04	0.00	0.04	0.13	0.00	0.13	0.22	0.00	0.22	0.01	0.00	0.01
72	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.03	0.03	0.00	0.00	0.00
Total	279.55	1.71	281.25	10.49	0.39	10.87	36.64	1.37	38.00	62.41	2.33	64.74	3.54	0.13	3.66

TABLE C-11: EMISSIONS BENEFIT - FREIGHT AND AMTRAK EMISSIONS SUMMARY - TONS PER YEAR

ETF Seg.	NOx Diesel	NOx Elect.	PM Diesel	PM Elect.	HC Diesel	HC Elect.	CO Diesel	CO Elect.	SOx Diesel	SOx Elect.	NOx Ben.	PM Ben.	HC Ben.	CO Ben.	SOx Ben.	ETF Seg.
1	3.38	0.02	0.11	0.00	0.06	0.02	0.63	0.03	0.30	0.00	3.35	0.11	0.04	0.60	0.30	1
2	1.03	0.01	0.04	0.00	0.02	0.01	0.14	0.01	0.09	0.00	1.02	0.04	0.01	0.13	0.09	2
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4
5	106.03	3.18	3.30	0.12	5.71	0.43	14.75	0.73	10.63	0.04	102.85	3.18	5.29	14.03	10.59	5
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8
9	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9
10	29.69	0.77	0.95	0.03	1.56	0.12	4.28	0.20	2.91	0.01	28.92	0.92	1.44	4.08	2.90	10
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11
12	225.13	5.83	7.20	0.25	11.82	0.89	32.44	1.51	22.06	0.09	219.30	6.95	10.94	30.93	21.97	12
13	227.10	6.52	6.94	0.25	13.12	0.86	33.11	1.46	22.67	0.08	220.58	6.69	12.26	31.65	22.59	13
14	79.39	1.83	2.67	0.10	3.26	0.34	10.10	0.58	7.55	0.04	77.56	2.57	2.92	9.52	7.51	14
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16
17	7.73	0.05	0.22	0.01	0.13	0.04	1.30	0.07	0.69	0.00	7.68	0.20	0.09	1.23	0.69	17
18	23.66	0.45	0.68	0.02	1.41	0.08	3.23	0.13	2.18	0.01	23.22	0.66	1.34	3.10	2.17	18
19	178 26	4.57	5.31	0.20	9.31	0.70	25.88	1.20	17.25	0.07	173.69	5.11	8.61	24.68	17.18	19
20	302.57	7.75	9.02	0.34	15.81	1.19	43.93	2.03	29.27	0.11	294.82	8.68	14.61	41.90	29.16	20
21	18.23	0.12	0 44	0.03	0.30	0.10	3.14	0.17	1.64	0.01	18.10	0.41	0.20	2.97	1.63	21
22	24 41	0.34	0.64	0.03	0 89	0.11	4.04	0.19	2.22	0.01	24.06	0.61	0.78	3.85	2.21	22
23	38.32	0.54	1.01	0.05	1.40	0.17	6.34	0.30	3.49	0.02	37.77	0.96	1.22	6.04	3.47	23
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25
26	114.73	3.23	3.49	0.13	6.45	0.44	16.21	0.74	11.23	0.04	111.50	3.36	6.02	15.47	11.19	26
27	670.30	18.89	20.36	0.73	37.72	2.55	94.69	4.32	65.62	0.24	651.41	19.63	35.17	90.37	65.38	27
28	1007.69	27.82	30.52	1.05	59.74	3.67	141.30	6.24	99.32	0.37	979.87	29.47	56.08	135.06	98 95	28
29	28.66	0.82	0.87	0.03	1.66	0.11	4.07	0.18	2.85	0.01	27.84	0.84	1.55	3 88	2.84	29
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30
31	166.50	5.25	5.25	0.20	9.16	0.69	24.56	1.18	16.93	0.07	161.25	5.05	8.47	23.41	16.86	31
32	126.86	4.00	4.00	0.15	6.98	0.53	18.73	0.90	12.90	0.05	122.86	3.85	6.45	17.83	12.85	32
33	231.91	7.31	7.31	0.28	12.76	0.96	34.24	1.64	23.59	0.10	224.60	7.03	11.80	32.60	23.49	33
34	142.72	4.50	4.50	0.17	7.85	0.59	21.07	1.01	14.51	0.06	138.22	4.33	7.26	20.06	14.46	34
35	392.47	12.37	12.37	0.47	21.60	1.63	57.95	2.78	39.92	0.16	380.10	11.90	19.97	55.17	39.75	35
36	9.14	0.19	0.26	0.01	0.62	0.03	1.19	0.04	0.86	0.00	8.94	0.26	0.60	1.15	0.84	36
37	53.64	1.53	1.64	0.06	3.11	0.20	7.61	0.34	5.34	0.02	52.10	1.58	2.91	7.26	5.32	37
38	205.19	6.17	6.32	0.23	11.34	0.81	28.60	1.39	20.57	0.08	199.02	6.09	10.52	27.22	20.49	38
39	244.11	7.35	7.52	0.28	13.49	0.97	34.03	1.65	24.47	0.09	236.76	7.24	12.52	32.38	24.38	39
40	548.83	16.28	17.02	0.62	29.97	2.19	76.72	3.73	54.89	0.21	532.55	16.40	27.78	73.00	54 69	40
41	144.43	4.28	4.48	0.16	7.89	0.58	20.19	0.98	14.45	0.05	140.14	4.32	7.31	19.21	14.39	41
42	821.18	24.36	25.47	0.93	44.84	3.27	114.80	5.58	82.14	0.31	796.82	24.54	41.57	109.22	81.82	42
43	40.82	1.28	1.27	0.05	2.27	0.16	5.94	0.28	4.07	0.02	39.54	1.22	2.11	5.66	4.06	43
44	973.39	30.70	30.22	1.12	54.44	3.87	141.42	6.60	97.24	0.36	942.68	29.11	50.57	134.83	96.88	44
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45
46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	46
47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47
48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48
49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	49
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50
51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	51
52	131.03	3.84	4.02	0.15	7.34	0.51	18.76	0.87	12.99	0.05	127.19	3.87	6.83	17.89	12.94	52
53	147.94	4.34	4.54	0.17	8.29	0.58	21.18	0.98	14.66	0.06	143.61	4.37	7.71	20.20	14.61	53
54	118.01	3.44	3.63	0.13	6.58	0.46	16.90	0.78	11.68	0.04	114.57	3.50	6.12	16.11	11.64	54
55	43.71	1.27	1.34	0.05	2.44	0.17	6.26	0.29	4.33	0.02	42.43	1.30	2.27	5.97	4.31	55
56	1084.98	31.02	33.87	1.17	67.40	4.13	179.62	7.03	107.96	0.39	1053.97	32.69	63.27	172.60	107.57	56
57	842.84	24.07	26.32	0.91	52.32	3.21	139.52	5.46	83.85	0.30	818.77	25.41	49.11	134.06	83.55	57
58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58
59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	60
61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	61
62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	62
63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63
64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	64
65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	65
66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66
67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	67
68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	68
69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	69
70	130.90	3.94	4.03	0.15	7.23	0.52	18.25	0.88	13.12	0.05	126.96	3.88	6.71	17.36	13.07	70
71	33.82	0.99	1.04	0.04	1.90	0.13	4.84	0.22	3.35	0.01	32.82	1.00	1.76	4.62	3.34	71
72	2.78	0.02	0.07	0.00	0.05	0.02	0.48	0.03	0.25	0.00	2.77	0.06	0.03	0.45	0 25	72
Total	9723.50	281.25	300.25	10.87	550.23	38.00	1432.37	64.74	966.02	3.68	9442.25	289.38	512.22	1367.62	962.35	

APPENDIX 11-4

APPENDIX 11-4

COST EFFECTIVENESS

<u>Cost Effectiveness Calculation Methodology</u>

The methodology used to calculate rail electrification cost effectiveness for the air quality impact analysis was developed by the Environmental Assessment Committee with the assistance of the Rail Electrification Task Force's Funding Committee and the District's Socio-Economic Section. Following is a summary of assumptions used in the analysis, as well as the cost calculations.

- A 30 year equipment life is assumed.
- The Discounted Cash Flow (DCF) method has been used. This is consistent with the District's 1991 Air Quality Management Plan revision.
- Capital costs associated with rail electrification have been incorporated into the cost analysis. This is also consistent with the methodology used in the 1991 Air Quality Management Plan revision.
- Cost effectiveness has been calculated by dividing capital cost by the total anticipated project emissions reduction.

TABLE D-1

Cost Effectiveness Per Route based on NOx Emission Reductions (DCF Method)

Route	tpd NOx	Total NOx (tpy) /Route	Cost Effectiveness	#1	#2	#3	#4	#5	#6	#7	#9	#10	#12	#13	#14, (15)	#17	#18	#19	#20	#21	#22	#72, (23)
2 Baldwin Park	0.66	107.23	$32,619.04	3.35	1.02	0	0	102.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 Moorpark	1.06	330.16	$11,184.76	3.35	1.02	0	0	0	0	0	0	28.92	219.3	0	77.56	0	0	0	0	0	0	0
4 Santa Clarita	1.37	473.18	$9,453.82	3.35	1.02	0	0	0	0	0	0	28.92	219.3	220.6	0	0	0	0	0	0	0	0
5 Lossan Corridor	1.84	585.48	$13,457.22	3.35	0	0	0	0	0	0	0	0	0	0	0	7.68	23.22	173.6	294.8	18.1	24.06	40.54
6 Riverside via Ontario	3.51	1210.71	$6,235.15	3.35	1.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Riverside-LAUPT via Full	4.02	1392.86	$5,689.25	3.35	0	0	0	0	0	0	0	0	0	0	0	7.68	23.22	173.6	294.8	0	0	0
8 Hemmet-Riverside	0.16	32.83	$88,953.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9 San Bern.-Irvine	3.41	1136.11	$5,726.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24.06	0
10 Redlands	0.03	0.00	$134,439.83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 SP W. Colton to Ports	11.44	4177.16	$3,538.89	0	0	0	0	102.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 AT&SF Barstow to Ports	12.54	4576.81	$3,530.73	0	0	0	0	0	0	0	0	0	0	0	0	0	23.22	173.6	294.8	0	0	0
13 UP Yermo to Ports	11.97	4368.10	$3,646.89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		OVERALL:	$6,290.96																			

TABLE D-1 (Continued)

#26	#27	#28	#29	#30	#31	#32	#33	#34	#35	#36	#37	#38	#39	#40	#41	#42	#43 -(44)	#48	#52	#53	#54	#55	#56	#57	#68	#69	#70	#71
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	161.3	122.9	224.6	138.2	380.1	0	52.1	0	0	0	0	0	0	0	127.2	0	0	0	0	0	0	0	0	0
111.5	651.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	127.2	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32.82
0	651.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	127.2	143.6	114.6	42.43	0	0	0	0	0	32.82
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	979.8	27.84	0	0	0	0	0	0	0	52.1	199	236.8	532.6	140.1	796.8	982.2	0	0	0	0	0	0	0	0	0	127	0
111.5	651.4	979.8	0	0	0	0	0	0	0	8.94	0	0	0	0	0	0	0	0	127.2	143.6	114.6	42.43	1054	818.8	0	0	0	32.82
0	0	979.8	27.84	0	161.3	122.9	224.6	138.2	380.1	0	0	0	0	0	0	0	0	0	127.2	143.6	114.6	42.43	1054	818.8	0	0	0	32.82

TABLE D-2

Route	Type	Total TPY NOx from Commuters	#1	#2	#3	#4	#5	#6	#7	#9	#10	#12	#13	#14, (15)	#17	#18	#19	#20	#21	#22	#72, (23)
2 Baldwin Park	C	132.4	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
3 Moorpark	C/F	56.08	1	1	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
4 Santa Clarita	C/F	25.19	1	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
5 Lossan Corridor	C	86.65	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
6 Riverside via Ontario	C	68.89	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Riverside-LAUPT via Full	C	73.59	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
8 Hemmet-Riverside	C	26.51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9 San Bern.-Irvine	C	108.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
10 Redlands	C	12.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 SP W. Colton to Ports	F	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 AT&SF Barstow to Ports	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
13 UP Yermo to Ports	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL:	589.99																			
	Mileage	467.50	0.6	0.3	0.6	11.6	2.7	17.2	1.2	23.7	1.2	9.1	23.7	20.8	3.2	1.3	7.6	12.9	7.9	6.2	27.3
Diesel NOx by Segment		9723.51	3.38	1.03	0	0	106.0	0	0	0	29.69	225.1	227.1	79.39	7.73	23.66	178.2	302.5	18.23	24.41	41.1
Electric NOx by Segment		281.24	0.02	0.01	0	0	3.18	0	0	0	0.77	5.83	6.52	1.83	0.05	0.45	4.57	7.75	0.12	0.34	0.56
Emission Reductions by Segment	NOx (tpy)	9442.27	3.35	1.02	0.00	0.00	102.9	0.00	0.00	0.00	28.92	219.3	220.6	77.56	7.68	23.22	173.7	294.8	18.10	24.06	40.54
from freight and Amtrak	PM	289.39	0.11	0.04	0.00	0.00	3.18	0.00	0.00	0.00	0.92	6.95	6.69	2.57	0.20	0.66	5.11	8.68	0.41	0.61	1.02
	HC	517.79	0.09	0.03	0.00	0.00	5.36	0.00	0.00	0.00	1.49	11.28	12.26	3.20	0.20	1.39	8.93	15.16	0.27	0.83	1.34
	CO	11373.18	0.55	0.15	0.00	0.00	14.10	0.00	0.00	0.00	4.13	31.29	31.65	9.81	1.34	3.15	25.00	42.44	3.03	3.90	6.58
	SOx	967.93	0.35	0.10	0.00	0.00	10.66	0.00	0.00	0.00	2.94	22.33	22.59	7.79	0.80	2.22	17.50	29.71	1.69	2.26	3.80

Mileage by Segment per Route

Route	Type	Route Miles	Within Basin Miles	Mileage per Segment #1	#2	#3	#4	#5	#6	#7	#9	#10	#12	#13	#14, (15)	#17	#18	#19	#20	#21	#22	#72, (23)
2 Baldwin Park	C	57.9	57.9	0.6	0.3	0.6	11.6	2.7	17.2	1.2	23.7	0	0	0	0	0	0	0	0	0	0	0
3 Moorpark	C/F	47.5	32	0.6	0.3	0	0	0	0	0	0	1.2	9.1	0	20.8	0	0	0	0	0	0	0
4 Santa Clarita	C/F	34.9	34.9	0.6	0.3	0	0	0	0	0	0	1.2	9.1	23.7	0	0	0	0	0	0	0	0
5 Lossan Corridor	C	133.7	67	0.6	0	0	0	0	0	0	0	0	0	0	0	3.2	1.3	7.6	12.9	7.9	6.2	27.3
6 Riverside via Ontario	C	59.1	59.1	0.6	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Riverside-LAUPT via Full	C	61.8	61.8	0.6	0	0	0	0	0	0	0	0	0	0	0	3.2	1.3	7.6	12.9	0	0	0
8 Hemmet-Riverside	C	39.1	39.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9 San Bern.-Irvine	C	52.8	52.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.2	0
10 Redlands	C	12	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 SP W. Colton to Ports	F	281.7	109.5	0	0	0	0	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 AT&SF Barstow to Ports	F	176.1	119.7	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	7.6	12.9	0	0	0
13 UP Yermo to Ports	F	186.8	118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL:	1143.4	763.8																			

TABLE D-2 (Continued)

#26	#27	#28	#29	#30	#31	#32	#33	#34	#35	#36	#37	#38	#39	#40	#41	#42	#43 -(44)	#48	#52	#53	#54	#55	#56	#57	#68	#69	#70	#71
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
0	0	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1
0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1
5.4	30	24.4	1.5	1	8.4	6.4	11.7	7.2	19.9	0.6	2.8	5.8	6.9	13.3	3.5	19.9	25	5.5	0.8	3.5	2.7	1	11.9	14.5	12	36	3.7	3.1
111.5	651.4	979.9	27.84	0.00	161.3	122.9	224.6	138.2	380.1	8.94	52.10	199.0	236.8	532.6	140.1	796.8	982	0.00	127.2	143.6	114.6	42.43	1054	818.8	0.00	0.00	127.0	32.82
3.36	19.63	29.47	0.84	0.00	5.05	3.85	7.03	4.33	11.90	0.26	1.58	6.09	7.24	16.40	4.32	24.54	30.33	0.00	3.87	4.37	3.50	1.30	32.69	25.41	0.00	0.00	3.88	1.00
6.15	35.90	56.08	1.55	0.00	8.47	6.45	11.80	7.26	19.97	0.60	2.91	10.52	12.52	28.16	7.41	42.13	53.05	0.00	6.90	7.79	6.23	2.31	63.76	49.55	0.00	0.00	6.71	1.78
15.60	91.09	135.1	3.88	0.00	23.41	17.83	32.60	20.06	55.17	1.15	7.26	27.22	32.38	73.38	19.31	109.8	140.9	0.00	17.95	20.27	16.22	6.01	173.1	134.5	0.00	0.00	17.36	4.63
11.32	66.11	98.95	2.84	0.00	16.86	12.85	23.49	14.46	39.75	0.84	5.32	20.49	24.38	55.07	14.49	82.39	101.3	0.00	13.00	14.68	11.75	4.35	108.1	83.99	0.00	0.00	13.07	3.36

#26	#27	#28	#29	#30	#31	#32	#33	#34	#35	#36	#37	#38	#39	#40	#41	#42	#43 -(44)	#48	#52	#53	#54	#55	#56	#57	#68	#69	#70	#71
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	8.4	6.4	11.7	7.2	19.9	0	2.8	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0	0
5.4	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	3.1
0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.5	0.8	3.5	2.7	1	0	0	0	0	0	3.1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0
0	0	24.4	1.5	0	0	0	0	0	0	0	2.8	5.8	6.9	13.3	3.5	19.9	25	0	0	0	0	0	0	0	0	0	3.7	0
5.4	30	24.4	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0.8	3.5	2.7	1	11.9	14.5	0	0	0	3.1
0	0	24.4	1.5	1	8.4	6.4	11.7	7.2	19.9	0	0	0	0	0	0	0	0	0	0.8	3.5	2.7	1	11.9	14.5	0	0	0	3.1

Table D-3

Route	Type	Route Miles	Within Basin Miles	--- Freight/Amtrak --- Diesel tpy NOx	Electric tpy NOx	Total Reduction	----- Commuters ----- Diesel tpy NOx	Electric tpy NOx	Total Reduction	Total tpy NOx Reductions	Total tpd NOx Reductions	Cost Effectiv (based on $4. DCF Method
2 Baldwin Park	C	57.9	57.9	110.44	3.21	107.23	133.54	1.14	132.4	239.63	0.66	$32,619.04
3 Moorpark	C/F	47.5	32	338.62	8.46	330.16	56.56	0.48	56.08	386.24	1.06	$11,184.76
4 Santa Clarita	C/F	34.9	34.9	486.33	13.15	473.18	25.41	0.22	25.19	498.37	1.37	$9,453.82
5 Lossan Corridor	C	133.7	67	599.34	13.86	585.48	87.39	0.74	86.65	672.13	1.84	$13,457.22
6 Riverside via Ontario	C	59.1	59.1	1249.54	38.83	1210.71	69.48	0.59	68.89	1279.6	3.51	$6,235.15
7 Riverside-LAUPT via Full	C	61.8	61.8	1431.66	38.8	1392.86	74.22	0.63	73.59	1466.45	4.02	$5,689.25
8 Hemmet-Riverside	C	39.1	39.1	33.82	0.99	32.83	26.74	0.23	26.51	59.34	0.16	$88,953.49
9 San Bern.-Irvine	C	52.8	52.8	1169.22	33.11	1136.11	109.56	0.93	108.63	1244.74	3.41	$5,726.50
10 Redlands	C	12	12	0	0	0.00	12.15	0.1	12.05	12.05	0.03	$134,439.83
11 SP W. Colton to Ports	F	281.7	109.5	4304.87	127.71	4177.16	0	0	0	4177.16	11.44	$3,538.89
12 AT&SF Barstow to Ports	F	176.1	119.7	4708.68	131.87	4576.81	0	0	0	4576.81	12.54	$3,530.73
13 UP Yermo to Ports	F	186.8	118	4499.14	131.04	4368.10	0	0	0	4368.1	11.97	$3,646.89
Total:		1143.4	763.8				595.05	5.06	589.99			
Overall:			467.5	9723.51	281.24	9442.27				10032.26	27.49	$6,290.96

APPENDIX 11-5

APPENDIX 11-5

Summary of Analyses of the Health Effects of EMFs Performed by Various Agencies and Institutions

1. **California Department of Health Services. 1990. Electric and Magnetic Fields: Measurements and Possible Effects on Human Health; What We Know, What We Don't Know in 1990. Special Epidemiological Studies Program, 1990.**

"The public concern about possible health hazards from the delivery and usage of electric power is based on suggestive data which, at this time, is both incomplete and inconclusive. With the scientific information now available, it is not possible to set a standard or say that any given level is safe or dangerous. At this time, no one knows the relative importance of average long term exposure, exposure to sudden intensities, exposure to different frequencies, or various combinations of all these with other factors. Stronger fields may not always pose a greater risk than weaker fields. A reasonable public policy at this time is to inform people about what is known and unknown about this matter, and to intensify and expand the efforts to gain the necessary knowledge. Until we have the necessary information, concerned individuals may wish to consider adopting a "prudent avoidance" strategy. The Department of Health Services is involved in research of these questions."

2. **Congress of the United States, Office of Technology Assessment. Carnegie Melon University. Department of Engineering and Public Policy. Biological Effects of Power Frequency Electric and Magnetic Fields. May 1989.**

"There is now a very large volume of scientific findings based on experiments at the cellular level and from studies with animals and people which clearly establish that low frequency magnetic fields can interact with, and produce changes in, biological systems. While most of this work is of very high quality, the results are complex. Current scientific understanding does not yet allow us to interpret the evidence in a single coherent framework. Even more frustrating, it does not yet allow us to draw definite conclusions about questions of possible risk or to offer clear science-based advice on strategies to minimize or avoid potential risks. In the long run, better scientific understanding is the only way to resolve problems posed by power frequency fields."

3. **National Cancer Institute. 1990. Collaborative Study of Electromagnetic Field Exposure and Childhood Leukemia. March 1990.**

The National Cancer Institute (NCI) and the Children's Cancer Study Group (CCSG) are collaborating on a 4-year large-scale investigation to determine if low-frequency electromagnetic field (EMF) exposure contributes to the development of acute lymphocytic leukemia. Results of the study should be available in early 1995.

4. **Peters, J., S. London, D. Thomas, J. Bowman, E. Sobel, and T. Cheng. 1991. "Exposure to Residential Electric and Magnetic Fields and Risk of Childhood Leukemia", American Journal of Epidemiology. November 1991.**

"The relation between exposure to electric and magnetic fields in the home, as assessed by measurements, wiring configuration, and self-reported appliance use, and risk of leukemia was investigated in a case-control study among children from birth to age 10 years in Los Angeles county, California. Cases were ascertained through a population-based tumor registry from 1980 to 1987. No clear association between leukemia risk and measured magnetic or electric fields were seen. The reports support an association between childhood leukemia and wiring configuration."

5. **Public Utilities Commission. 1991. Administrative Law Judge's Ruling Announcing the California EMF Consensus Group. September 1991.**

Pursuant to the PUC's Order Instituting Investigation (OII) on the Commission's, own motion to develop policies and procedure for addressing the potential health effects of electric and magnetic fields of utility facilities, dated January 15, 1991, the California EMF Consensus Group has been established. The goal of this Consensus Group, which consists of representatives from the PUC, CEC, DHS, utility companies, and environmental organizations, is to propose near-term priorities for utility-funded EMF research as well as interim procedures to guide utility activities in the following areas:

a. Providing information and performing field measurements for members of the public;

b. Constructing new transmission and distribution lines, substations, and other facilities, and modifying existing facilities;

c. Responding to concerns raised by those living, working, or spending recreational time close to existing facilities (including responding to the discovery of a potential cancer cluster).

6. **Public Utilities Commission. 1989. Potential Health Effects of Electric and Magnetic Fields From Electric Power Facilities. Report to the California State Legislature by the California Public Utilities Commission in Cooperation with the California Department of Health Services under SB 2519. September 1989.**

Under SB 2519, adopted on September 29, 1988, the CPUC and the DHS were required to conduct a study of the potential health effects associated with exposure to electric and magnetic fields from electric utility facilities. This Bill requires the state's larger utilities to fund research projects on the biological effects of EMFs.

"Taken together, the body of scientific evidence for electric and magnetic fields posing a significant health risk is not yet compelling, but it is worrisome. It is recommended that California take no action at the present to regulate electric and magnetic fields around electric power facilities. Any current actions are premature given current scientific understanding of this public health issue. Too little is known presently to be able to determine whether or what rules would provide useful protection." Three high-priority research projects have been selected for funding.

7. **U.S. Environmental Protection Agency. 1991. A Research Strategy for Electric and Magnetic Fields: Research Needs and Priorities, Review Draft. June 1991**

This document describes a strategic framework which identifies the major research topics and their relative priorities in the following areas:

- Animal and human studies to determine if adverse health effects (cancer and reproductive, nervous, and immune system effects) might result from EMF.
- Investigation of biophysical mechanisms, including both physical and biological interactions, that underline any effects which may occur from exposure to EMF.

- Improved assessment of human exposure to EMF, including source identification and characterization, instrumentation development, exposure measurement and modeling, EMF coupling to biological objects and laboratory exposure systems.
- Determining what type of control technology, if any, may be needed to prevent and reduce human exposure to EMF.

8. **U.S. Environmental Protection Agency. 1990. Evaluation of the Potential Carcinogenicity of Electromagnetic Fields, Review Draft. October 1990.**

"While there are epidemiological studies that indicate an association between EM fields or their surrogates and certain types of cancer, other epidemiological studies do not substantiate this association. There are insufficient data to determine whether or not a cause and effect relationship exists."

"With our current understanding, we can identify 60-HZ magnetic fields from power lines and perhaps other sources in the home as a possible, but not proven, cause of cancer in humans. The absence of key information makes it difficult to make quantitative estimates of risk. Such quantitative estimates are necessary before judgements about the degree of safety or hazard of a given exposure can be made. This situation indicates the need to continue to evaluate the information from ongoing studies and to further evaluate the mechanisms of carcinogenic action and the characteristics of exposure that lead to these effects."