North American Trade and Transportation Corridors:

Environmental Impacts and Mitigation Strategies

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ICF Consulting

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EXECUTIVE SUMMARY

Trade between Canada, the United States and Mexico has grown rapidly since the implementation of the North American Free Trade Agreement (NAFTA). This study examines the environmental impacts of that trade on five bi-national segments of three primary NAFTA trade corridors, with a particular focus on air pollution emissions. The corridor segments selected for the analysis are Vancouver-Seattle, Winnipeg-Fargo, Toronto-Detroit, San Antonio-Monterrey and Tucson-Hermosillo. The study determines current and future commodity flows, freight vehicle traffic volumes and emissions in each of these corridor segments. The impacts of several mitigation strategies are also explored.

Currently, NAFTA trade contributes significantly to air pollution in all the corridors, particularly NO_x and PM-10 emissions. Cross-border freight is responsible for 3% to 11% of all mobile source NO_x emissions in the corridors and 5% to 16% of all mobile source PM-10 emissions. Trucking carries most of the freight in the corridors and contributes the bulk of trade-related emissions – typically three-quarters of NO_x and more than 90% of PM-10. Truck idling associated with border crossing delay contributes significantly to CO emissions, particularly in corridors where border delay is problematic. As much as 6% of all trade-related CO emissions in the corridors are caused by truck idling.

By 2020, due to the large expected reduction in emission rates for trucks, total trade-related emissions of NO_x and PM-10 will decline or remain constant compared to current levels. This occurs despite trade volumes that grow by two to four times. In the U.S.-Canada corridors, truck emissions of NO_x and PM-10 per ton-kilometer will drop to about one-tenth their current levels. The gains in the U.S.-Mexico corridors will not be as large under the assumption that low-sulfur diesel will not be widely available in Mexico, but truck emissions of NO_x and PM-10 per ton-kilometer are still expected to drop to about one-fifth their current levels.

Lower emission rates are expected for locomotives by 2020, but the rates are not expected to decline as rapidly as truck emission rates because standards will not be as strict and because vehicle turnover is less rapid. Consequently, in corridors with higher trade growth, NO_x and PM-10 emissions from rail will increase 50% to 100% by 2020. In all corridors, because of the decline in truck emissions, rail will contribute a much larger share of trade-related NO_x and PM-10 emissions.

Trade-related emissions of greenhouse gases and CO will not be reduced under the new emission standards, and are therefore expected to rise substantially by 2020. Under the baseline 2020 growth scenario, CO_2 emissions from NAFTA trade will increase by 2.4 to 4 times over their current levels in the five corridors.

Changes to assumptions about trade growth rates or future mode share can have a major effect on estimations of future emissions. For example, if the growth in truck and rail traffic follows the trend over the past decade, NO_x and PM-10 emissions from trade could be as much as 50% higher than the estimated 2020 Baseline levels. If this occurs, 2020 emissions of NO_x and PM-10 could exceed 1999 levels in some corridors. Changes to the rail/truck mode share would also affect future emissions, though less significantly. Because of the large reduction expected in truck emission rates, a shift to rail would increase NO_x and PM-10 emissions in most corridors, though it would reduce emissions of CO and CO_2.

Opportunities exist to achieve lower trade-related emissions through implementation of mitigation strategies. The study explores five such strategies:

- Use of natural gas for heavy-duty trucks is an effective strategy to reduce trade emissions (particularly PM-10) through the next decade. By 2020, the vast improvement in diesel engine emissions means that natural gas will probably not offer an emission reduction in the Canada-U.S. corridors. In U.S-Mexico corridors in 2020, under the assumption that low-sulfur diesel fuel is not widely available in Mexico, use of natural gas by 20% of Mexican trucks would reduce PM-10 trade truck emissions by 13%.
- Commercial vehicles face an average delay of up to one hour to cross Canada-U.S. and U.S.-Mexico borders. Policy changes and investments could cut this delay in half, resulting in a reduction of 0.2 to 0.6 metric tons of CO per day (1.6% to 2.5% of trade-related truck emissions in the corridor segments).
- The use of low-sulfur diesel fuel in Mexico would allow Mexican trucks to achieve the dramatic emission reductions expected for U.S. and Canadian trucks. If Mexican truck emission rates match those in the U.S. by 2020, trade-related emissions of NOx, VOC and PM-10 in the San Antonio-Monterrey corridor would be cut by more than half.
- Improving the efficiency of freight transport by reducing empty vehicle mileage will increase efficiency and lower all pollutant emissions from trade. In the Toronto-Detroit corridor, reducing the fraction of empty trucks from 15% to 10% would eliminate over 0.5 metric tons of NO_x and 600 metric tons of CO_2 per day in 2020 (5% of the trade-related truck total). The U.S.-Mexico corridors have the potential for even larger reductions, but the data needed for such analysis are incomplete.
- Allowing the use of longer combination vehicles (LCVs) in NAFTA corridors will reduce truck volumes and associated emissions. Because LCVs lower the cost of shipping by truck, some freight would shift from rail to truck. Increasing the truck weight limits in five U.S. midwestern states to 47,854 kilograms (105,500 pounds) and allowing Rocky Mountain Double configurations would reduce emissions of all pollutants by 4% to 7% compared to the 2020 baseline.

Some of the data needed to assess environmental impacts of trade and transportation corridors are unavailable or highly uncertain. A coordinated effort to collect and disseminate information is needed, particularly in the following areas:

- Cross-border traffic volumes, including number of empty versus full trucks and rail cars;
- Freight origin-destination patterns in the border regions;
- Data and methodology to estimate railroad emissions; and
- Measurements of average commercial vehicle delay at border crossing.

1 INTRODUCTION

The implementation of the North American Free Trade Agreement in 1994 strengthened the already healthy economic relationships between Canada, the United States and Mexico. Since the signing of NAFTA, U.S. trade with Canada has nearly doubled and now totals $410 billion per year. U.S.-Mexico trade has grown even more rapidly, more than tripling to $252 billion annually. Canada-Mexico trade, while still quite small at $7.5 billion, has increased more than two-fold over the same period. This trade has undoubtedly increased prosperity in all three nations. But there have also been environmental consequences in corridors that carry the trade.

The liberalization of North American trade can have a variety of both positive and negative environmental impacts. In a basic sense, trade can affect the environment through changes in the scale of production, through wider dissemination of products, and indirectly through altering the structure of production processes.[1] This paper considers environmental impacts associated with only one element of trade liberalization – the physical movement of goods between nations. And although North American goods movement occurs by a variety of means – highways, railways, waterways, air and pipeline – we focus primarily on trucking and rail freight, since these modes contribute most significantly to adverse environmental impacts.

A large body of research has explored the environmental effects of freight transportation, yet very little has tried to isolate the impacts of freight associated with international trade. This is a challenging task, since NAFTA trade occurs in the context of other freight and transportation activity in multiple local, state/provincial and national jurisdictions. Furthermore, the available information on North American goods movement is generally not structured to assess how trade affects the environment along freight corridors. A goal of this study is to highlight areas of incompatible or inadequate technical data and bring focus on the need for better coordination in tri-national environmental planning

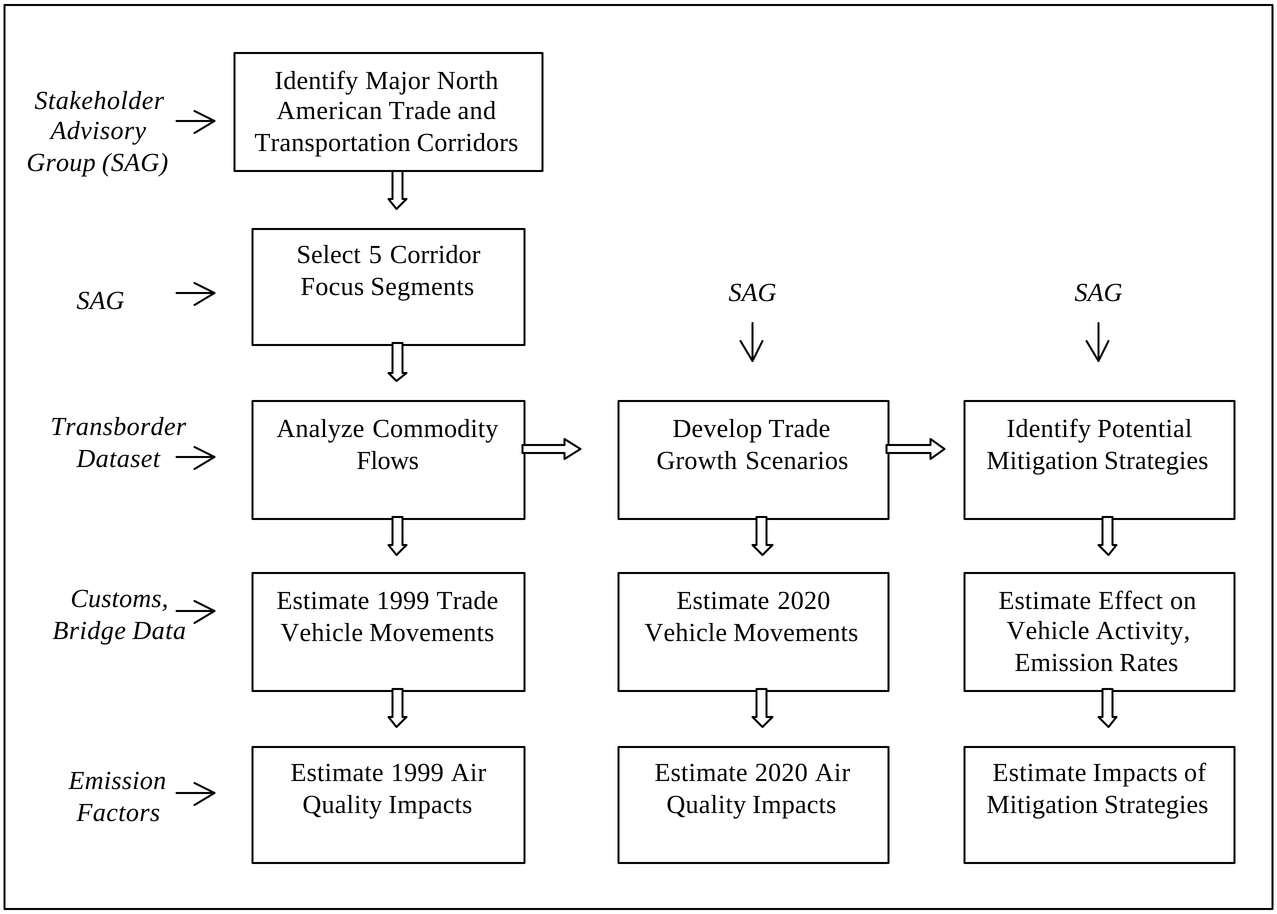
The primary purpose of this report is to identify the current and future air quality impacts that occur as a result of the development of North American trade and transportation corridors. Five bi-national corridor segments are selected for detailed analysis, as discussed in Section 2. In Section 3, current levels of trade, truck and railroad movements, and pollutant emissions are calculated for each corridor. Section 4 presents a similar analysis for the year 2020 based on trade growth scenarios. Section 5 evaluates the effectiveness of various mitigation strategies in reducing trade-related emissions. Other types of environmental impacts associated with truck and rail freight are briefly discussed in Section 6. Section 7 identifies areas where existing data are insufficient to properly evaluate environmental impacts. A summary of the findings is presented in Section 8.

2 METHODOLOGY

The study methodology is illustrated by the roadmap shown in Exhibit 1. Each major element is described in greater detail below.

[1] *NAFTA Effects – A Survey of Recent Attempts to Model the Environmental Effects of Trade.*

Exhibit 1: Study Methodology Roadmap



2.1 Corridor Selection

The first task was to select specific trade and transportation corridors for the analysis. This was accomplished by first identifying major North American trade corridors, crossing all three nations, and then selecting segments of these full corridors for detailed analysis. Most corridors are generally defined by highway routes, although all corridors selected for this analysis include freight rail service and possibly waterborne freight service.

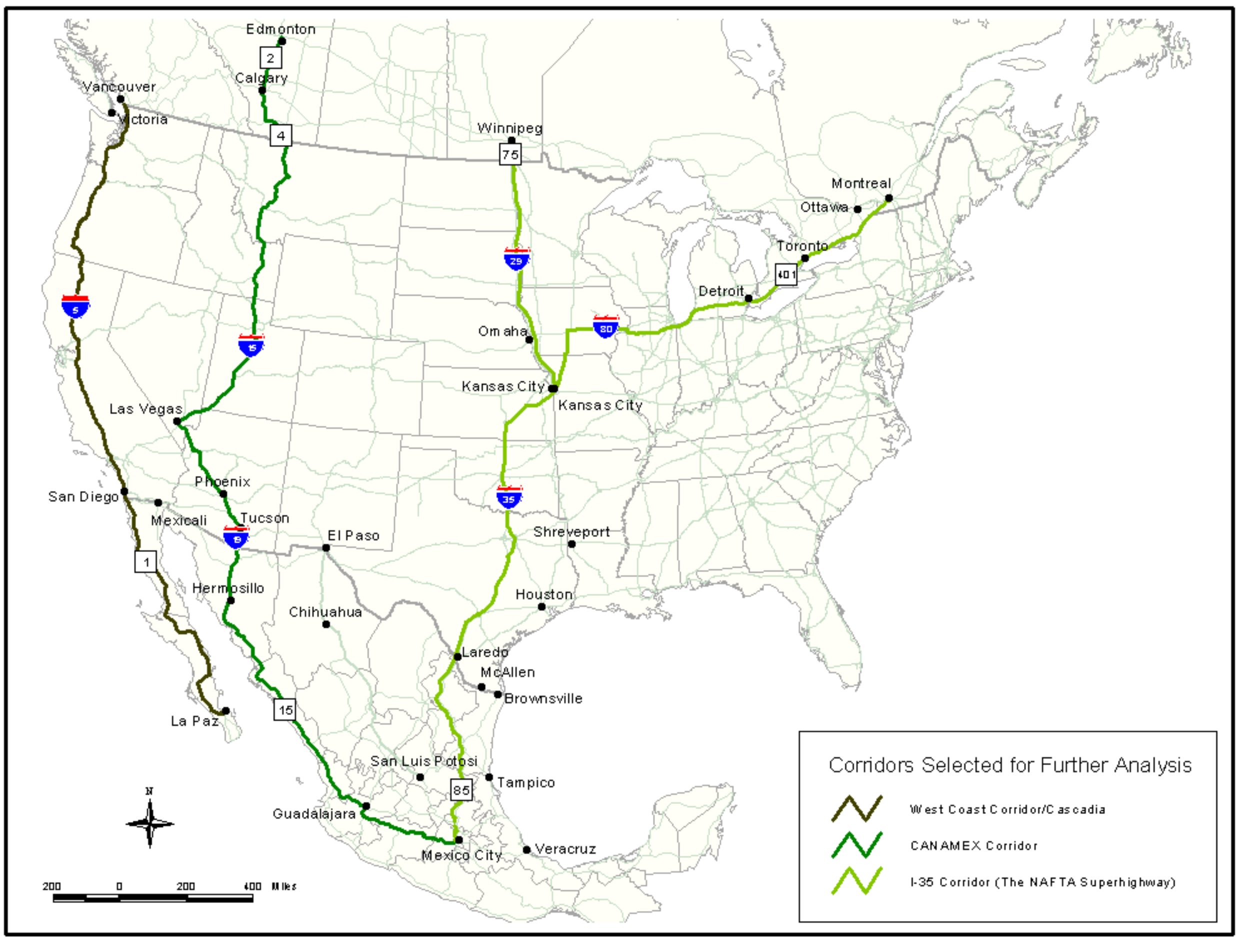
Initially, seven major corridors were identified based on a review of previous studies. Three corridors stood out as being the most significant in terms of Canada-U.S.-Mexico trade: the West Coast Corridor, the CANAMEX Corridor, and the North American Superhighway Corridor. We solicited feedback from the Stakeholder Advisory Group (SAG) to verify the appropriateness of these three corridors and to identify segments that should serve as the focus of the study. These corridors are shown in Exhibit 2 and described below.

- The West Coast Corridor runs from Vancouver, British Columbia, along the West Coast of the U.S. following Interstate 5, to Tijuana, Mexico and further south into Baja

California. It is also sometimes known as the Cascadia Corridor, the I-5 Corridor, or the Pacific Highway. The U.S. portion is federally designated as High Priority Corridor #30. Rail service runs parallel to the highway route throughout most of the corridor.

- The CANAMEX Corridor runs from Edmonton, Alberta through Calgary and into Montana, then to Salt Lake City, Las Vegas and Phoenix before crossing the Mexican border at Nogales and continuing to Hermosillo and Guadalajara. The U.S. portion has been designated as High Priority Corridor #26. It is sometimes referred to as the I-15 Corridor. Parallel rail service runs south from Tucson.
- The North American Superhighway Corridor (NASCO) runs from Winnipeg, Manitoba through Omaha, Kansas City, Dallas and Laredo, Texas, then enters Mexico and runs through Monterrey to Mexico City. It is also called the Mid-Continent Corridor or the I-35 Corridor, while the northern portion is also called the Red River Trade Corridor. A branch runs east from Kansas City through Chicago, Detroit, and on to Toronto and Montreal. Parallel rail service runs throughout the entire corridor.

Exhibit 2: Selected North American Trade and Transportation Corridors



These three corridors were characterized along the following dimensions: 1) the transportation system (highway and rail), 2) socioeconomic characteristics of the major urban areas, and 3) an identification of critical segments along the full corridors. Five of these critical segments were then selected for detailed analysis of trade, transportation and environmental impacts. The goal was to define segments that are long enough to allow the capture of trade impacts beyond the immediate border area but short enough so that corridor freight activity is still dominated by NAFTA trade. In selecting the segments, we chose those that were identified as most critical by SAG members, those that cross an international boundary, and those that offer both highway and rail alternatives. The five segments are listed below:

- West Coast Corridor North (Vancouver British Columbia to Seattle/Olympia, Washington)
- North American Superhighway Corridor Northwest (Winnipeg, Manitoba to Fargo, North Dakota)
- North American Superhighway Corridor Northeast (Toronto, Ontario to Detroit/Ann Arbor, Michigan)
- North American Superhighway Corridor South (San Antonio, Texas to Monterrey, Nuevo Leon)
- CANAMEX Corridor South (Tucson, Arizona to Hermosillo, Sonora)

2.2 Commodity Flows

Commodity flow data were used to analyze trade and transportation in each corridor segment. By building the analysis off a base of commodity flow data rather than simply vehicle counts, we can explore issues such as origin/destination patterns, changes in trade levels in particular industries, changes in vehicle size and weight, and shifts in mode share.

The commodity flow information was developed from analysis of the Transborder Surface Freight Dataset, maintained by the U.S. Bureau of Transportation Statistics. This dataset is populated electronically from customs reports and is considered fairly accurate for border crossings by surface transportation modes. The dataset includes information on shipment weight and value, mode, commodity, port of entry (POE), and state/province of origin and destination. The dataset does not include a single file that contains all of this detail simultaneously, however. In particular, no file contains both commodity detail and POE detail. Therefore, we estimated commodity flows through particular POEs by multiplying the commodity mix between each state/province pair by the portion of flow between that pair that uses the particular POE. In addition, adjustments to the database were needed to account for the fact that U.S. exports are reported only in terms of shipment value. To convert these values to weight, we used the U.S. import files to estimated value to weight ratios for each commodity (and in the case of Canada-U.S. flows, for each province).

Because the commodity flow analysis was conducted using a database built from U.S. Customs Service records, shipments between Canada and Mexico are not represented. Canada-Mexico commodity flows are currently small compared to flows between these counties and the U.S., and can be considered as having no significant impact when conducting a transportation and environmental analysis. Two-way Canada-Mexico merchandise trade totaled $7.5 billion in 1999, only 2% of the value of Canada-U.S. merchandise trade and 4% of U.S.-Mexico merchandise trade. These amounts are therefore likely within the margin of accuracy for the data and analysis in this report.

Table 1 summarizes truck and rail commodity flows through the five corridor segments.[2] The Toronto-Detroit Corridor (which includes both the Detroit-Windsor and Port-Huron crossings) carries by far the highest freight tonnage – more than the other four corridors combined. All corridors have significant rail flows though only in one (Winnipeg-Fargo) does rail tonnage exceed truck tonnage.

Table 1: Summary of 1999 Cross-Border Commodity Flows (millions of kg)

Corridor Segment	By Truck			By Rail			By Truck and Rail		
	N-bound	S-bound	Sub-Total	N-bound	S-bound	Sub-Total	N-bound	S-bound	Total
Vancouver-Seattle	3,112	3,711	6,822	840	3,557	4,398	3,952	7,268	11,220
Winnipeg-Fargo	2,098	2,358	4,456	652	4,132	4,784	2,750	6,490	9,240
Toronto-Detroit *	22,355	21,677	44,032	5,466	12,104	17,569	27,821	33,780	61,601
San Antonio-Monterrey	7,281	10,345	17,626	2,994	5,950	8,944	10,275	16,295	26,571
Tucson-Hermosillo	2,385	1,390	3,775	981	579	1,560	3,366	1,969	5,335

* Northbound flows are U.S. to Canada, Southbound flows are Canada to U.S.

2.3 Freight Vehicle Movements

Determining environmental impacts requires information on freight vehicle movements, both full and empty, in a corridor. Commodity flows may not be proportional to freight vehicle traffic because many vehicles travel empty or carry less than their maximum capacity. We collected information on cross-border truck and rail movements from U.S. Customs, Canada Customs, and private bridge and tunnel operating authorities.[3] These agencies report crossings for all commercial vehicles, including smaller two- and three-axle trucks that may not be engaged in international trade. Because the focus of this study is NAFTA-related trade, we calculated the number of larger trucks (four or more axles) at each crossing, and assumed that this represents the number of trade-related freight trucks. Smaller trucks are typically service-related vehicles that are not engaged in long-distance merchandise trade. Information on truck size at the border crossings is available from a variety of border crossing surveys, though it is not consistently reported.[4] In corridors where the border region is sparsely populated, such as Winnipeg-Fargo, nearly all freight traffic at the border is associated with longer-distance trade, and large trucks make up over 95% of all trucks. Where large population centers lie on each side of the border, a higher percentage of service trucks cross the border daily and tend to bias commercial vehicle counts.

[2] Note that the full commodity flow tables include origin or destination information by 50 U.S. states and 98 commodities (2-digit Harmonized Tariff System) and therefore cannot easily be displayed in a report format.
[3] Southbound truck volumes at Nogales were not available, and were assumed to equal northbound volumes.
[4] See *1995 Commercial Vehicle Survey: Station Summary Report*; *Bi-National Border Transportation Planning and Programming Study*; Leidy 1995; *Lower Mainland Truck Freight Study;* and *Prairie Provinces Transportation System Study*.

Cross-border rail car volumes were available for some corridors but not for all. Some customs stations do not compile rail car traffic statistics at all, or do not distinguish between full and empty cars. At other crossings, like the rail tunnels between Ontario and Michigan, the information is considered proprietary. As described below, this lack of information did not preclude emissions calculations because rail emissions are determined from freight tonnage and fuel consumption.

We also used the commodity flows to estimate freight vehicle movements. Commodity flow tonnage was converted to the number of loaded freight vehicles (truck trailers or rail cars) using average payload information. For trucks, average payloads were derived from commodity densities by 2-digit Harmonized Tariff System (HTS) code while for rail cars, average payloads were developed from the 1992 Rail Waybill Sample.[5] [6] These figures were then used to calculate the number of loaded freight vehicles. For truck freight, a scaling factor was derived for each corridor and direction that relates commodity flow tonnage to total vehicle counts. This scaling factor was used to estimate how future changes in commodity flows would affect vehicle movements.

Table 2 shows cross-border volumes of freight vehicles. Trade truck volumes are based on counts at border stations and include both full and empty vehicles. Rail volumes represent loaded cars only, calculated from commodity flow data.

Table 2: Cross-Border Freight Traffic Volumes, 1999

Corridor Segment	Trade Trucks (loaded and empty)			Rail Cars (loaded only)		
	N-bound	S-bound	Total	N-bound	S-bound	Total
Vancouver-Seattle	396,586	426,464	823,050	12,156	51,429	63,585
Winnipeg-Fargo	172,295	190,433	362,728	10,478	53,638	64,116
Toronto-Detroit *	2,337,266	2,340,007	4,677,273	78,869	202,947	281,816
San Antonio-Monterrey	1,189,209	1,045,324	2,234,533	56,451	87,200	143,651
Tucson-Hermosillo	219,471	219,471	438,942	13,792	8,831	22,623

* Northbound flows are U.S. to Canada, Southbound flows are Canada to U.S.

2.4 Future Trade Scenarios

Trade growth scenarios were developed to investigate environmental impacts in 2020 under alternative conditions. A 2020 Baseline Scenario was developed for each bi-national corridor segment based on historic trends and forecasts from other studies. Because the past decade has been a period of historically high trade growth among NAFTA countries as well as a period of relatively strong economic growth overall, the Baseline Scenarios in all five cases envision somewhat slower growth than seen in recent years. The scenarios are not intended to be trade forecasts, but merely illustrate a range of possible future conditions. The impacts of each

[5] Figliozzi, 2001.
[6] Hancock, 2001.

Baseline Scenario are then compared with one or more alternative scenarios, each of which assumes some change to the transportation industry or infrastructure in the corridor. In some cases, the alternatives include more rapid trade growth by either truck or rail. Other alternatives assume a change in shipping cost by one mode, resulting in mode shifts. The magnitude of the mode shifts was estimated using the cross elasticities shown in Table 3.[7] These figures describe the percentage of rail freight diverted given a change in the relative cost of shipping by truck versus rail. For example, a one percent decrease in trucking cost would shift 3.6% of railroad's finished farm produce tonnage to trucking. These elasticities account for the fact that some products are more suited to one mode or another and are unlikely to experience diversion under any cost changes.

Table 3: Rail Ton-Mile Cross-Elasticity by Commodity

Commodity	Rail Ton-Mile Cross Elasticity
Bulk Farm Products	0.03
Finished Farm Products	3.60
Bulk Food Products	0.73
Finished Food Products	2.10
Lumber and Wood	0.65
Furniture	0.44
Pulp and Paper	0.82
Bulk Chemicals	0.58
Finished Chemicals	3.35
Primary Metals	1.35
Fabricated Metals	6.25
Machinery	4.25
Electrical Machinery	4.45
Motor Vehicles	0.25
Motor Vehicle Parts	1.25
Waste and Scrap	0.19
Bulk All Else	0.18
Finished All Else	4.20

2.5 Emission Factors

In each corridor, we calculated the impact of cross-border trade on emissions of oxides of nitrogen (NOx), volatile organic compounds (VOC), carbon monoxide (CO), particulate matter less than 10 microns in diameter (PM-10), and carbon dioxide (CO2). Air pollution emissions are generally calculated by applying freight vehicle activity data to emission factors. Properly determining these emission factors is critical to the analysis process and the resulting conclusions. Details of their development are provided below.

[7] From *A Guidebook for Forecasting Freight Transportation Demand*.

1999 Truck Emission Factors

Heavy-duty truck emission factors for NO_x, VOC and CO were estimated using the U.S. EPA's MOBILE5 model. PM-10 emission factors were estimated using EPA's PART5 model, and CO_2 factors were estimated from fuel combustion characteristics for diesel.[8] All trade trucks were assumed to be powered by diesel engines. Two sets of emission factors were developed – an on-highway emission rate based on a 55 mph average speed and an idle emission factor. Fuel economy data were based on annual average fuel economy statistics as published by the U.S. Department of Energy.[9]

The emission factors are dependent upon the age of the fleet and mileage accumulation rates. The age distributions for the U.S. and Canadian trucks were based on line haul truck registration data. The trucks were assumed to have national average levels of tampering and not subject to an Inspection/Maintenance program. PM-10 factors only reflect exhaust emissions, not re-entrained road dust. The Mexican line-haul fleet was assumed to have the same age distribution as Canada and the U.S. However, pre-1993 Mexican trucks are treated as unregulated emissions (pre-1988 U.S. fleet with appropriate mileage accumulation), since Mexico had no diesel truck emission standards prior to that model year. We assumed the Mexican drayage fleet (for cross-border movements) was an average of five years older than the U.S. and Canadian line-haul fleets, with the resulting net effect that only 10% of the fleet was post-1993 trucks. Diesel fuels in Mexico were assumed to be the same as the U.S., with 500 parts per million (ppm) sulfur.

2020 Truck Emission Factors

Calculations of emissions in 2020 depend heavily on the assumptions about future-year truck emission factors. In December 2000, the U.S. EPA approved very stringent emission standards for model year 2007 and later heavy-duty highway engines. NO_x emissions under the new standards will be 20 times lower than current standards, while VOC and PM-10 emissions will be ten times lower. The standards will be phased in over three years, with all new engines meeting the standards by 2010. The dramatic emission reductions are made possible largely because of U.S. EPA rules regarding the sulfur content of diesel fuel. Emissions control technologies for heavy-duty diesel engines, such as catalytic particulate filters and NO_x catalysts, are not able to function with high sulfur levels in diesel fuel. EPA's December 2000 rulemaking requires that by 2006, the sulfur content of diesel be reduced to 15 ppm, down from the current standard of 500 ppm. Canada has adopted a similar standard. For this study, we assumed that the new heavy-duty truck emissions standards would take effect as scheduled in both the U.S. and Canada. However, it is possible that implementation of the new standards will be delayed, and this would result in considerably higher 2020 emission factors for U.S. and Canadian trucks.

Emission factors for 2020 were determined in the same way as for 1999, but with the inclusion of the 2004 and the new U.S. 2007 diesel regulations. We assumed that Canada will adopt the new U.S. diesel standards and they will take effect concurrent with the U.S. standards. A version of the MOBILE5 model was run which incorporates the 2004 emission standards (note that the 2004 standards do not affect PM emissions). Since the MOBILE5 and PART5 models do not

[8] Stodolsky, 2000
[9] *Annual Energy Outlook*.

currently include the 2007 emission standards, these were incorporated outside the model assuming no deterioration and a current conversion factor for brake-horsepower versus fuel consumption. In 2020 only 8.4% of the line haul fleet will be 2006 or earlier trucks.

Emission factors for the 2020 Mexican line-haul fleet assumed adoption of the U.S. 2004 standards, but not the more stringent 2007 standards. The Mexican line-haul fleet was assumed to have the same age and fleet distribution as the U.S. and Canadian line-haul fleets. Separate emission factors for the older drayage truck fleet were not used in 2020. We assume that use of these vehicles for cross-border movements will be phased out. Diesel fuels in Mexico were assumed to remain at the current level of 500 ppm sulfur. All truck emission factors are shown in Tables 4 and 5.

Table 4: Truck Emission Factors, Freeway

		Truck Emission Factors, Freeway (g/mile)				
		NOx	VOC	CO	PM10	CO2
1999	U.S./Canada	12.8	1.06	6.50	0.75	1612
	Mexico Line Haul	19.3	1.50	7.28	1.13	1612
2020	U.S./Canada	1.38	0.32	6.21	0.051	1612
	Mexico	4.73	0.96	6.21	0.262	1612

Table 5: Truck Emission Factors, Idling

		Truck Emission Factors, Idling (g/minute)				
		NOx	VOC	CO	PM10	CO2
1999	U.S./Canada	0.78	0.21	1.76	0.036	173
	Mexico Drayage	1.72	0.39	2.44	0.082	173
2020	U.S./Canada	0.08	0.05	1.68	0.003	173
	Mexico	0.32	0.19	1.95	0.017	173

One result of the new emissions standards is that by 2020, truck emissions of NO_x and PM-10 per ton-kilometer are considerably lower than rail in the U.S.-Canada corridors. In the three U.S.-Canada corridors studied here, rail NO_x and PM-10 emissions per ton-kilometer are two- to three-times higher than trucking. (The variation depends on the amount of border delay for trucks.) In the U.S.-Mexico corridors, rail NO_x and PM-10 emissions per ton-kilometer remain slightly lower than those for trucks. In all corridors, rail emissions of CO and CO2 per ton-kilometer are only about one-tenth of the rate for trucks.

Rail Emission Factors

Rail locomotive emissions are typically calculated based on fuel use rather than miles of travel. In April 1998, the U.S. EPA finalized emission standards for NOx, hydrocarbons (HC), CO, PM-10 and smoke for newly manufactured and rebuilt diesel-powered locomotives, which had been unregulated in the U.S. before this action. The standards call for a 45% reduction in NO_x emissions for locomotives built between 2002 and 2004, and a 59% reduction in NO_x for those built in 2005 and later. Hydrocarbon and PM-10 emissions for locomotives built in 2005 and later must be 40% lower. Because of the long life of locomotives, the benefits of these new standards will be only partially realized by 2020. We assume that both Canada and Mexico will adopt similar standards. Sulfur in fuel contributes to particulate emissions, so the introduction of low-sulfur diesel in the U.S. and Canada will likely reduce locomotive PM-10 emissions even without new control technologies. There is very little information on this effect to date, but one study suggests that PM-10 may be reduced approximately 19%.[10] We have incorporated this reduction to estimate 2020 U.S. and Canadian locomotive emissions, shown in Table 6.

Table 6: Locomotive Emission Factors

	Locomotive Emission Factors (g/gal)				
	NOx	HC	CO	PM10	CO2
1999	269.4	10.0	26.5	6.69	21.68
2020	140.0	7.9	26.5	3.96 (4.89)*	21.68

* Mexican locomotives

To calculate 1999 railroad fuel use, we estimated an average fuel consumption rate per revenue-ton-mile of freight hauled.[11] This figure (386 ton-miles per gallon) reflects all Class 1 railroad operations in the U.S. Railroads are becoming more fuel efficient for several reasons, including the introduction of more AC-generation locomotives, the development of more efficient diesel engines, and lower rail car tare weights. To estimate the fuel consumption rate for 2020, a curve was fit to historic data and projected to future years. Fuel efficiency is thus projected to reach 456 revenue ton-miles per gallon in 2020.[12] Fuel consumption rates were applied to corridor railroad ton-miles for 1999 and the 2020 scenarios. Fuel consumption was then multiplied by the emission factors to estimate locomotive emissions.

It is quite possible that the availability of low sulfur diesel will lead to future emissions standards for locomotives that are lower than the 2005 standards. In the U.S., Argonne National Laboratory is beginning research study of advanced emission controls for locomotives. However, there are currently no plans to reduce locomotive emission standards in the U.S. If lower standards are implemented before 2020, the slow turnover of the locomotive fleet means that the average emission rates in 2020 will probably not be very different from those shown in Table 6.

2.6 Stakeholder Advisory Group

The study was guided by a Stakeholder Advisory Group (SAG). The role of the SAG was to assist the research team with: 1) the selection of trade and transportation corridors, 2) the identification of existing environmental initiatives in the corridors, and 3) the selection of environmental mitigation measures for analysis. The SAG will also provide comments on this

[10] *Diesel Fuel Effects on Locomotive Exhaust Emissions.*
[11] *Railroad Facts*.
[12] *Air Quality Issues in Intercity Freight.*

working paper. In addition, it is hoped that the SAG will play a role in increasing awareness of the project's results and thereby help to sustain the long-term goals of the effort.

The SAG is comprised of representatives from both government and non-government organizations (NGOs). Government representatives include staff from environmental agencies (Environment Canada, U.S. Environmental Protection Agency, Instituto Nacional de Ecología de Mexico), trade/commerce agencies (Canadian Department of Foreign Affairs and International Trade, U.S. Department of Commerce, Secretaría de Economía de Mexico) and transportation/energy agencies (Transport Canada, U.S. Department of Energy, Secretaría de Comunicaciones y Transportes de Mexico). The SAG also includes a representative from at least one NGO in each country, including the Manitoba Clean Environment Commission, Environmental Defense, the Foundation for Intermodal Research and Education, and a Mexican trucking company.

3 CURRENT TRADE AND AIR QUALITY IMPACTS

This section describes the current levels of trade-related transportation activity in each corridor and its impacts on air quality. Emissions are estimated for four criteria pollutants (NO_x, VOC, CO and PM-10) as well as CO_2. From the freight transportation sector, NO_x and PM-10 emissions present the biggest concern and the greatest potential for air quality benefits. NO_x is a precursor to ground-level ozone (smog) and is chiefly produced by high-compression internal combustion engines. PM-10 includes the fine soot particles produced in diesel engines. Most of the particulate matter from trucks and locomotives consists of the fine particles known as PM-2.5, which are most dangerous to human health. In the U.S., heavy-duty trucks are responsible for approximately 20% of mobile source NO_x and PM-10 emissions nationwide, while locomotives contribute approximately 5%.

In each corridor, we identify urban areas that do not meet national air quality standards for ozone, particulate matter or CO. Note that the U.S. EPA recently announced its intention to revise the existing ozone and PM-10 standards. For ozone, the one-hour standard will be replaced with an eight-hour standard to protect against longer exposure periods. The PM-10 standard will be supplemented with a new PM-2.5 standard, based on the recognition that these fine particles contribute more to health effects than coarse particles. Implementation of these standards has been halted because of legal challenges. If they do take effect, they may result in some urban areas in the corridors being re-classified to non-attainment status. Canada is also ratifying a nationwide PM-2.5 standard

The freight sector is not a major contributor of CO nationally. But heavy-duty trucks can contribute significantly to localized concentrations (hot spots) of CO in urban areas. CO_2 is a common gas and does not pose a direct threat to human health. However, it is the primary component of the greenhouse gases (GHGs) that contribute to global warming.

In general, the emissions calculations involve multiplying truck and rail traffic volumes by the corridor length by the appropriate emission factor. Although they are similar, the five corridor segments are not exactly equal in length. In order to simplify the comparisons between corridor segments in terms of total trade-related emissions and the impacts of border delay, the length of the corridor segments have been standardized for the purpose of emissions calculations. Thus, each corridor segment is assumed to be 364 kilometers long (226 miles). This is the exact length of the Winnipeg-Fargo corridor and the Vancouver-Seattle/Olympia corridor. The other three corridors (Toronto-Detroit/Ann Arbor, San Antonio-Monterrey, and Tucson-Hermosillo) are slightly longer, so the emissions calculations reflect freight movement along only a portion of the full corridor segment.[13]

Truck idling emissions are also estimated based on border delay and presented separately. The impact of border idling generally looks quite small as compared to full corridor emissions. If shorter segments were chosen for analysis, the contribution of idling would appear greater.

To get a sense of the significance of corridor emissions associated with NAFTA trade, we compare them to an inventory of all mobile source emissions. The U.S. EPA prepared a 1996 national inventory at the county level for REMSAD modeling that was based on the EPA's National Emission Trends inventory. We sum the emissions for all the counties in the corridor, including all counties traversed by the highway route(s) and those within 20 kilometers of the highway. The sum, the aggregate mobile source emissions for the corridor area, is compared against the trade-related emissions. A county-level inventory was not available for CO_2.

3.1 Vancouver-Seattle Corridor

Exhibit 3

The northern segment of the West Coast Corridor (Exhibit 3) starts in Vancouver, which has a population of approximately 1.8 million. Vancouver is home to major seaports and is the western terminus of both the Canadian Pacific (CP) and Canadian National (CN) railroads. Highway 99 runs south of Vancouver to the U.S. border at Blaine, Washington. Commercial vehicles cross nearby to the east at BC Highway 15. In the U.S. the corridor follows Interstate 5 to the Seattle region, which has major seaports and a population of 3.4 million. CP and CN rail service runs from Vancouver to the U.S. border, where they meet BNSF lines continuing to Seattle and farther south. The aggregate population of the corridor is 5,473,000. By 2020, this population is forecast to grow 36% to 7,451,000.

This segment carries the fifth highest volume of truck freight between the U.S. and Canada. Under the U.S. Clean Air Act, the Seattle-Tacoma area (King and Pierce Counties) is designated as a Non-attainment Area for particulate matter (PM-10). It is also a

[13] Toronto-Detroit is 377 kilometers (234 miles); San Antonio-Monterrey is 496 kilometers (308 miles); Tucson-Hermosillo is 406 kilometers (252 miles).

Maintenance Area for ozone (under the one-hour standard) and carbon monoxide. The Lower Fraser Valley (Vancouver area) has had ozone problems in the past, though there have been no exceedances of Canadian national objectives in recent years.

Commodity flows in the corridor are dominated by wood and paper products, reflecting the concentration of these industries in the Pacific Northwest region. Southward flows of these products are much heavier than northward flows. Total surface commodity flows in 1999 were 11.1 million metric tons, with 61% carried by truck. The bulk of trade trucks move between British Columbia and Washington, Oregon and California. Most rail flows originate in BC or Alberta, and move to the U.S. West Coast or Texas.

For emissions calculations, the corridor is assumed to extend from Vancouver to Olympia, Washington, a distance of 364 kilometers (226 miles). Average commercial vehicle border delay is assumed to be 37 minutes in both directions.[14] All freight flows are assumed to move the full length of the segment. Trade-related emissions for the corridor segment are shown in Table 7. Truck freight contributes the bulk of emissions, including 76% of NOx, 88% of VOC and PM-10, and over 90% of CO and CO2. Truck idling at the border is responsible for 4% of CO emissions. Comparing emissions with the mobile source inventory for the region that encompasses the U.S. corridor segment, trade emissions make up 4.6% of PM-10 and 2.8% of NOx.

Table 7: Vancouver-Seattle Corridor Trade Emissions, 1999 (kg/day)

	NOx	VOC	CO	PM10	CO2
Truck Line Haul	6,533	540	3,312	382	821,535
Truck Idling	65	18	147	3	14,459
Truck Subtotal	6,598	558	3,460	385	835,994
Rail	2,030	78	206	52	76,465
Total	8,628	635	3,666	437	912,459
Total in U.S. Segment	6,946	534	3,090	366	765,441
% of Mobile Source Inventory	2.8%	0.3%	0.2%	4.6%	N/A

3.2 Winnipeg-Fargo Corridor

The northwest portion of the North American Superhighway Corridor (Exhibit 4) runs south on Highway 75 from Winnipeg, which has a population of 667,000. The highway route crosses the border at Emerson, Manitoba and Pembina, North Dakota, then continues on I-29 to Fargo, with a population of 170,000. The rest of the corridor is mostly rural and sparsely populated. The aggregate 1999 corridor population is 949,000. Population in the corridor is forecast to grow slowly, reaching 1,016,000 by 2020, a 7% increase. A rail line runs south from Winnipeg, crossing the border just east of Pembina at Noyes, Minnesota, where it joins the extensive BNSF

[14] *WTA and BCTA Trucking Survey Results Summary*

network. The Emerson-Pembina crossing is the seventh largest in terms of U.S.-Canada truck freight by weight. The U.S. portion of the corridor does not include any Non-attainment or Maintenance Areas under the U.S. Clean Air Act. Similarly, Winnipeg has not had any recent violations of Canadian national air quality objectives.

Exhibit 4

Approximately 9.2 million metric tons of freight moved through the corridor in 1999, equally split between trucking and rail. The mix of commodities carried by truck is more diverse than in the other Canada-U.S. corridors, and no single commodity group dominates the flow. There are large southbound flows of agricultural products (animals, oil seeds, processed plant products), wood and coal. Northbound shipments include large flows of agricultural supplies like animal feed and fertilizer, plus machinery and paper. Most truck flows through the corridor are between Manitoba and the upper midwestern states of Minnesota, North Dakota, Illinois and Wisconsin. Rail flows show a heavy imbalance (87%) in the southbound direction. They are dominated by fertilizer shipments (largely to Minnesota, Illinois and Indiana) and cereals shipments (largely to Minnesota and Illinois).

The length of the corridor is 364 kilometers (226 miles). No information is available on average border delay for trucks, but peak queues can reportedly have 30 to 40 vehicles.[15] We assume 25 minutes of average delay, less than the Pacific Highway crossing but more than the 20 minutes reported at uncongested crossings. All freight flows are assumed to move the full length of the segment. Table 8 shows emissions from NAFTA freight in the corridor. This corridor shows the highest contribution of rail to total trade emissions, including 44% NO_x and 25% of PM-10. Compared to the emissions inventory for the area of the U.S. corridor segment, trade contributes 15.7% of mobile source PM-10 emissions and 11.3% of mobile source NOx, the highest portions of the five corridors examined. The high significance of trade-related emissions in this corridor is expected since the U.S. portion is relatively sparsely populated and lacks a large industrial base.

[15] *Canada/U.S. International Border Crossing Infrastructure Study*.

Table 8: Winnipeg-Fargo Corridor Trade Emissions, 1999 (kg/day)

	NOx	VOC	CO	PM-10	CO2
Truck Line Haul	2,879	238	1,460	168	362,061
Truck Idling	19	5	44	1	4,306
Truck Subtotal	2,899	243	1,504	169	366,366
Rail	2,279	84	225	57	83,176
Total	5,178	328	1,728	226	449,543
Total in U.S. Segment	3,344	226	1,199	155	309,667
% of Mobile Source Inventory	11.3%	1.0%	0.5%	15.7%	N/A

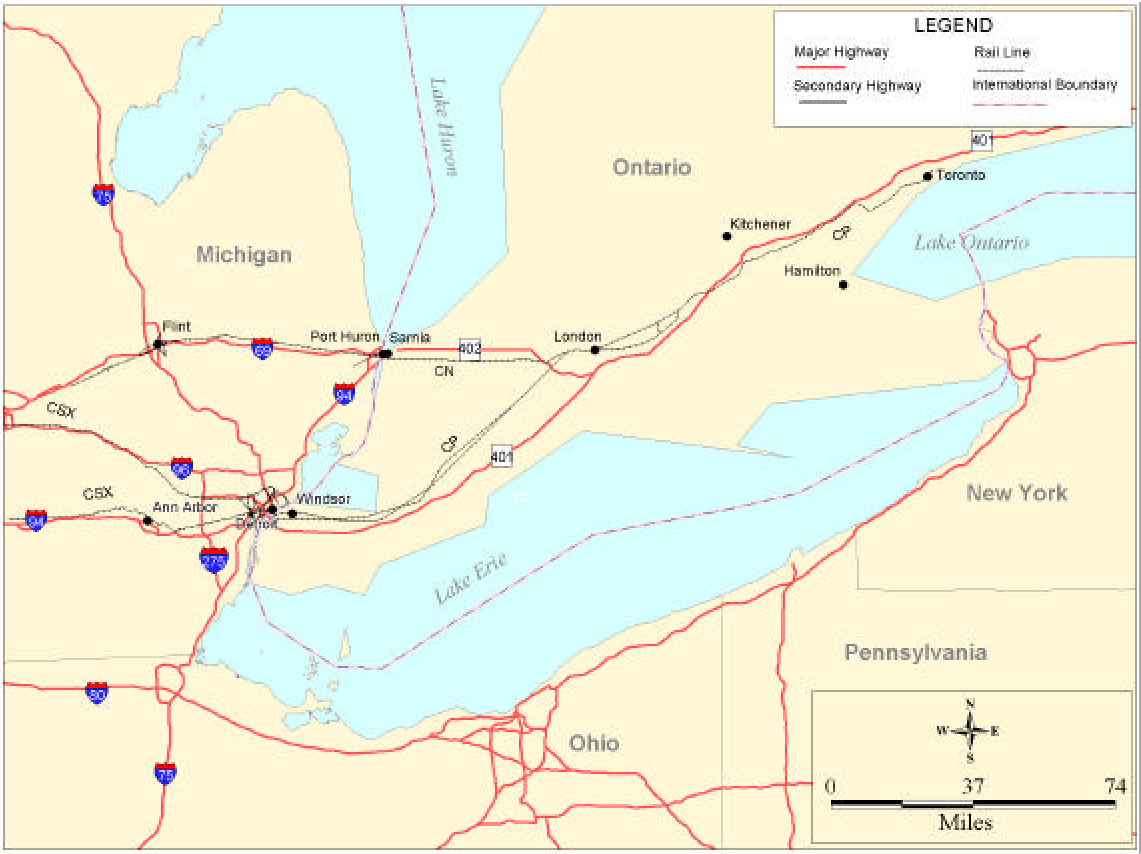
3.3 Toronto-Detroit Corridor

The northeastern branch of the North American Superhighway Corridor (Exhibit 5) runs west from Toronto along Highway 401. It passes through the heavily populated regions of southwest Ontario before crossing the international border at Windsor-Detroit. Most commercial vehicles here use the Ambassador Bridge, though some also use the Detroit-Windsor Tunnel. The busiest border crossing in North America, the Ambassador Bridge carried 12.5 million vehicles in 1999, including 3.4 million trucks. From Detroit, I-94 runs west to Ann Arbor and, eventually, Chicago. As an alternative route, trucks can drive due west from London, Ontario using Highway 402 to cross at the Blue Water Bridge between Sarnia and Port Huron. The Blue Water Bridge was recently doubled to six lanes, and carried 4 million vehicles in 1999, including 1.5 million trucks. The Detroit-Windsor and Port Huron-Sarnia crossings rank first and third in terms of U.S.-Canada truck freight by weight.

CN and CP rail lines largely parallel the highway routes. CP operates the Detroit-Windsor rail tunnel while CN operates the St. Clair River Tunnel at Sarnia. The St. Clair River Tunnel is a new facility handling modern double-stack cars and RoadRailer service. Norfolk Southern, Conrail and BNSF all provide service between Detroit and points west. The 1999 aggregate corridor population is approximately 10.7 million, including 2.3 million in the Toronto area and 4.3 million in the Detroit area. Population is forecast to grow by 24% by 2020, reaching 13.2 million. Most of this growth will occur in southwestern Ontario, as Detroit's population is expected to remain fairly stable. Under the current U.S. EPA standards, the Detroit region is a Maintenance Area for ozone and carbon monoxide, while Wayne County (Detroit) is a Maintenance Area for PM-10. The Windsor-Toronto corridor has Canada's highest ozone and particulate matter levels, with an average of several violations of national ozone level objectives each year.

Two-way commodity flows through these border crossings (Windsor-Detroit and Sarnia-Port Huron) total over 61 million metric tons, more than the commodity flows through the other four corridor segments combined. Approximately 72% of the tonnage moves by truck. Approximately one-quarter of all truck shipments in the corridor are automobiles and related parts, though there are also large flows of steel, wood, paper products and machinery. Michigan is the dominant endpoint for truck shipments on the U.S. side, with neighboring states of Ohio, Illinois and Indiana accounting for much of the rest. Rail flows are also large, with tonnage to the U.S. more than twice that in the reverse direction. Rail flows of autos and auto parts are heavy into the U.S., though they are not significant in the reverse direction. Chemicals are the largest commodity group shipped into Ontario, followed by plastics and cereals. Rail flows into Ontario originate largely in Texas.

Exhibit 5



For emissions calculations, a 364 kilometer (226 mile) highway route was assumed (roughly Kitchener, Ontario to Ann Arbor, Michigan). The route through Port Huron-Sarnia is 21 kilometers longer than the route through Detroit. No information is available on average delay at any of the three crossings. Observations suggest that both the Ambassador and Blue Water Bridges do not experience significant commercial vehicle delays on average.[16] Thus, border delay was assumed to be 20 minutes, consistent with other crossings without large queues. All freight flows are assumed to move the full length of the segment.

Emissions from NAFTA trade are shown in Table 9. This corridor has the highest levels of both truck and rail emissions of the five corridors studied – nearly twice the levels of the next highest corridor, San Antonio-Monterrey. Truck freight contributes the bulk of emissions – 81% of NO_x and over 90% of the other pollutants. Truck idling at the border contributes 2% of the trade-

[16] See *Canada/U.S. International Border Crossing Infrastructure Study*; Giermanski 1999.

related CO emissions. Compared to the mobile source emissions inventory for the area of the U.S. segment, trade-related emissions make up a significant portion of NO_x (4.8%) and PM-10 (7.4%). Given that the Detroit metropolitan area is home to over 5 million people and contains a major industrial presence, this high percentage is somewhat surprising, and it underscores tremendous trade volumes in the corridor.

Table 9: Toronto-Detroit Corridor Trade Emissions, 1999 (kg/day)

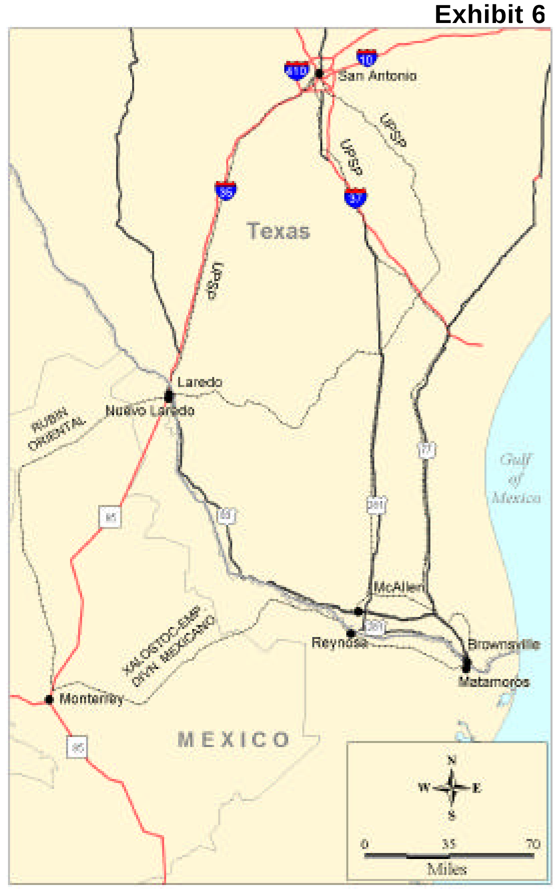
	NOx	VOC	CO	PM10	CO2
Truck Line Haul	37,764	3,122	19,147	2,209	4,748,684
Truck Idling	199	54	452	9	44,415
Truck Subtotal	37,963	3,176	19,599	2,218	4,793,098
Rail	8,700	322	857	216	317,516
Total	46,663	3,498	20,456	2,434	5,110,615
Total in U.S. Segment	13,315	996	5,829	671	1,415,665
% of Mobile Source Inventory	4.8%	0.4%	0.2%	7.4%	N/A

3.4 San Antonio-Monterrey Corridor

The southern segment of the North American Superhighway Corridor (Exhibit 6) runs south from San Antonio on I-35 to Laredo at the Mexican border. In Mexico, the route follows MX 085 (also toll road 85D) to Monterrey. Rail service to Laredo is provided by Union Pacific (UP), BNSF and the regional Texas Mexican Railway Company (Tex Mex). The UP lines provide direct connections with Mexico's Ferrocarril del Noreste (FNE). The FNE line largely parallels MX-085, running from Laredo through Monterrey to Mexico City.

The aggregate corridor population in 1999 is 4.2 million, including 1.1 million in both San Antonio and Monterrey. Tremendous growth is forecast for this corridor, with 2020 corridor population expected to reach 6.4 million. The fastest growth is expected in the border area. Webb County, Texas, which includes Laredo, is expected to grow over 2.5 times by 2020, reaching 507,000. Nuevo Laredo's population will be at least 440,000 by 2020. Air pollution from ozone and particulate matter is a serious problem in Monterrey. In 1997, Mexican air quality standards were exceeded on 36

Exhibit 6



days for ozone and nine days for PM-10. Air pollution levels in Laredo and Nuevo Laredo do not currently exceed the health-based ambient standards for the United States or Mexico, though there are few monitoring stations in the area.

Total 1999 commodity flows in the corridor were over 33 million metric tons, with 71% carried by truck. Southbound commodities by truck were led by coal, plastics, electrical equipment and auto parts. Much of this freight is component parts that are assembled in Mexico and trucked back to the U.S. as finished products. Thus, northbound truck flows are led by electrical equipment, machinery and automobiles. A large part of truck freight (44%) moves to and from Texas. After Texas, however, the common truck shipment endpoints are located far from the border, in states like Michigan, California and Illinois. This reflects the fact that the corridor serves U.S.-Mexico trade relationships throughout the U.S. rather than just those between neighboring border states. Nearly two-thirds of rail commodity flows are southbound. Raw materials like wood pulp, cereals, cement and stone, and coal are the leading southbound rail commodities, originating in Texas, Georgia and midwestern farming states. Northbound rail flows are led by automobiles shipped to Michigan and beverages shipped to Texas.

Any analysis of U.S.-Mexico trade flows must consider the impact of maquiladora factories. Begun in 1965, the maquiladora program consists primarily of manufacturing plants just south of the border that assemble finished products using U.S. components, then ship the products back to the U.S. As a percentage of total trade, maquiladoras have the greatest impact on the El Paso-Cuidad Juarez and San Ysidro-Tijuana crossings. Both Nuevo Laredo and Nogales have large numbers of maquiladoras as well. At Laredo-Nuevo Laredo, it is estimated that 13% of northbound trade and 12% of southbound trade is associated with maquiladoras.[17] Because this freight generally does not move the full length of the corridor segment, we adjusted the truck activity data accordingly.

For emissions calculations, we assumed a 364 kilometer (226 mile) corridor, which would extend as far north as roughly Pearsall, Texas. There are two major border crossings for trucks in the corridor. The Lincoln-Juarez Bridge connects the downtown areas of Laredo and Nuevo Laredo and lies at the end of I-35 and MX 085. The other crossing is the Columbia Bridge, located 35 kilometers (22 miles) northwest of the downtown areas. Use of this crossing adds approximately 64 kilometers to a border crossing trip, though border crossing delays are significantly less. Recent surveys indicate that 61% of trade trucks in this corridor use the Lincoln-Juarez Bridge with the remainder using the Columbia Bridge. Our calculation of 1999 emissions impacts assumes this split.

Current regulations restrict the operation of Mexican trucks in the U.S. to only commercial zones around the border crossing.[18] Similarly, U.S. carriers are generally not allowed to operate on Mexican federal highways. Because of these restrictions and customs processing requirements, the U.S.-Mexico trade corridors have developed a unique system of transferring freight. In general, both northbound and southbound freight is carried to terminals in the border region

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[17] *Binational Border Transportation Planning and Programming Study*.

[18] A recent NAFTA arbitration panel ruled in favor of allowing full access to Mexican trucks, and the Bush Administration has indicated that it will comply. As described in Section 4, we assume that the restrictions will be lifted in analyses of future scenarios.

using line-haul trucks. Trailers are then pulled across the border using drayage trucks that are largely Mexican-owned. Once across the border, line haul trucks carry the freight to its ultimate destination. Drayage trucks are generally older than line-haul trucks and produce higher emissions per mile. To account for this system in emissions calculations, we assume that all truck freight between San Antonio and Laredo moves by U.S. line-haul trucks, and all freight between Nuevo Laredo and Monterrey moves by Mexican line-haul trucks. Cross-border moves, which include only a fraction of the full trip distance but all of the border delay idling, are assumed to be done by Mexican drayage trucks in both directions.

Table 10 shows emissions in the corridor in 1999. Truck freight contributes 84% of NO_x and over 90% of the other pollutants. Truck idling contributes 6.3% of trade-related CO emissions, the highest portion of the five corridors. Compared to the mobile source inventory for the region encompassing the U.S. segment, NAFTA trade is responsible for 12.4% of PM-10 emissions and 8.5% of NOx, second only to Winnipeg-Fargo in this regard.

Table 10: San Antonio-Monterrey Corridor Trade Emissions, 1999 (kg/day)

	NOx	VOC	CO	PM-10	CO2
Truck Line Haul	21,129	1,707	9,665	1,236	2,316,476
Truck Idling	480	110	682	23	38,925
Truck Subtotal	21,609	1,817	10,347	1,259	2,355,401
Rail	4,261	158	420	106	155,523
Total	25,871	1,975	10,767	1,364	2,510,924
Total in U.S. Segment	15,566	1,303	7,615	863	1,794,510
% of Mobile Source Inventory	8.5%	0.9%	0.5%	12.4%	N/A

3.5 Tucson-Hermosillo Corridor

The southern segment of the CANAMEX Corridor (Exhibit 7) runs south from Tucson, Arizona (pop. 804,000) on I-19 to the border. Nogales, Arizona is a small city (pop. 20,000), but its counterpart in Sonora State is over eight times larger. From Nogales, Sonora, the corridor route follows MX 015 south to Santa Ana and Hermosillo (pop. 609,000). UP provides rail service from Tucson to Nogales, where the line connects with the Ferrocarril Del Norte Pacifico network, which runs down the west coast of Mexico. The 1999 aggregate population in the corridor is 1.7 million, with a 2020 forecast of over 2.4 million. Nogales, Arizona (Santa Cruz County) is a PM-10 Non-attainment area under the current U.S. EPA standards, and Nogales, Sonora is also believed to exceed PM-10 standards.[19] Tucson is a Maintenance Area for carbon monoxide. No air quality information is available for Hermosillo.

This corridor carries 5.3 million metric tons of commodities, 71% by truck. Unlike the Laredo-Nuevo Laredo crossing, the Nogales crossing serves primarily trade between the neighboring

[19] *U.S.-Mexico Border Environmental Indicators 1997.*

Exhibit 7

border states (Arizona and Sonora). Northbound truck freight consists of vegetables and fruits/nuts bound for Phoenix and other urban markets. Nogales is the only major U.S.-Mexico border crossing that experiences significant seasonal fluctuations in trade, due to the high percentage of agricultural products. Southbound truck freight consists of plastics, iron and steel, coal, and electrical equipment. No significant tonnage of truck freight currently moves between Mexico and the northern parts of the CANAMEX corridor. Rail carries 1.5 million metric tons of freight in the corridor, led by northbound shipments of cement and stone to Arizona. Northbound automobile shipments by rail are also significant, originating at the Ford plant in Hermosillo. Southbound rail flows include ores and steel from Arizona and auto parts from Michigan.

For emissions calculation, the corridor was assumed to be 364 kilometers (226 miles) in length, running as far south as the town of Carbó in Sonora State. Trucks cross the border at the Mariposa crossing, approximately 2.5 kilometers west of downtown Nogales. Rail traffic crosses at the DeConcini gate in the downtown area. Border crossing delay for trucks averages 50 minutes northbound and 20 minutes southbound.[20] As with the San Antonio-Monterrey corridor, we assume that the line haul portion of truck trips are conducted by U.S. and Mexican trucks in their respective countries, while cross-border movements (and all idling) is done by the Mexican drayage fleet. Maquiladora trade is a significant part of the total at this crossing, and was recently estimated to be 29% of northbound and 47% of southbound trade.[21] Truck activity data was adjusted to account for this in emission calculations.

NAFTA-trade emissions in the corridor are shown in Table 11. Trucking contributes 83% of NO_x and over 90% of the other pollutants. Truck idling at the border is responsible for 6.2% of CO emissions from trade, second only to the Laredo/Nuevo Laredo crossing in this percentage. Compared to the inventory of all mobile source emissions of the area encompassing the segment, NAFTA trade has a smaller impact than in the other corridors. Trade-related emissions for the U.S. segment make up 4.3% of the PM-10 inventory and 2.7% of the NO_x inventory.

[20] *Binational Border Transportation Planning and Programming Study*
[21] *Binational Border Transportation Planning and Programming Study*.

Table 11: Tucson-Hermosillo Corridor Trade Emissions, 1999 (kg/day)

	NOx	VOC	CO	PM-10	CO2
Truck Line Haul	3,515	279	1,480	205	344,028
Truck Idling	72	17	103	3	7,294
Truck Subtotal	3,587	296	1,583	209	351,323
Rail	743	28	73	18	27,125
Total	4,330	323	1,656	227	378,448
Total in U.S. Segment	1,370	125	738	80	167,870
% of Mobile Source Inventory	2.7%	0.3%	0.2%	4.3%	N/A

3.6 Other Freight Transportation Modes

Waterborne Freight

Waterborne trade accounts for a substantial portion of freight flows in North America. Approximately 56% of Canada-Mexico trade tonnage moves by water. Major commodities include oil seeds and cereals southbound and petroleum northbound. Between Canada and the US, more than 20% of freight tonnage moves by water. Canadian maritime exports to the U.S. are led by coal, petroleum and paper products, while imports consist primarily of petroleum. (Figures for US – Mexico trade are less complete, but also show large amounts of maritime trade.)[22] While this trade has been growing steadily on an absolute basis, it has been losing market share. Ten years ago waterborne freight accounted for 63% of Canada-Mexico trade and 28% of Canada-U.S. trade.

Much of the Canada-U.S. waterborne trade moves between Atlantic Ocean ports and therefore does not have direct environmental impacts within the NAFTA corridors analyzed in this report. However, both the Great Lakes and West Coast ports also handle large volumes of NAFTA trade. Hamilton, Ontario, at the western end of Lake Ontario, is the largest Canadian port in terms of the value of maritime shipments from the U.S. The port of Vancouver ranks second for U.S. exports.

Nearly all U.S.-Mexico waterborne trade moves through the Gulf of Mexico. The trade is dominated by U.S. oil imports originating on the coast of Campeche and Veracruz, moving to ports in Texas and Louisiana. There are also significant U.S.-Mexico shipments from the port of Altamira, near Tampico. This route may provide an alternative to the land-borne route of San Antonio-Monterrey-Mexico City

[22] U.S. Department of Transportation, Bureau of Transportation Statistics, U.S. Department of Commerce, Census Bureau; Statistics Canada; Transport Canada; Instituto Mexicano del Transporte; Instituto Nacional de Estadística, Geografíe Informática; and Secretaría de Comunicaciones y Transportes, *North American Transportation in Figures*.

Large freight ships are usually powered by residual fuel oil (bunker fuel), and most also have diesel motors for auxiliary on-board power. Emissions depend on several factors, including the distance traveled and the type and age of the vessel engines. The loading and unloading time spent in port may be an important factor in their impact on urban air quality. On the whole, maritime emissions are a small portion of total emissions. A 1997 emissions inventory for the U.S. found that marine vessels contribute 1.0% of NO_x emissions nationwide and 0.1% of PM-10.

The large percentage shares of trade might suggest that maritime serves a broad variety of markets, and that there is as a result a possible opportunity to use it more extensively as an emissions reduction strategy. Certainly maritime does serve a wide variety of markets. Further, innovations such as feeder barges have shown the ability to carry traffic that would otherwise have gone to rail, and demonstrate the potential to increase their services. Overall, however, these large tonnage market shares reflect the fact that intra-North American maritime trade generally has the same commodity characteristics as other water-borne transit, and is best suited for bulk commodities.

Pipeline

There are also large commodity flows via pipeline from Canada to the U.S., primarily petroleum and natural gas. Canada exported 52 million metric tons of fuels via pipeline in 1999, a larger tonnage than southbound truck and rail commodity flows in any single corridor. Nearly all of this originates in Alberta and flows to the midwestern and central plains states. The emissions impacts of pipelines generally depend on the stationary engines used to compress or pump the pipeline fluids.

4 FUTURE TRADE SCENARIOS AND AIR QUALITY IMPACTS

Trade and transportation in all five corridors will grow substantially in coming years. This section presents trade scenarios for 2020 and an estimate of their air quality impacts. A 2020 baseline scenario is developed for each corridor based on likely trade growth rates. Alternative scenarios are then used to compare changes in trade growth or changes to the transportation industry against the baseline. All air quality impacts are estimated using the 2020 emission factors described in Section 2.

It is difficult to predict border crossing delay 20 years into the future. All five corridor segments will experience a two- to four-fold increase in traffic, which will undoubtedly overburden some existing border facilities. At the same time, the infrastructure at all border crossings is likely to be upgraded substantially. For example, there are currently plans to add a fourth crossing linking Laredo with Nuevo Laredo, and the Ambassador Bridge Authority has indicated it will twin that bridge when the need arises. Given these uncertainties, for the purposes of 2020 emissions calculations we assume the same border crossing delay through each port of entry system as exists currently.

4.1 Vancouver-Seattle Corridor

Baseline Scenario

The 2020 Baseline Scenario for the Vancouver-Seattle corridor envisions truck and rail commodity flows growing at 4.2% annually, resulting in total flows of 26.6 million metric tons by 2020. This is more than Transport Canada forecasts for growth in freight tonnage by for-hire trucking (2.3% annually through 2015), but less than recent growth in cross-border truck volumes (6.5% annually between 1986 and 1996).[23] [24]

Table 12 shows trade-related emissions in 2020 under the Baseline Scenario. Due to the dramatic improvement expected in truck emissions, and to a lesser extent, rail emissions, NO_x and PM-10 emissions drop to less than half of the 1999 levels despite a more than doubling of freight tonnage. Rail emissions make up a much larger portion of total trade emissions than in 1999 – 57% of NO_x and 55% of PM-10. Emissions of CO and CO2 more than double compared to 1999, similar to the growth in trade.

Table 12: Vancouver-Seattle Corridor Trade Emissions, 2020 Baseline Scenario

	Annual Commodity Flow (million kg)	Annual Vehicles*	Emissions (kg/day)				
			NOx	VOC	CO	PM-10	CO2
Truck	16,186	1,952,758	1,678	399	7,842	62	1,983,469
Rail	10,434	150,860	2,187	123	415	62	153,569
Total	26,620	N/A	3,865	522	8,256	123	2,137,038
Percent of 1999	237%	237%	44%	82%	225%	28%	234%

* Loaded rail cars only

Alternative Scenario – Improved Rail Service

We explore the impact of an alternative scenario in which rail captures a larger mode share of future commodity flows. The Washington State Department of Transportation recently began a "Short-Haul Intermodal Initiative," an effort to promote rail service improvements that would allow rail to capture a larger share of intermodal traffic between British Columbia and Washington. There are other opportunities to further improve rail service in the corridor. For example, the existing BNSF line north of Seattle includes several tunnels that don't allow modern double-stack container operations. And the proposed merger of CN and BNSF would reportedly cut transit times between Vancouver and California by 12 to 24 hours.

Trucking currently captures 61% of surface freight in the corridor, including 87% of the higher value products (over $1 per pound). Truck and rail mode share is almost evenly split for the lower value commodities (under $1 per pound), which indicates an opportunity for rail to capture a larger share.

[23] *Freight Transport Trends & Forecasts to 2015*.
[24] *Transportation and North American Trade*.

To estimate the impact of rail service improvements, we assume a 10% rail shipping cost reduction and apply this to the cross-elasticities shown in Table 3. The result is a diversion of over 700,000 metric tons of freight from truck to rail, a 6.8% increase in rail tonnage over the 2020 baseline. Diverted commodities are led by wood, plastics, wood pulp and fertilizers. Truck traffic in the corridor drops by 84,000 vehicles annually. Because of the large improvements expected in truck NO_x and PM-10 emissions, the impact of the mode shift is an 2.1% increase in NO_x emissions and a 1.4% increase in PM-10. Emissions of other pollutants fall by 1.5% to 3.6%, as shown in Table 13.

Table 13: Vancouver-Seattle Corridor – Impact of Improved Rail Service (kg/day)

	NOx	VOC	CO	PM-10	CO2
1999	8,693	635	3,666	437	912,459
2020 Baseline	3,865	522	8,256	123	2,137,038
2020 Improved Rail Service	3,945	514	7,961	125	2,065,803
Percent Change (2020 Baseline vs. Alternative)	2.1%	-1.5%	-3.6%	1.4%	-3.3%

4.2 Winnipeg-Fargo Corridor

Baseline Scenario

Under the 2020 Baseline Scenario, truck and rail freight tonnage in the Winnipeg-Fargo corridor grows by 6% annually, resulting in a total of 31.4 million metric tons. Table 14 shows 2020 emissions under the Baseline Scenario. Emissions of NO_x and PM-10 fall to 86% and 60% of 1999 levels respectively. While this drop is striking in the face of tripling freight volumes, it is less than the reduction in the other two U.S.-Canada corridors because of the large mode share for rail. Rail freight is not expected to reduce emission rates as dramatically as trucks, and thus will be responsible for approximately three-fourths of trade-related NO_x and PM-10 by 2020. CO2 emissions from trade increase to more than three times 1999 levels.

Table 14: Winnipeg-Fargo Corridor Trade Emissions, 2020 Baseline Scenario

	Annual Commodity Flow (million kg)	Annual Vehicles*	Emissions (kg/day) NOx	VOC	CO	PM-10	CO2
Truck	15,150	1,233,117	1,057	250	4,884	39	1,245,485
Rail	16,262	217,966	3,408	192	646	96	239,357
Total	31,412	N/A	4,465	442	5,530	135	1,484,842
Percent of 1999	340%	340%	86%	135%	320%	60%	330%

* Loaded rail cars only

Alternative Scenario – Higher Growth in Truck Traffic

Several indicators suggest that truck traffic could grow more rapidly than a 6% annual rate. Between 1986 and 1996, truck volumes at the Emerson-Pembina crossing have increased by an average of 9.4% per year. Exports to Canada from Minnesota, Manitoba's leading trade partner, increased by 9.9% annually over the past six years. Winnipeg's mayor expects that trade in the corridor could grow by 12% annually in the short term.[25] While Winnipeg has long served as a transport hub for east-west movements across the Prairie Provinces, there is at least anecdotal evidence that future growth will be in north-south trade instead. Winnipeg is strategically positioned within 24 hours driving time of large U.S. markets in Wisconsin, Minnesota and Illinois. Some industry representatives have predicted that Winnipeg-Minneapolis will become a strong trade corridor in future years.[26]

As an alternative to the 2020 Baseline Scenario, we calculate freight volume and emissions if truck freight were to grow at 9% annually. Total commodity flow tonnage would be 38% higher than under the Baseline assumptions, shown in Table 15. Railroad freight still contributes the bulk of NO_x and PM-10 trade emissions, but trucking's share rises from only one-quarter to over one-third. Unlike the 2020 Baseline, NO_x emissions are slightly higher than in 1999. CO2 and CO emissions rise nearly 70% compared to the Baseline levels, and are now over 5 times the levels in 1999.

Table 15: Winnipeg-Fargo Corridor – Impact of Greater Truck Traffic

	Annual Commodity Flow (million kg)	Emissions (kg/day) NOx	VOC	CO	PM-10	CO2
1999	9,240	5,178	328	1,728	226	449,543
2020 Baseline	31,412	4,465	442	5,530	135	1,484,842
2020 Higher Truck Growth	43,486	5,307	641	9,422	166	2,477,417
Percent Change (2020 Baseline vs. Alternative)	38%	19%	45%	70%	23%	67%

4.3 Toronto-Detroit Corridor

Baseline Scenario

Because economic relationships between Ontario and the Midwestern states were already well-developed by the early 1990's, growth in freight traffic through this corridor has been less than total bi-national trade growth in recent years. Between 1986 and 1996, truck traffic through the three crossings grew by 5.7% per year.[27] Another study estimates that future trade through this corridor will grow by 5% annually.[28] This figure is used as the basis for the 2020 Baseline

[25] Toulin, 1999
[26] *Prairie Provinces Transportation System Study*.
[27] *Transportation and North American Trade*.
[28] *Southwest Ontario Frontier International Gateway Study*.

Scenario for both truck and rail commodity flows. Total cross-border tonnage reaches 172 million metric tons by 2020.

Trade-related emissions for the 2020 Baseline Scenario are shown in Table 16. NO_x emissions fall to less than half 1999 levels, and PM-10 emissions fall to less than one-third 1999 levels. Rail and trucking now contribute roughly equal amounts of these pollutants. Both CO and CO2 emissions rise to 2.7 times their 1999 levels, in proportion to the growth in freight volume.

Table 16: Toronto-Detroit Corridor Trade Emissions, 2020 Baseline Scenario

	Annual Commodity Flow (million kg)	Annual Vehicles*	Emissions (kg/day) NOx	VOC	CO	PM-10	CO2
Truck	122,672	13,030,708	11,342	2,674	52,165	416	13,353,393
Rail	48,947	785,129	10,662	600	2,021	302	748,796
Total	171,619	N/A	22,004	3,274	54,186	718	14,102,189
Percent of 1999	279%	279%	47%	94%	265%	29%	276%

* Loaded rail cars only

Alternative Scenario – Improved Rail Service

Over the last decade, railroads have lost mode share for intermodal freight in this corridor.[29] Both CN and CP are now investing in new technologies in an attempt to recapture some of this traffic from trucking. Two prominent developments are the Iron Highway and RoadRailer service. The Iron Highway, originally developed by CSX, uses long, articulated platforms that are divided in the middle to form ramps. Truck trailers can be easily loaded and unloaded without the need for cranes. CP is marketing this service in southern Ontario and Quebec under the name "Expressway." RoadRailer technology, currently used by Norfolk Southern Railway in the U.S., employs specialized truck trailers that can be converted to rail cars using detachable wheel/axle assemblies (bogies). Conventional locomotives can pull a train of up to 120 RoadRailer trailers. CN has introduced the service in the Toronto-Detroit corridor and plans to extend RoadRailer service to Chicago. There is also the potential to use VIA passenger trains to pull express freight using RoadRailer technology. These service improvements could significantly increase rail mode share, while additional rail service improvements could be achieved if the Detroit-Windsor tunnel is expanded to handle modern double-stack and auto carrier trains. In the Baseline Scenario, the trucking mode share is 71% of all freight in the corridor, including 60% of the lowest value commodities (under $1 per pound). This suggests significant opportunities for rail to capture a greater mode share.

We analyze the impact of an alternative growth scenario with improved rail service. A 10% reduction in rail shipping cost relative to trucking is assumed, and applied to the cross-elasticities in Table 3. The result is a 12% increase in rail tonnage compared to the Baseline (about 5.8 million metric tons), with plastics, iron and steel, and automobile parts making up the majority of diverted commodities. Nearly 600,000 trucks are removed from the corridor annually. Table 17 shows the emissions impacts of this modal diversion relative to the Baseline. Because of the

[29] *Assessment of Modal Integration & Modal Shift Opportunities*.

emissions advantage of trucking in 2020, NO_x and PM-10 rise by 3.7% and 2.7% in this scenario. Emissions of other pollutants fall, with CO and CO2 emissions declining more than 3%.

Table 17: Toronto-Detroit Corridor – Impact of Improved Rail Service (kg/day)

	NOx	VOC	CO	PM-10	CO2
1999	46,663	3,498	20,456	2,434	5,110,615
2020 Baseline	22,004	3,274	54,186	718	14,102,189
2020 Improved Rail Service	22,818	3,240	52,381	737	13,667,435
Percent Change (2020 Baseline vs. Alternative)	3.7%	-1.0%	-3.3%	2.7%	-3.1%

4.4 San Antonio-Monterrey Corridor

Baseline Scenario

The rate of trade growth in this corridor is expected to be the highest of the five included in the study. Recent trends show tremendous increases in both truck and rail traffic. While these rates reflect the early years of NAFTA and will likely slow somewhat, strong growth is still expected. Bi-national trade through the corridor differs from the other major U.S.-Mexico corridors in that it is dominated by trade with Mexico’s central industrial region rather than with border maquiladoras. Commodity flows consist of a variety of goods and are not significantly dependent on any one industry. The 2020 Baseline Scenario assumes 6.8% annual growth through 2020, resulting in nearly 106 million metric tons of freight by that year.

To estimate environmental impacts, the Baseline Scenario assumes a lifting of border operating restrictions for both U.S. and Mexican trucks. A recent NAFTA arbitration panel ruled in favor of allowing full access to Mexican trucks, and the Bush Administration has indicated that it will comply. Half the trucks operating the full corridor are assumed to be U.S. carriers, and half Mexican. As described in Section 2, the 2020 emission factors for Mexican line-haul trucks are significantly lower than in 1999, but still higher than U.S./Canada emission factors because they do not assume the use of low-sulfur diesel fuel. The use of older drayage trucks to pull trailers over the border is assumed to be phased out, so line haul trucks carry all freight between San Antonio and Monterrey. The fraction of maquiladora trade is assumed to remain constant. There are currently two bridges available for trucks crossing in the Laredo/Nuevo Laredo area. The Colombia Bridge opened in 1991 its use has been growing steadily. It offers less delay but adds 70 kilometers to a trip. Another crossing is planned for the downtown area. To estimate 2020 emissions, we assume that half of trade trucks will use the Columbia Bridge (up from 40% currently) and the other half will use existing and new downtown crossings.

Emissions under the 2020 Baseline Scenario are shown in Table 18. With respect to NO_x and PM-10 emissions, all of the growth in trade activity in the corridor is offset by cleaner vehicles, resulting in a slight decline compared to 1999 levels. Trucking continues to contribute the bulk of these emissions – 71% of NO_x and 80% of PM-10. CO and CO2 emissions grow the most rapidly of the five corridors, increasing four-fold.

Table 18: San Antonio-Monterrey Corridor Trade Emissions, 2020 Baseline Scenario

	Annual Commodity Flow (million kg)	Annual Vehicles*	Emissions (kg/day) NOx	VOC	CO	PM-10	CO2
Truck	70,171	8,895,760	18,078	3,882	38,427	924	9,703,413
Rail	35,608	571,880	7,463	420	1,415	226	524,098
Total	105,779	N/A	25,541	4,302	39,842	1,150	10,227,511
Percent of 1999	398%	398%	99%	218%	370%	84%	407%

* Loaded rail cars only

Alternative Scenario – Higher Growth in Truck Traffic

Several factors could lead to growth in freight movement by truck that exceeds the Baseline Scenario. Truck border crossings at Laredo grew by an astonishing 11.4% annually between 1990 and 1997.[30] While this period includes the early years of NAFTA, it also includes the U.S. recession in the early 1990's and the Mexican financial crisis in 1995. The San Antonio-Monterrey corridor serves as the primary conduit for U.S.-Mexico trade and will continue to do so. Not only does it link the U.S. with Monterrey, Mexico's third largest city, but it also serves as the primary link between Mexico City and the U.S. Thus, as the U.S.-Mexico trade relationship continues to mature and broaden beyond maquiladoras, this corridor will undoubtedly maintain its prominence.

Lifting the operating restrictions that currently prevent U.S. and Mexican trucks from operating in each other's territory will also likely boost truck freight. The U.S. limits the operation of Mexican trucks to commercial zones around the border municipality and, in response, Mexico bans U.S. trucks from its federal highways. Due to these restrictions, truck shipments between the countries are carried by at least three different vehicles – a line-haul truck to the border area, a drayage truck across the border, and another line-haul truck to the final destination. Allowing full cross-border access for U.S. and Mexican could reduce shipment costs substantially.

To explore the impact of more rapid growth in truck traffic, we assume that truck freight in the corridor grows at 8.6% annually, consistent with recent trends. This would result in 2020 commodity flows by truck that are 5.5 times 1999 levels. Truck volumes would increase at the same rate, if truck size and empty backhaul percentages remain constant. Rail freight volumes are assumed to grow at Baseline levels (6.8% annually). The environmental implications of this scenario are significant, as shown in Table 19. Pollutant emissions are 30 to 40% higher than under the 2020 Baseline Scenario. Unlike the Baseline, in which the lower emission factors for NO_x and PM-10 more than offset the growth in traffic since 1999, this alternative scenario produces considerably higher NO_x and PM-10 emissions compared to 1999. CO and CO2 emissions rise to over five times their current levels.

[30] Because of a change in data reporting procedures at the Laredo customs station, counts for 1998-2000 cannot be compared to those for 1997 and earlier.

Table 19: San Antonio-Monterrey Alternative Scenario – Impact of Greater Truck Traffic (kg/day)

	NOx	VOC	CO	PM-10	CO2
1999	25,871	1,975	10,767	1,364	2,510,924
2020 Baseline	25,541	4,302	39,842	1,150	10,227,511
2020 Greater Truck Traffic	33,142	5,934	55,999	1,538	14,307,441
Percent Change (2020 Baseline vs. Alternative)	30%	38%	41%	34%	40%

Alternative Scenario – Higher Growth in Rail Traffic

Another alternative scenario for the corridor involves a higher annual growth in rail traffic. Between 1990 and 1997, the average annual growth in Laredo-Nuevo Laredo rail car crossings was 11.7%, even higher than the growth in truck traffic. Several factors could ensure that strong growth in rail freight continues. Mexico's railroads were privatized in 1997, and after several years of investment, are now showing high levels of efficiency and profitability. Transportacion Ferroviaria Mexicana (TFM) is the principal trunk-line carrier between Mexico City, Monterrey and Nuevo Laredo. The railroad has recently made numerous infrastructure improvements in the corridor, including a new train control system between Monterrey and Nuevo Laredo, new switching yards near the border, and many expanded sidings. Transit times from Nuevo Laredo to Mexico City have been reduced from 60 hours to 34 hours for intermodal trains and 44 hours for merchandise trains.[31] TFM's partnership with the Kansas City Southern and Texas-Mexican Railroads are also succeeding in improving the efficiency of cross-border rail shipments. The greatest potential for rail in the corridor may lie with intermodal freight, and both U.S. and Mexican railroads are investing in new or improved intermodal facilities.

As an alternative 2020 scenario, we assume 9% annual growth in rail freight tonnage through the corridor. This results in 54.6 million metric tons of rail freight through the corridor in 2020, a six-fold increase over 1999 levels. Truck freight growth follows the Baseline Scenario. Table 20 shows the emissions impacts of this scenario. Pollutant emissions rise between 2% and 16% compared to the Baseline, with emissions of NO_x and PM-10 showing the greatest increase. However, the emissions impacts are considerably less than the first alternative scenario of greater truck traffic.

Table 20: San Antonio-Monterrey Alternative Scenario – Impact of Greater Rail Traffic (kg/day)

	NOx	VOC	CO	PM-10	CO2
1999	25,871	1,975	10,767	1,364	2,510,924
2020 Baseline	25,541	4,302	39,842	1,150	10,227,511
2020 Greater Rail Traffic	29,530	4,526	40,598	1,270	10,507,629
Percent Change (2020 Baseline vs. Alternative)	16%	5%	2%	10%	3%

[31] Vantuono, 1999.

4.5 Tucson-Hermosillo Corridor

Baseline Scenario

Commodity flows through this corridor reflect less diversity than those passing through other large U.S.-Mexico corridors, and include more minerals and agricultural products. Thus, trade growth is not expected to match the high levels seen in the San Antonio-Monterrey corridor. The 2020 Baseline Scenario envisions an annual growth rate of 4.6%. Total freight reaches 13.7 million metric tons by 2020.

As with the San Antonio-Monterrey corridor, truck operating restrictions are expected to be lifted by 2020, so both U.S. and Mexican carriers operate the full length of the segment without the use of drayage at the border. The fraction of maquiladora trade is assumed to remain constant. Table 21 shows emissions under the 2020 Baseline. Both NO_x and PM-10 emissions fall to nearly half of 1999 levels due primarily to lower truck emission rates. Trucking is still responsible for most of these emissions – 68% of NO_x and 77% of PM-10. As in the other corridors, emissions of CO and CO2 increase in proportion with trade volumes.

Table 21: Tucson-Hermosillo Corridor Trade Emissions, 2020 Baseline Scenario

	Annual Commodity Flow (million kg)	Annual Vehicles*	Emissions (kg/day) NOx	VOC	CO	PM-10	CO2
Truck	9,706	1,128,684	1,798	389	4,056	91	1,024,372
Rail	4,011	58,172	841	47	159	27	59,042
Total	13,718	N/A	2,639	436	4,215	118	1,083,415
Percent of 1999	257%	257%	61%	135%	254%	52%	286%

* Loaded rail cars only

Alternative Scenario – Mode Shift from Rail to Trucking

An alternative scenario for the Tucson-Hermosillo Corridor explores the impact of a mode shift from rail to trucking. In the Baseline Scenario, trucking carries 71% of all commodities and 64% of the lowest value goods (under $1 per pound), with little change in mode share for longer distances. There are several reasons to believe that as trade grows in this corridor, the rail mode share will decline. First, and most importantly, the freight movements in this corridor are fairly short in distance, which tends to favor trucking. Currently, 72% of truck freight and 75% of rail freight is moving to and from Arizona, and the major population centers of Arizona are within 24 hours driving distance of Nogales, Santa Ana and Hermosillo. Second, truck shipping costs will likely fall when Mexican vehicles are accorded full access to the U.S. highway system. Third, trade growth between Sonora and California will not affect the corridor because it generally moves through Mexicali-Calexico. Fourth, double-stack rail operations are already in place from the U.S. to Hermosillo, so future rail service improvements may be less significant than in other corridors.

To explore the impact of a higher mode share for trucking, we assume a 10% decrease in truck shipping costs relative to rail. When this change is applied to the cross-elasticities shown in Table 3, the result is a 2.7% increase in bi-directional trucking tonnage, with approximately 260,000 metric tons of freight diverted from rail. Annual truck volumes increase by 32,000 vehicles. Table 22 shows the impact of this scenario on emissions. Compared to the 2020 Baseline, NO_x and PM-10 emissions change very little. Emissions of other pollutants rise by 1.8 to 2.5%.

Table 22: Tucson-Hermosillo Corridor – Impact of Mode Shift to Trucking (kg/day)

	NOx	VOC	CO	PM-10	CO2
1999	4,330	323	1,656	227	378,448
2020 Baseline	2,639	436	4,215	118	1,083,415
2020 Greater Truck Mode Share	2,635	444	4,319	119	1,108,381
Percent Change (2020 Baseline vs. Alternative)	-0.2%	1.8%	2.5%	0.6%	2.3%

5 MITIGATION STRATEGIES

The previous section illustrates how strict new standards will dramatically reduce NO_x and PM-10 emissions from trucks. Yet rapid growth in freight transportation will offset much of the gains. In addition, if the new standards for ozone and particulate matter are implemented in the U.S., there will likely be increased emphasis on reducing emissions from diesel engines. A variety of strategies can mitigate some of the air quality impacts associated with freight transportation in NAFTA trade corridors. This section explores five such strategies: alternative fuels, reducing border delay, lower truck emission standards in Mexico, reducing empty freight mileage, and use of longer combination vehicles.

5.1 Alternative Fuels

The use of alternative fuels can play an important role in reducing pollutant emissions from the freight transportation sector. Alternative fuels include compressed natural gas (CNG), liquefied natural gas (LNG), propane, ethanol, methanol, as well as electric vehicles. Most alternative fuel programs to date have focused on lighter two- and three-axle vehicles, such as parcel delivery and service/utility fleets, but larger trucks can also use alternative fuels. Natural gas (LNG and CNG) and propane are the most viable fuels for the larger trucks involved in long distance freight. Because of the need for refueling and maintenance facilities, most use of alternative fuels has thus far been limited to urban areas. In an effort to promote their use for intercity freight, several regions are working to develop “clean corridors” – heavily traveled intercity routes with alternative fueling infrastructure.

The first clean corridor in the U.S. is being developed by a coalition known as the Interstate Clean Transportation Corridor (ICTC). The triangular corridor will link major cities in California and Nevada. The ICTC will provide LNG fuel at 10 locations along the route, servicing approximately 250 heavy-duty trucks and 500 local delivery trucks. Clean corridors are also being promoted as a strategy to mitigate environmental impacts from cross-border freight traffic. In Texas, a coalition of public agencies is working to create a clean corridor along I-35. Called the International Clean Transportation Corridor-3 (ICTC-3), the primary objective of the coalition at this point is education and outreach. The group includes Clean Cities coordinators and stakeholders from the Laredo, Houston, San Antonio, Austin, Dallas/Fort Worth, Oklahoma City, Kansas City, Omaha, Red River Valley, and Winnipeg coalitions. The ICTC-3 also serves as the alternative fuels working group of the North American Superhighway Coalition. The Laredo-San Antonio segment of the corridor is particularly promising because it passes through the two counties (Webb and Zapata) that are Texas' largest natural gas producers. The ICTC-3 is also promoting alternative fuels in Monterrey, Mexico, and recently led a group of U.S. alternative fuel vehicle manufacturers and equipment suppliers to meet with Mexican fleet managers and trade association staff there. Another clean corridor has been proposed for the northern portion of the West Coast Corridor, from Oregon to Vancouver.[32]

Compared to today's heavy-duty diesel trucks, CNG and LNG trucks offer lower emissions of NOx, VOC, CO and PM-10, though the benefits are greatest for PM-10. Table 23 shows that PM-10 emissions per mile from natural gas trucks are 12 times lower than the average U.S. and Canadian truck, and 18 times lower than the average Mexican line-haul truck. If 10% of trucks in any corridor were running on natural gas today, truck PM-10 emissions would reduced by 9% and NO_x emissions would be reduced by approximately 4%. The impact of heavy-duty natural gas vehicles on GHGs is uncertain, as it depends greatly on fuel efficiency assumptions. One recent study found slightly higher CO2 emissions per mile from heavy-duty trucking using natural gas.[33]

Table 23: Truck Line-Haul Emission Factors, 1999

	Emission Factors in g/mile (1999)				
	NOx	VOC	CO	PM10	CO2
Natural Gas	7.5	0.70	5.09	0.06	1709
U.S./Canada Diesel	12.8	1.06	6.50	0.75	1612
Mexico Diesel	19.3	1.50	7.28	1.13	1612

In future years, the emissions benefits of natural gas will decrease as diesel trucks become cleaner. As described in Section 2, the U.S. emission standards beginning in 2007 are dramatically lower than current standards, and would be lower than today's natural gas trucks as well. While natural gas trucks could also benefit somewhat from the control technologies (particulate filters and NO_x catalysts) that will be in place after 2007, it is not clear if they would actually have lower emissions than diesel after that point. Cummins Engine, one of the largest heavy-duty engine manufacturers in North America, is reportedly planning no further enhancements to their CNG engines because of the future availability of low emission diesel engines. Another large manufacturer, Detroit Diesel, will stop producing CNG engines completely. Staff at the U.S. Department of Energy's Argonne National Laboratory estimate that

[32] *Alternative Fuel News*.
[33] Chandler, 2000.

natural gas will maintain an emissions advantage over diesel trucks only to about 2010.[34] For this reason, we have not explored the impact of alternative fuels on the U.S.-Canada trade corridors in 2020. It should be noted, however, that if the introduction of low sulfur diesel is delayed, natural gas trucks may play an important role meeting air quality goals beyond 2010.

In the U.S.-Mexico trade corridors, natural gas vehicles can provide benefits under the assumption that Mexico does not adopt the U.S./Canada low sulfur diesel fuel standards. To explore this mitigation strategy, we calculate emissions in the San Antonio-Monterrey corridor, where efforts to promote use of alternative fuels are already underway. We assume use of natural gas by 20% of Mexican line-haul trucks in the corridor (10% of the total). As under the 2020 Baseline scenario, operating restrictions are assumed to be lifted, allowing both Mexican and U.S. trucks to drive the full corridor distance. The emission factors shown in Table 23 are used for the natural gas trucks, with the exception that NO_x emissions are assumed to equal the lower rates of the 2020 diesel fleet. As shown in Table 24, PM-10 emissions are reduced significantly (13%) under this scenario.

Table 24: Impact of Natural Gas Trucks on San Antonio-Monterrey Corridor, 2020 (kg/day)

	NOx	VOC	CO	PM-10	CO2
2020 Baseline (Trucks)	18,078	3,882	38,427	924	9,703,413
20% Mexican Nat. Gas Trucks	18,078	3,726	37,745	806	9,760,790
Percent Change	0%	-4.0%	-1.8%	-12.7%	0.6%

Other types of alternative fuels and engine technologies could also lower trucking emissions, such as electric hybrid engines or fuel cells. While these options are not yet commercially available for heavy-duty trucks, they may provide a cleaner alternative to diesel by 2020. There has also been some effort to explore the use of alternative fuels in locomotives. Several demonstration projects have found that locomotives retrofitted to run on LNG achieved reduced NO_x emissions. This technology is still in its infancy, however, and cannot currently be considered as a viable mitigation strategy.[35]

5.2 Reducing Border Delay

Commercial vehicles can face considerable delay in crossing North America's international borders – delay during customs procedures and delay in queues to reach the customs station itself. Because trucks spend most of this delay time with engines idling, reducing border delay can reduce vehicle emissions. Options to reduce delay and its air quality impacts are discussed for the two corridors with the highest current levels of delay – San Antonio-Monterrey and Vancouver-Seattle.

[34] Saricks, 2001
[35] *Air Quality Issues in Intercity Freight*.

San Antonio-Monterrey Corridor

The Laredo/Nuevo Laredo Port of Entry System consists of four border crossings. Three of the crossings link the two downtown areas – Convent Street, Lincoln-Juarez and the rail crossing, with Lincoln-Juarez currently handling most commercial truck traffic. The fourth is the Columbia crossing, located 35 kilometers northwest of Laredo, Texas. It opened in 1991 but has been underutilized in part because its distance from the terminus of I-35 and MX-085 adds 64 kilometers to a border crossing trip, but also because roadway connections to the crossings had until recently been inadequate. A new four-lane roadway has just been completed linking the crossing with Monterrey, so usage will likely increase. A fourth vehicle crossing (Laredo IV) is being planned just west of Laredo, as is a new railroad bridge.

All three roadway bridges are privately-owned and charge a toll. On the U.S. side, the U.S. Customs Service handles inspection operations for all crossings. On the Mexican side, the City of Nuevo Laredo and the State of Tamaulipas operate the rail crossing and two downtown vehicle crossings. The Columbia Bridge, however, is located in and operated by the Municipio of Anahuac and the State of Nuevo Leon. This disjointed administrative structure makes it more difficult to coordinate management of the port of entry system.

Border Crossing Procedures

For northbound commercial traffic, the first control point is the Mexican export inspection booth. Processing time by Mexican export officials typically lasts only about one minute, but about two percent of trucks receive export inspections, which last 90 minutes on average. Northbound vehicles then proceed to manually-operated toll booths in order to cross the bridge. On the U.S. side, all trucks (including empty trucks) enter the commercial processing area. Their first stop is the U.S. primary inspection booths. Only document inspection occurs here, lasting about one minute on average, but long queues are common, particularly in the late afternoon. In a 1997 survey, a queue of over 100 trucks lasted from 3:30 to 6:30 pm, with waiting times exceeding two hours. After document inspection, approximately 13% of trucks are selected for secondary inspection, which lasts an average of 28 minutes but can take much longer. All trucks then undergo a final document inspection upon exiting, usually lasting less than one minute. The total average delay for northbound trucks to cross the border is estimated to be 55 minutes, with 31 minutes of this waiting in queues.[36]

Southbound trucks do not receive U.S. export inspection. They proceed directly to the toll booths, where tolls are manually collected. Backups at the toll booths can be extensive. In a survey conducted in 1997, the afternoon peak queue exceeded 200 vehicles and reached over 4.5 kilometers. The creates conflicts with cross traffic on Laredo local streets, and can lead to increased congestion (and emissions) within the City of Laredo. Once on the Mexican side, trucks proceed to the document inspection booths, where approximately 10% of trucks are selected for a primary inspection. Primary inspections at Nuevo Laredo last three to four hours on average. In the past, 10% of vehicles receiving primary inspections were selected for secondary inspection, equivalent to about one percent of total southbound trucks. The secondary inspection is a repetition of the primary inspection (lasting another three hours), performed for

[36] *Binational Border Transportation Planning and Programming Study*.

quality control purposes, and is reportedly being phased out. After completing inspection, Mexican exit processing reviews documents in a process that normally takes less than one minute. The total southbound truck border crossing process is estimated to average 60 minutes.[37]

Opportunities for Delay Reduction

There are significant opportunities to reduce delay at the U.S.-Mexico border. For northbound movements, the U.S. primary inspection booths are the largest capacity constraint. The existing bridge and approach roadway system does not significantly limit northbound vehicle flows, and will never reach saturation flow given the capacity of existing U.S. inspection facilities. Previous studies of the Juarez-Lincoln Bridge have produced several recommendations to improve efficiency at the primary inspection booths, including:[38]

- Adding primary inspection booths;
- Encouraging use of the Columbia Bridge as an alternative crossing;
- Discouraging unnecessary crossing by bobtail trucks (tractors without trailers) by increasing their toll rates or implementing NAFTA provisions to permit more return loads; and
- Encouraging off-peak (late evening) crossing.

Southbound flows are constrained by the processing rate at the toll booths, the Laredo traffic control system, and Mexican customs processing. Recommended efficiency improvements include:

- Encouraging use of the Columbia Bridge as an alternative crossing;
- Improving traffic operations on the bridge approach in Laredo;
- Adding more southbound bridge toll booths;
- Use of electronic toll collection;
- Extending the operating hours of Mexican inspection facilities; and
- Implementing the North American Trade Automation Prototype system to expedite processing.

Environmental Mitigation Impacts

With traffic expected to increase substantially by 2020, future demands on the border crossing system will be great. Several additional crossings have been proposed for the Laredo area, and more will likely be considered in the coming years. Given these uncertainties, it is impossible to predict average truck delay in 2020. We calculate base case emissions under the assumption that capacity improvements are implemented such that average delay remains unchanged. To explore the impacts of reduce border delay, we assumed a lower average delay in 2020 both northbound and southbound.

[37] *Binational Border Transportation Planning and Programming Study*.
[38] *Border Congestion Study: Study Findings and Methodology*.

A recent study of border congestion found that an average of 30 minutes of border crossing delay at Laredo/Nuevo Laredo (Lincoln Bridge) is "avoidable".[39] If current average delay is reduced by this amount, delay per truck would be 25 minutes northbound and 30 minutes southbound. The impact of this change on 2020 truck emissions is shown in Table 25. Emissions from truck idling would fall by 35% for the entire port of entry system. Compared to trade truck emissions along the entire corridor, the impact is much smaller (1.6% reduction in CO). Note, however, that this scenario only estimates the emission reduction from trade trucks. Any improvements at the Lincoln-Juarez Bridge would also reduce passenger vehicle delay and associated emissions at that crossing.

Table 25: Impact of Reduced Border Delay on San Antonio-Monterrey Corridor, 2020 (kg/day)

	NOx	VOC	CO	PM-10	CO2
Baseline Scenario 2020					
Truck Idling	189	124	1,737	10	178,826
Truck Total	18,078	3,882	38,427	924	9,703,413
Reduced Border Delay 2020					
Truck Idling	122	80	1,121	6	115,471
Truck Total	18,011	3,838	37,812	920	9,640,059
Percent Change					
Truck Idling	-35%	-35%	-35%	-35%	-35%
Truck Total	-0.4%	-1.1%	-1.6%	-0.4%	-0.7%

Vancouver-Seattle Corridor

Border delay is also significant at the Pacific Highway/Blaine crossing in the Seattle-Vancouver corridor. Traffic volumes have grown rapidly in recent years, and current demand exceeds capacity during peak periods. In a recent survey of trucking companies, drivers reported average delay for loaded trucks in excess of 50 minutes. The situation is particularly bad in the northbound direction, where both commercial and passenger vehicles share a single approach lane. A U.S. and Canadian coalition of business and government entities known as the International Mobility & Trade Corridor Project is currently leading efforts to improve cross-border mobility in the corridor.

The border crossing procedures are similar to those for northbound trucks at Laredo. Once they enter the customs facility, all commercial vehicles undergo a quick primary inspection. Certain vehicles are then selected for secondary inspection, which takes much longer. When trucks enter secondary inspection, the driver typically visits a broker to complete their paperwork, then delivers the paperwork to the customs office. Customs inspectors review the manifests and determine whether or not the cargo should be manually inspected. If not, the truck is released to exit the facility. If an inspection is required, the driver moves the truck to the customs warehouse for manual inspection. Shipments that fail inspection are impounded.

[39] *Border Congestion Study: Study Findings and Methodology*.

Shortening average processing times at the border can be achieved by reducing the percentage of vehicles that require secondary inspection. Many commercial vehicles are "pre-cleared" for border crossing and rarely require secondary inspection.[40] These include:

- Vehicles that file customs paperwork on a monthly basis;
- Line release vehicles that are part of an expedited crossing program; and
- Vehicles that use advanced technology (ITS) to expedite border clearance.

The use of ITS to reduce the need for secondary inspections is particularly promising. One variation is known as the Pre-Arrival Processing System, or PAPS. PAPS was initially developed in Buffalo, and expanded by the North Border Leadership Group (consisting of U.S. Customs representatives along the U.S-Canadian border). It relies on bar codes to provide pre-arrival information to customs, and was recently initiated at the Pacific Highway crossing. A recent study of the impacts of ITS for commercial vehicle border crossing found that high penetration of the technologies could reduce average processing times by roughly 40%.[41]

To determine the impact of reduced border delay on emissions, we assume that average commercial vehicle delay drops from 37 minutes to 15 minutes. As shown in Table 26, compared to the 2020 Baseline this reduces truck idling emissions at the border by nearly 60%. Trade truck emissions of NO_x and PM-10 are cut by about 0.5% across the entire corridor segment, while CO2 emissions are cut by 1.0%.

Table 26: Impact of Reduced Border Delay on Vancouver-Seattle Corridor, 2020 (kg/day)

	NOx	VOC	CO	PM-10	CO2
Baseline Scenario 2020					
Truck Idling	16	10	333	0.5	34,305
Truck Total	1,678	399	7,842	62	1,983,469
Reduced Border Delay 2020					
Truck Idling	6	4	135	0.2	13,907
Truck Total	1,669	393	7,644	61.3	1,963,071
Percent Change					
Truck Idling	-59%	-59%	-59%	-59%	-59%
Truck Total	-0.6%	-1.5%	-2.5%	-0.5%	-1.0%

Other corridors may present different opportunities to reduce delay. For example, the commercial vehicle facilities at Emerson-Pembina currently close at 11 pm and reopen at 8 am. Providing 24-hour customs service would allow truck shipments to be spread more evenly throughout the day and may reduce delay somewhat. The actual magnitude of commercial vehicle border delay at Emerson-Pembina and most other crossings is not well understood.

5.3 Lower Truck Emission Standards in Mexico

In calculating 2020 emissions in the U.S.-Mexico corridors, we assume that Mexican trucks would meet the 2004 emissions standards planned for the U.S. and Canada, but would not meet

[40] Nozick, 1998.
[41] Nozick, 1998.

the 2007 standards that rely on the availability of low-sulfur (15 ppm) diesel fuel. It is possible that low sulfur fuel will be available in Mexico, at least in heavily traveled corridors such as Monterrey-Nuevo Laredo. There is some indication that PEMEX, the national oil company, is considering introducing cleaner diesel fuels in high density corridors.[42]

We calculate the emissions benefits that could be gained from providing low sulfur diesel fuel, and associated emission control technologies, in the Monterrey-Nuevo Laredo Corridor. As a most optimistic scenario, we assume that all NAFTA trade trucks operating in the corridor would use the fuel and be equipped with NO_x catalysts and particulate traps, and would begin meeting the new U.S. heavy duty truck emissions standards starting in 2007 (the same schedule as the U.S.) As shown in Table 27, the emission benefits of this scenario are dramatic. Total NAFTA trade trucks emissions of NO_x and VOC are reduced by over 50%, and PM-10 emissions are reduced by over two-thirds.

Table 27: Impact of Low-Sulfur Diesel on San Antonio-Monterrey Corridor, 2020 (kg/day)

	NOx	VOC	CO	PM-10	CO2
2020 Baseline (Trucks)	18,078	3,882	38,427	924	9,703,413
Mexican Low Sulfur Diesel	8,206	1,952	38,427	301	9,703,413
Percent Change	-55%	-50%	0%	-67%	0%

A more modest scenario, in which one-quarter of Mexican trade trucks in the corridor meet the 2007 U.S. standards, still results in large emission reductions. Emission reductions compared to the Baseline would range from 12% lower NO_x to 17% lower PM-10.

5.4 Reducing Empty Freight Mileage

Improvements to freight operating efficiencies can reduce trade-related environmental impacts. One area of potential improvement is a reduction in empty mileage movements. When truck and rail carriers cannot arrange for a return shipment, trailers and rail cars travel empty. Reducing these inefficiencies can reduce freight vehicle movements and their associated emissions. Of course, given the keen competition in the industry, most carriers strive to maximize utilization of their equipment without government intervention. But some policy steps may help to reduce empty mileage. For example, the use of electronic data interchange (EDI) can reduce transaction costs in the truck-freight market and facilitate better load matching. It is also believed that U.S. operating restrictions on Mexican trucks leads to excessive deadheading at the U.S.-Mexican border.

There may be less potential for a reduction in empty rail mileage in NAFTA corridors because rail commodity flows currently exhibit a much larger north-south imbalance. For example, southbound rail tonnage in the Vancouver-Seattle corridor is over four times northbound tonnage. Similarly, current rail flows from Ontario to eastern Michigan are more than twice those in the reverse direction. Commodity flows by truck, on the other hand, are fairly evenly balanced between northbound and southbound across all three of the U.S.-Canada corridors.

[42] *Binational Border Transportation Planning and Programming Study*.

We explore the environmental impact of reducing empty backhauls in the Toronto-Detroit corridor. Commodity flows by truck through Detroit-Windsor and Port Huron-Sarnia are evenly split by direction. Based on surveys of commercial vehicles at Windsor and Sarnia, approximately 15% of large trucks in both directions are empty, and another 15% are a quarter to half full.[43] We calculate the impact of reducing the percentage of empty trucks to 10%. As shown in Table 28, over 500 kilograms of NO_x and 21 kilograms of PM-10 emissions can be eliminated per day, a 5% reduction from baseline levels.

Table 28: Impact of Reducing Empty Mileage on Toronto-Detroit Corridor, 2020 (kg/day)

	NOx	VOC	CO	PM-10	CO2
2020 Baseline (Trucks)	11,342	2,674	52,165	416	13,353,393
Backhauls Reduced	10,775	2,540	49,556	395	12,685,723
Change	-567	-134	-2,608	-21	-667,670
Percent Change	-5%	-5%	-5%	-5%	-5%

The fraction of empty trucks between Ontario and Eastern Michigan is actually fairly low compared to many trade corridors. It is not uncommon to find 30% to 40% of trucks on major interurban highways traveling empty. Empty fractions appear to be much higher in the San Antonio-Monterrey corridor, though studies of the Laredo/Nuevo Laredo crossing are inconsistent. One study, based on customs data, suggests that 45% of northbound shipments at Laredo are empty.[44] Another, based on weigh-in-motion (WIM) data, found that only 22% of northbound 5-axle trucks are empty.[45] The actual figure is probably somewhere between these two. There is no information on the empty truck fraction in the southbound direction, or at other points in the corridor north or south of the border.

In the San Antonio-Monterrey corridor, it is generally accepted that current operating restrictions are contributing to the high empty fraction. Northbound truck shipments are typically carried to Nuevo Laredo by Mexican line haul trucks, drayed across the border by another Mexican truck, then carried by a U.S. truck in Texas. This system makes it difficult for trucks to find loads for their return trip, particularly the drayage fleet. Because the extent of empty mileage through the corridor is not known, it is difficult to calculate the potential emissions benefits of more efficient operations. Clearly there would be significant benefits to reducing empty mileage of drayage trucks at the border, as these trucks are generally older than the line haul trucks and have higher emission rates (though we expect use of drayage trucks for cross-border movements to be phased out by 2020). Reducing empty mileage would also cut border delay, particularly southbound queues at the Lincoln Bridge toll plaza, which would reduce emissions from all vehicles. It is likely that the percentage reduction in emissions would be much larger than in the Toronto-Detroit corridor.

[43] *1995 Commercial Vehicle Survey: Station Summary Report*.
[44] *Binational Border Transportation Planning and Programming Study*.
[45] Leidy, 1995.

On the other hand, the potential to reduce empty mileage is limited where large trade imbalances exist. Commodity flows between the U.S. and Mexico are not as evenly split by direction as in the U.S.-Canada corridors. For example, southbound truck flows at Laredo/Nuevo Laredo exceed northbound flows by over 40%. As long as this continues, some level of empty backhauls will persist.

5.5 Longer Combination Vehicles

Truck size and weight limits can affect the cost of freight movement by truck, and therefore the volume of truck traffic and related environmental impacts. These limits are determined by a variety of regulations at the federal and state/provincial level. In the U.S., the federal government sets both "floors" and "ceilings" on state truck size and weight limits. All states are required to allow five-axle trucks with a gross vehicle weight of 36,287 kilograms (80,000 pounds) on Interstates.

The term longer combination vehicles (LCVs) generally refers to trucks that are both longer and heavier than this standard. LCVs can take many forms, but the most common are the Rocky Mountain Doubles (48-foot lead trailer followed by a 28-foot trailer), Turnpike Doubles (two 48-foot doubles) and triples (three 28-foot trailers). Before 1991, many U.S. states had raised their limits to allow LCVs, but federal law in that year froze maximum size and weight limits in every state. Grandfather exemptions allow states to keep less restrictive limits if they were already in place in 1991.

In Canada, a memorandum of understanding (MOU) between the provinces, first signed in 1988, determines both size and weight limits. Weight limits are much higher than in the U.S. – up to 62,500 kilograms (130,790 pounds) for 8-axle combinations. Length limits allow trucks up to 25 meters (82 feet), though many fleets receive permits to operate longer vehicles. In Mexico, truck regulations applicable on national highways are established by the federal government, and the size and weight limits are generally similar to Canadian limits. A NAFTA provision calls for Canada, the U.S. and Mexico to develop a harmonized schedule of truck size and weight limits, but little progress has been made on this front.

Because they are the lowest common denominator, the U.S. regulations tend to govern the size and weigh of trucks involved in U.S./Canada trade. For any particular roadway, however, the actual truck operating restrictions may be subject to a myriad of unique state and provincial rules. For example, there is significant use of LCVs at the Alberta-Montana border crossings. A 1994 survey shows that 21% of trucks at Coutts-Sweetgrass pull double trailers, primarily because of Montana's policy to allow Canadian LCVs on I-15.[46]

Use of LCVs in the Winnipeg-Fargo corridor is much more limited. North Dakota allows trucks up to 47,854 kg (105,500 lbs) on Interstates with a permit, and also allows Rocky Mountain Doubles and Turnpike Doubles. However, many of the states south and east of North Dakota do not allow LCVs, primarily because of concerns about their impact on highway safety. This tends to limit their use in the corridor.[47] Analysis of commodity flow data suggests that only 10% of

[46] Nix, 1998.
[47] Only 3.2% of trucks in a 1996 survey had more than five axles (*Prairie Provinces Transportation System Study*).

trucks crossing at Emerson/Pembina have a U.S. trip end in North Dakota, while a much larger share (45%) of the trucks traveling in this corridor are moving between Manitoba and the states of Minnesota, Iowa, Illinois, Wisconsin and Missouri, which generally do not allow LCVs.

We explore the impact of allowing LCVs throughout the upper midwestern states in a manner consistent with North Dakota's current policy. We assume all of the trucks moving between Canada and the states of Minnesota, Iowa, Wisconsin, Illinois and Missouri (45% of the corridor total) would be operating as either Rocky Mountain Doubles or six-axle single trailer combinations, with a maximum weight limit of 47,854 kg (105,500 lbs). This would allow roughly a 36% increase in average payload weight and, for the Rocky Mountain Doubles, a 62% increase in cargo volume. We apply these larger average payloads to the commodity flows to and from the upper midwestern states. The immediate impact would be an 11% reduction in trade truck traffic. However, an increase in truck size and weight would effectively reduce trucking costs, and thus divert some freight from rail to truck. This issue needs to be accounted when calculating environmental impacts.

Several studies have examined the impact of changes in truck size and weight limits on the U.S. freight rail industry. One study estimated that eliminating the 36,287 kg (80,000 lbs) weight limit alone would divert 2.2% of railroad ton-miles to truck nationwide. A study for the American Trucking Association found that allowing nationwide operation of LCVs would divert 5% of rail ton-miles to truck. The American Association of Railroads estimates that nationwide use of LCVs would result in direct diversion of 11% of rail ton-miles, plus another 8% as a result of rail service cutbacks that would follow.[48]

Because our scenario for the Winnipeg-Fargo corridor envisions use of trucks only up to 47,854 kilograms (105,500 pounds) rather than heavier LCVs, we assume a 5% diversion of rail tonnage to truck. Only rail freight moving to and from the midwestern states would be affected. We calculate a slight increase in emission factors for the larger trucks based on the relationship between energy use and GVW.[49] Table 29 shows the impact of the LCV scenario on freight traffic volumes and emissions in 2020, compared to the Baseline Scenario. The total impact is a reduction in emissions of all pollutants. CO and CO2 show the greatest reduction (7%), while NO_x and PM-10 emissions fall by approximately 4%. The mode shift to trucking has the effect of furthering the NO_x and PM-10 reductions, while slightly offsetting the reductions in other pollutants.

[48] *A Guidebook for Forecasting Freight Transportation Demand*.
[49] Nix, 1991.

Table 29: Impact of LCV Use on Winnipeg-Fargo Corridor, 2020

Scenario	Mode	Freight/year (million kg)	Annual Vehicles*	Emissions (kg/day) NOx	VOC	CO	PM10	CO2
2020 Baseline	Truck	15,150	1,233,117	1,057	250	4,884	39	1,245,485
	Rail	16,262	217,966	3,408	192	646	96	239,357
	Total	31,412	N/A	4,465	442	5,530	135	1,484,842
LCV Scenario	Truck	15,150	1,093,820	947	224	4,377	35	1,116,358
-- Immediate Impact	Rail	16,262	217,966	3,408	192	646	96	239,357
	Total	31,412	N/A	4,355	416	5,023	131	1,355,715
LCV Scenario	Truck	15,598	1,125,650	975	230	4,505	36	1,148,844
-- Total Impact	Rail	15,814	207,068	3,314	187	628	94	232,765
(with mode shift)	Total	31,412	N/A	4,289	417	5,133	130	1,381,609
	Change			-3.9%	-5.6%	-7.2%	-4.2%	-7.0%

* Loaded rail cars only

It should be noted that any reduction in shipping cost (through use of LCVs or other means) may lead to some increase in total freight volumes due to induced demand. If the savings from lower transport costs are passed on to consumers, consumption (and aggregate demand) may increase, leading to more shipments. It is difficult to estimate the magnitude of these impacts, however. Since transport costs typically make up only a fraction of merchandise price, any increase in shipping volumes would likely be small. Also note that the increase in emission rates associated with larger trucks is not well-understood. These calculations assume that fuel consumption and emission rates per mile would rise approximately 2% as GVW increases to 47,854 kilograms (105,000 pounds). If the fuel consumption increase for the heavier trucks is actually larger, the emission reductions would be smaller or might be eliminated altogether.

6 OTHER ENVIRONMENTAL IMPACTS

Increases in freight transportation can have adverse environmental impacts outside of air quality. These impact occur through increased levels of truck and rail traffic in a corridor and also through construction activities associated with building new or expanded freight handling facilities, widening highways, double- or triple-tracking rail lines, or building new segments of highway or rail. Four areas of environmental impacts are discussed below – water resources, biological resources, noise and ground-borne vibration, and hazardous materials. No quantification of these impacts is attempted.

6.1 Water Resources

Increased truck traffic can contribute to higher levels of runoff pollution from highways, including particulates and heavy metals from vehicle exhaust fumes, copper from brake pads, tire and asphalt wear deposits, and drips of oil, grease, antifreeze, hydraulic fluids, and cleaning agents. Contamination of surface water beyond the corridor itself could occur in the event of a spill of material in transport. Spills can permeate the surrounding soil and contaminate the groundwater. Improperly disposed motor oil is an extremely concentrated water contaminant – one quart of motor oil can contaminate a million gallons of fresh water.

Construction impacts to water resources are often related to run-off from the impervious surfaces created by construction sites and erosion of barren rock and soil surfaces exposed during excavation. The use of vehicle washing effluents and oil and hazardous materials at the construction facility could also lead to surface water contamination. When construction involves work in surface water, like the dredging of a new tunnel alignment, there is a danger of disturbing of contaminated sediments. Ground excavation in areas with a long history of industrial activity may disturb shallow groundwater containing elevated levels of heavy metals and hazardous organic compounds. The development of new railroad lines can contribute to leaching of creosote into soil and groundwater. Creosote is a hazardous material containing carcinogenic impurities, and is used to treat railroad ties to protect against decay and rot.

6.2 Biological Resources

Increases in freight traffic volumes can adversely impact sensitive species with habitat near the corridor. However, construction impacts on biological resources are a much bigger concern. Construction of a new right-of-way can lead to destruction or fragmentation of habitat. Construction can also impact biological resources when higher levels of run-off lead to a large physical disturbance of habitats, such as fish-spawning areas and water vegetation. High run-off volumes of water from hot paved surfaces can boost surface water temperatures, harming fish and other aquatic life. Open water disposal of dredged material can alter bottom habitats, decrease water quality, and adversely affect marine organisms.

6.3 Noise and Ground-Borne Vibration

Intrusive noise and vibration can degrade the quality of life for people in affected areas. In extreme cases, excessive noise can pose a threat to hearing. Sound above 65 dB(A) is enough to cause annoyance and sound above 125 dB(A) is considered painful.[50] Noise can cause stress and other health problems and can affect the habitat of species living near the roadway or rail line.

Increased use of a transportation system generates greater noise impacts. Noise from road and rail transport comes primarily from engine operations, but also includes noise generated from pavement/rail-wheel contact, aerodynamic effects and the vibration of structures. Near a grade crossing, locomotive horns are typically the most significant contributor to noise. Typical noise levels for highway vehicles at a distance of 7.5 meters range from about 70 dB(A) for automobile traffic to 85 dB(A) for a heavy trucks. Noise levels for railroad operations are approximately 90dB(A) for an electric locomotive, 92dB(A) for a diesel locomotive, and 120 dB(A) for a locomotive horn. For safety reasons, locomotives typically sound a horn at a grade crossing, so increases in train frequency can significantly boost average noise levels for a population living near a crossing. A recent trend to mitigate these impacts is to ban locomotive horns in exchange for improvements to crossing protection.

[50] Sound is most often measured on a nonlinear scale in units of decibels (dB). An adjusted scale, the A-weighted scale, emphasizes sound frequencies that people hear best. On this scale, a 10-dB(A) increase in sound level is generally perceived by humans as a doubling of sound.

Perceptible noise and vibration caused by construction equipment may cause annoyance to people in the vicinity. As a general rule, the total noise level during a typical 12-hour, daytime construction workday is about 90 dB(A) at 15 meters from the construction site. Impact pile driving can cause daytime annoyance out to a distance of approximately 76 meters and potential vibration damage to structures at distances less than about 12 meters from the pile driving. Tracked vehicles such as bulldozers as well as equipment used for vibratory compaction and excavation can create substantial noise and vibration during earth moving operations. Loaded trucks on construction surfaces can cause annoyance at distances up to 61 meters away. If exposed to sufficient high levels of ground vibration, a building may suffer structural damage, such as glass breaking or cracking plaster.

6.4 Hazardous Materials

Higher volumes of freight transport increase the likelihood of the accidental release of hazardous materials. Most reported incidents of hazardous waste spills occur in the highway sector, which transports over 60 percent of the hazardous materials in the United States, with rail reporting the next largest number of incidents. Spills may impose substantial costs for product loss, carrier damage, property damage, evacuations, and response personnel and equipment. The environmental impact depends on the type and quantity of material spilled, amount recovered in cleanup, chemical properties (such as toxicity and combustibility), and impact area characteristics (such as climatic conditions, flora and fauna density, and local topography). The hazardous materials most likely to be involved in a spill include corrosive and flammable liquids, gasoline, fuel oil, sulfuric acid, and compound cleaning liquids.

During construction activity, the likelihood for encountering contaminated soils or groundwater is greater as the volume of the earth to be moved increases. The proximity of hazardous waste sites to the project will also affect the chance of encountering contaminated soils or groundwater. Petroleum-related contamination is the most commonly encountered problem but is one for which relatively well-developed procedures are available. Proximity of the project alignment to oil fields increases the possibility that associated hydrocarbon contaminants may be encountered, including hydrogen sulfide gas. Soil contamination is a common issue with construction projects, though it mainly affects project implementation and cost more than human health or ecology.

6.5 Summary of Other Environmental Impacts

The specific impacts of increased trade on environmental quality other than air depend greatly on local conditions. In general, increased freight activity within an existing corridor poses greater concerns for air quality impacts than non-air impacts. Noise is probably the most significant non-air impact resulting from higher traffic levels, particularly rail traffic, in places where the corridor passes through populated areas. The likelihood of a hazardous materials release may also increase with freight traffic levels. If increased trade leads to the expansion of facilities or construction of new facilities, non-air impacts can be much more significant, and water and biological resources then become a major concern.

7 DATA NEEDS AND OPPORTUNITIES FOR COOPERATION

The process of determining the environmental impacts of cross-border trade reveals a number of areas where necessary information is non-existent or highly uncertain. It is important that these deficiencies are addressed as trade-related environmental issues become more prominent. Four specific areas are mentioned below, followed by several examples of ways to improve information collection and environmental monitoring.

7.1 Data Needs

Cross-Border Traffic Volumes

At many border crossings, truck and rail traffic counts are not readily available. Obtaining the data usually requires contacting the individual customs stations, but many customs stations do not have records of rail traffic or do not release cross-border traffic information at all. It is also important to know the fraction of empty rail cars at a border crossing to properly estimate environmental impacts. Yet this information is rarely available, in part because customs offices do not compile it, and also because some rail crossings (e.g., tunnels) are privately operated and therefore the information is considered proprietary. One exception is the Texas-Mexico border crossings. Truck and rail traffic volumes for all POEs are regularly collected and published by Texas A&M International University.

Freight Origin-Destination Patterns

A variety of commercial vehicles cross the international borders, including service/utility trucks, short haul delivery trucks moving goods between the two border towns, intermodal drayage trucks, and long-haul trade trucks carrying goods to or from the interior of a country. Each affects air quality in a different way. To do a detailed environmental analysis, some information on goods movement patterns should be obtained from an origin-destination (O-D) survey of commercial vehicles at the border. A good example is Transport Canada's recently completed National Roadside Survey, which includes detailed interviews with truckers in border areas. In some cases, these interviews have been supplemented with additional surveys sponsored by local agencies or border trade alliances. In the U.S., California performs periodic O-D surveys at its border with Mexico. No such program exists in Arizona, Texas, or Mexico.

Railroad Emissions Calculations

Because of limitations in the data and methodology, estimations of railroad emissions are subject to large uncertainties. As described in Section 2, rail emissions are calculated by applying average emission factors to estimated fuel use, which is based on freight ton-kilometers. The average fuel consumption rates inherently account for some movement of empty rail cars. But cross-border traffic could exhibit a percentage of empty cars that is quite different from the average. This is particularly true in corridors with large imbalances in rail freight, such as Vancouver-Seattle and Winnipeg-Fargo. It is likely that the standard emissions estimation methodology underestimates rail fuel use in these corridors because of a large number of empty cars. Given that rail will contribute much more significantly to future corridor emissions, better information is needed on freight railroad traffic and its fuel use.

Border Delay Measurements

With the high level of attention paid to border crossing delay, it is surprising that so little quantitative information is available on the actual magnitude of delay. Of the five corridor segments included in this study, a measurement of average border delay was available for only two crossings, and these were based on a single-day field survey in 1997.[51] Several other studies discuss maximum delay or maximum queue lengths, but this says little about the experience of an average trucker. Together with O-D surveys, border delay surveys should become part of a regular data collection scheme by the border trade alliances. In addition to environmental concerns, this would give the coalitions the ability to monitor border congestion and make a better case for new border infrastructure projects.

7.2 Data Collection and Sharing Opportunities

A variety of government, university and private sector organizations take an interest in border trade issues, and some of these could serve as a means to collect and distribute needed information on transportation and the environment in NAFTA corridors. Nearly all large border crossings have one or more public and private sector coalitions that exist to promote trade and regional development. These may be complemented by larger corridor coalitions, such as the CANAMEX Corridor Coalition or the North American Superhighway Corridor Coalition, that have more of a North American focus. Most of the corridor coalitions exist primarily to support highway modes, though some promote multi-modalism and environmental initiatives. In assessing environmental impacts, they can serve a useful role by monitoring traffic volumes and delay.

University research institutes can be an excellent source of border transportation and environmental information. For example, a consortium of Texas universities, including Texas A&M International University, the University of Texas at Austin, the University of Texas at El Paso, and Texas A&M, have contributed a substantial body of research on the effects of NAFTA implementation, with a focus on the Texas border area. Recent studies by this group have included examinations of border trade truck volumes, border truck size and weight issues, trade flow patterns, and border air pollution levels. The University of Manitoba Transport Information Group (UMTIG) is another example of a research institution involved study of NAFTA trade and transportation issues. Most institutes, however, do not appear to have taken much interest in border environmental issues.

State and provincial agencies should also play a role in monitoring the environmental impacts of trade and transportation at the corridor level. One example is the Oregon Department of Transportation's "I-5 State of the Interstate Report – 2000." The report and data, delivered on CD ROM, provides an assessment of the existing and forecast safety, geometric, and operating conditions on Interstate 5 through Oregon. It also contains an inventory of environmental

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[51] *Binational Border Transportation Planning and Programming Study*.

conditions in the corridor, including landscape conditions and sensitive species habitats. Truck and rail activity are discussed only in narrative form, but could be incorporated into such a system in more detail.

Finally, federal agencies support the collection, analysis and dissemination of information related to environmental impacts of trade and transportation. The U.S. EPA has a program called the "U.S. – Mexico Border Information Center On Air Pollution," known by its Spanish acronym CICA. CICA provides technical support and assistance in evaluating air pollution problems along the Mexico-U.S. border, including air pollutants and control strategies, pollution prevention and control technology applications, emission inventory, dispersion modeling and ambient monitoring. The program maintains a website (http://www.epa.gov/ttn/catc/cica/) that includes detailed air quality data from monitoring sites in both the U.S. and Mexico. Most of the air quality information pertains to the areas that currently experience the most serious air pollution problems – San Diego-Tijuana, Calexico-Mexicali, Nogales-Nogales and El Paso-Ciudad Juarez, though some air quality monitoring data is available for Laredo and Hidalgo, Texas.

8 SUMMARY

This study examines the environmental impacts resulting from the development of North American trade and transportation corridors, with a primary focus on air pollution emissions. Five corridor segments are selected for analysis: Vancouver-Seattle, Winnipeg-Fargo, Toronto-Detroit, San Antonio-Monterrey and Tucson-Hermosillo. Current and future levels of trade, transportation and emissions are estimated for each corridor segment. Strategies to mitigate air quality impacts are discussed, and their effects are compared against a baseline scenario.

Current Trade and Air Quality Impacts

Currently, NAFTA trade contributes significantly to air pollution in the major north-south corridors, particularly NO_x and PM-10 emissions. Cross-border freight is responsible for 3% to 11% of all mobile source NO_x emissions in the corridors and 5% to 16% of all mobile source PM-10 emissions. Trucking carries the most freight in the corridors and contributes the bulk of trade-related emissions – typically three-quarters of NO_x and more than 90% of PM-10. The exception is the Winnipeg-Fargo corridor, where rail and truck volumes are roughly equal, and rail contributes a larger portion of emissions. Truck idling associated with border crossing delay contributes significantly to CO emissions, particularly in corridors where border delay is problematic. CO emissions from idling at the border are as high as 6% of all trade-related CO emissions in the corridor segment.

Future Trade and Air Quality Impacts

By 2020, due to the large expected reduction in emission rates for trucks, total trade-related emissions of NO_x and PM-10 will decline or remain constant compared to current levels. This occurs despite trade volumes that grow by two to four times. In the U.S.-Canada corridors, truck emissions of NO_x and PM-10 per ton-kilometer will drop to about one-tenth their current levels. The gains in the U.S.-Mexico corridors will not be as large under the assumption that low-sulfur diesel will not be widely available in Mexico, but truck emissions of NO_x and PM-10 per ton-kilometer are still expected to drop to about one-fifth their current levels.

The change in NO_x and PM-10 emissions from rail freight alone depends on trade growth rates. In corridors that will experience relatively slow growth (Vancouver-Seattle), the lower expected emission rates for locomotives will nearly offset the growth in rail freight volume. Corridors with higher trade growth (Winnipeg-Fargo and San Antonio-Monterrey), NO_x and PM-10 emissions from rail will increase by 50% to 100%. In all corridors, because of the decline in truck emissions, rail will contribute a much larger share of trade-related NO_x and PM-10.

Trade-related emissions of greenhouse gases and CO will not be reduced under the new emission standards, and are therefore expected to rise substantially by 2020. Under the baseline 2020 growth scenario, CO2 emissions from NAFTA trade will increase by 2.4 to 4 times over their current levels in the five corridors.

The 2020 Baseline scenarios used to estimate future emissions rely on assumptions about trade growth rates and mode share. Changes to these assumptions will affect future emissions levels. For example, the growth in truck and rail traffic could be stronger than the rates assumed under the baseline. If the trade growth follows the trend over the past decade, NO_x and PM-10 emissions from trade could be as much as 50% higher than the 2020 Baseline levels. If this occurs, 2020 emissions of NO_x and PM-10 could exceed 1999 levels in some corridors. Changes to the rail/truck mode share would also affect future emissions, though less significantly. Because of the large reduction expected in truck emission rates, a shift to rail would increase NO_x and PM-10 emissions in most corridors, though it reduces emissions of CO and CO2.

Mitigation Strategies

Natural gas powered trucks emit far lower amounts of PM-10 compared to today's diesel trucks. PM-10 emissions from trade could be cut by 9% if just 10% of today's trucks were converted to natural gas. By 2020, the vast improvement in diesel engine emissions means that alternative fueled vehicles lose much of their advantage. In the U.S.-Canada trade corridors, natural gas vehicles are not expected to offer a significant emissions improvement over the 2020 diesel fleet powered by low-sulfur fuel. In the U.S.-Mexico corridors, natural gas is likely to provide air quality benefits through 2020. If 20% of Mexican trade trucks in the San Antonio-Monterrey corridor burn natural gas, PM-10 emission levels would be reduced 13% from the 2020 baseline.

Commercial vehicles face large delays at some international borders, and reducing this delay will produce air quality benefits, particularly through reductions in CO emissions. Studies suggest that at the most congested crossings (Laredo-Nuevo Laredo, Nogales-Nogales, Blaine-Pacific Highway), policy changes and investments could cut average delay in half. At Laredo-Nuevo Laredo, reducing avoidable delay on the Lincoln Bridge would cut the CO idling emissions from trade trucks by over 600 kilograms per day in 2020, 1.6% of all CO emissions from trade trucks. At Blaine-Pacific Highway, nearly 200 kilograms of CO per day could be eliminated by expanding the use of commercial vehicle pre-clearance, equivalent to 2.5% of trade truck CO emissions in the corridor.

The use of low-sulfur diesel fuel in the U.S. and Canada will allow heavy-duty trucks to cut NO_x and PM-10 emission rates to only a fraction of current rates. While stricter emission standards are likely for Mexican trucks, the Mexican government currently has no plans to require low-sulfur fuels. Using low-sulfur diesel and advanced emission control technologies could have a major impact on truck emissions in the U.S.-Mexico corridors. If Mexican truck emission rates match those in the U.S. by 2020, trade-related emissions of NOx, VOC and PM-10 in the San Antonio-Monterrey corridor will be cut by more than half.

Improving the efficiency of freight transport by reducing empty vehicle mileage will lower all pollutant emissions from trade. In the Toronto-Detroit corridor, reducing the fraction of empty trucks from 15% to 10% would eliminate over 0.5 metric tons of NO_x and 600 metric tons of CO2 per day in 2020 (5% of the trade truck total). The U.S.-Mexico corridors have the potential for even larger reductions, but the data needed for such analysis is incomplete. Ports of entry with large trade imbalances will have less opportunity for reducing empty backhauls. Many north-south corridors currently have these imbalances in rail freight.

Allowing the use of longer combination vehicles (LCVs) in NAFTA corridors will reduce truck volumes and associated emissions. Because LCVs lower the cost of shipping by truck, some freight would shift from rail to truck. Use of LCVs is widespread in Canada, but because many U.S. states restrict their use, the standard 5-axle single-trailer truck dominates most north-south corridors. By increasing the truck weight limits in five U.S. midwestern states to 47,854 kilograms (105,500 pounds) and allowing Rocky Mountain Double configurations, emissions of all pollutants could be reduced by 4% to 7% compared to the 2020 baseline.

Data Issues

Some of the data needed to assess environmental impacts of trade and transportation corridors are unavailable or highly uncertain. A coordinated effort to collect and disseminate information is needed, particularly in the following areas:

- Cross-border traffic volumes, including number of empty versus full trucks and rail cars;
- Freight origin-destination patterns in the border regions;
- Data and methodology to estimate railroad emissions; and
- Measurements of average commercial vehicle delay at border crossings.

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