

FREIGHT ACTIVITY AND AIR QUALITY IMPACTS IN SELECTED NAFTA TRADE CORRIDORS

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ABSTRACT

This paper examines the current and future air quality impacts that occur as a result of the development of North American trade and transportation corridors, and explores strategies to mitigate these impacts. The analysis focuses on five specific bi-national corridor segments: Vancouver-Seattle, Winnipeg-Fargo, Toronto-Detroit, San Antonio-Monterrey and Tucson-Hermosillo. For each segment, commodity flow and ground freight traffic volumes (truck and rail) are used to develop a sketch-level estimate of current air pollution emissions associated with cross-border trade. Cross-border freight is found to be responsible for 3% to 11% of all mobile source NO_x emissions and 5% to 16% of all mobile source PM-10 emissions in the corridor regions. Trade forecasts to 2020 are used to develop a sketch-level estimate of future trade-related emissions. CO_2 emissions from cross-border trade will increase by 2.4 to 4 times over their current levels in the five corridors. Due to the expected improvement in criteria pollutant emission controls for trucks and locomotives, total trade-related emissions of NO_x and PM-10 in 2020 will decline or remain constant compared to current levels, despite trade volumes that grow by two to four times. The paper also discusses the impact of six emission mitigation strategies: alternative fuels for heavy trucks, reducing border delay, low sulfur diesel and use of advanced emission controls for trucks in Mexico, reducing empty freight mileage, expanded use of longer combination vehicles, and use of advanced emission controls for locomotives.

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 primary purpose of this paper 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. 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 air quality 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 – this paper focuses on trucking and rail freight, since these modes contribute most significantly to adverse air quality impacts.

A number of studies have explored the air quality effects of domestic ground freight transportation (2,3). Other studies have examined transportation issues in cross-border trade corridors (4,5,6,7,8). Yet very few have tried to isolate the environmental 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.

This paper describes a sketch-level analysis of the emissions caused by cross-border freight transport in five corridor segments. We use the shorthand term “NAFTA trade” to refer to North American cross-border freight movement. However, the paper considers only current and future impacts and does not directly address the effects of NAFTA or any other trade agreement on freight movement or emissions levels. In addition, although NAFTA trade has environmental impacts throughout all three nations, the analysis focuses on the border regions only. Many of the paper’s assumptions carry an inherent degree of uncertainty, including the trade forecasts, vehicle fleet composition, mode share, and emission factors. These uncertainties should be recognized when reviewing the analysis results.

METHODOLOGY

Figure 1 summarizes the methodology used to conduct this study. A Stakeholder Advisory Group (SAG), comprising government and non-government representatives from all three nations provided input to the study at various points. Initially, seven major North American corridors were identified based on a review of other related 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 (see Figure 2).

Corridor Segments for Analysis

Five corridor 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 described below.

- Vancouver, British Columbia to Seattle/Olympia, Washington: This segment follows Highway 99 south from Vancouver, then joins I-5 in Washington. Parallel rail service is provided by CP and CN in British Columbia and BNSF in Washington. The corridor is home to major seaports in Vancouver and Seattle, and 1.8 million people.
- Winnipeg, Manitoba to Fargo, North Dakota: Running south from Winnipeg on Highway 75, the corridor segment joins I-29 in North Dakota. Rail service parallels the highway route. The segment is mostly rural outside of Winnipeg and Fargo, and has an aggregate population of 949,000.
- Toronto, Ontario to Detroit/Ann Arbor, Michigan: This corridor segment runs west from Toronto along Highway 401 to the Ambassador Bridge at Detroit, with an alternative route using Highway 402 to the Blue Water Bridge at Port Huron, Michigan. Inside the U.S., the segment follows I-94 southwest to Ann Arbor. Tunnels operated by CP and CN provide cross-border rail service at Detroit-Windsor and Sarnia-Port Huron.

The corridor is home to approximately 10.7 million people, including 2.3 million in the Toronto area and 4.3 million in the Detroit area. The Ambassador Bridge is the busiest vehicular border crossing in North America.

- San Antonio, Texas to Monterrey, Nuevo Leon: This segment runs south from San Antonio (population 1.1 million) on I-35 to Laredo and Nuevo Laredo at the Mexican border, site of the busiest U.S.-Mexico commercial border crossing. The route follows MX 085 to Monterrey (population 1.1 million). Several freight railroads provide service in the corridor. The aggregate corridor population in 1999 is 4.2 million.
- Tucson, Arizona to Hermosillo, Sonora: This corridor segment follows I-19 south from Tucson, Arizona (pop. 804,000) to the border towns of Nogales, Arizona and Nogales, Sonora, then continues on MX 015 to Santa Ana and Hermosillo (pop. 609,000). UP provides rail service south to Nogales, where lines connect with the Ferrocarril Del Norte Pacifico network.

Trade and Traffic 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 were able to 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.

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. Information on cross-border truck and rail movements was collected from U.S. Customs, Canada Customs, and private bridge and tunnel operating authorities. 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 represents the number of trade-related freight trucks, shown in Table 1. Average border crossing delay was also estimated for each Port of Entry (POE).

Cross-border rail car volumes were available for some corridors but not all. Because railroad emissions were calculated based on freight tonnage and fuel consumption, this lack of information did not preclude emissions calculations. Commodity flow data and average payloads were used to calculate the loaded rail car volumes also shown in Table 1 (9).

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. At Laredo-Nuevo Laredo, it is estimated that 13% of northbound trade and 12% of southbound trade is associated with maquiladoras (4). Maquiladora trade is a more significant part of trade at the Nogales-Nogales crossing, estimated to be 29% of northbound and 47% of southbound trade. Because this freight generally does not move the full length of the corridor segment, we adjusted the truck activity data accordingly.

Current regulations restrict the operation of Mexican trucks in the U.S. to only commercial zones around the border crossing. 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 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 current line-haul truck freight in the U.S. and Mexico moves by U.S. and Mexican line-haul trucks, respectively. 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. 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. Therefore, we assume that the operating restrictions will be lifted in analyses of future scenarios.

Future Trade Scenarios

Trade growth scenarios were developed to investigate emissions impacts from NAFTA trade in 2020. A 2020 Baseline Scenario was developed for each bi-national corridor segment based on historic trends and forecasts developed in other studies (4,5,10,11). The baseline trade annual growth rates range from 4.2% in the Vancouver-Seattle corridor to 6.8% in the San Antonio-Monterrey corridor. 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.

Truck Emission Factors

In each corridor, we calculated the impact of cross-border trade on emissions of oxides of nitrogen (NO_x), volatile organic compounds (VOC), carbon monoxide (CO), particulate matter less than 10 microns in diameter (PM-10), and carbon dioxide (CO₂). From the freight transportation sector, NO_x and PM-10 emissions present the biggest concern and the greatest potential for air quality benefits. CO₂ is a common gas and does not pose a direct threat to human health, but it is the primary component of the greenhouse gases (GHGs) that contribute to global warming.

Air pollution emissions are generally calculated by applying freight vehicle activity data to emission factors. For the current year analysis (1999), heavy-duty truck emission factors for NO_x, VOC, CO and PM-10 were estimated using the EPA's MOBILE5 and PART5 models. Two sets of truck emission factors were developed – an on-highway emission rate based on a 55 mph average speed and an idle emission rate. The age distribution for the U.S. and Canadian trucks was based on line-haul truck registration data, and the Mexican line-haul fleet was assumed to have a similar age distribution. 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.

Emission factors for U.S. and Canadian trucks in the year 2020 incorporate the new stringent EPA emission standards for heavy-duty trucks that begin to take effect in 2007. 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 dramatic emission reductions are made possible largely because of EPA rules regarding the sulfur content of diesel fuel, which will be reduced from the current 500 ppm to 15 ppm. Canada has published a notice of intent to adopt a similar fuel standard. The 2020 emission factors were calculated outside the MOBILE model, since it does not yet include these new standards.

Emission factors for the 2020 Mexican line-haul fleet assumed adoption of the U.S. 2004 standards (which affect NO_x) but not the more stringent 2007 standards. Separate emission factors for the older drayage truck fleet were not used in 2020, as we assumed 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.

Rail Emission Factors

Rail locomotive emissions are typically calculated based on fuel use rather than miles of travel. In April 1998, the EPA finalized emission standards for NO_x, 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.

Current and future locomotive emission factors were based on the Class I line-haul emission rates used in EPA's 1998 *Regulatory Support Document* (12). We also anticipate that the U.S. and Canada will adopt low-sulfur standards for locomotive diesel fuel by 2020. Because sulfur in fuel contributes to particulate emissions, we assume that 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% (13).

To calculate 1999 railroad fuel use, we estimated an average fuel consumption rate per revenue-ton-mile of freight hauled (14). This figure (386 ton-miles per gallon) reflects all Class 1 railroad operations in the U.S. Railroads are becoming more fuel efficient for a number of reasons. 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 (2). 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.

One result of the new truck emissions standards is that by 2020, truck emissions of NO_x and PM-10 per ton-kilometer are 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 1.5 to 2.7 times higher than trucking. (The variation depends on the truck empty fraction and the amount of border delay.) 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 enjoys a large advantage over trucking in terms of emissions of other pollutants and fuel consumption per ton-kilometer. Rail emissions of CO and CO₂ per ton-kilometer are only about one-tenth of the rate for trucks in 2020.

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. Although there are currently no plans to reduce locomotive emission standards in the U.S., Argonne National Laboratory is beginning a research study of advanced emission controls for locomotives. We analyzed a scenario in which advanced locomotive emission controls are applied to engines built in 2010 and later. This scenario is described below with other mitigation strategies.

CURRENT TRADE AND AIR QUALITY IMPACTS

This section describes the current levels of trade-related transportation activity in each corridor and its impacts on emissions. 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 has been standardized for the purpose of emissions calculations. Truck idling emissions are estimated based on average border delay for commercial vehicles.

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 for the U.S. portion of the corridor segment. A county-level inventory was not available for CO₂.

It is important to reiterate that the study estimates only the emissions from freight vehicles involved in international trade. Emissions from trucks and locomotives making purely domestic moves within the corridors are not estimated, nor are any incremental passenger vehicle emissions that result from trade-induced congestion. Table 2 presents a summary of the emissions from current cross-border freight. Emissions are highest in the Toronto-Detroit corridor, reflecting the high commercial traffic volumes there. Compared to the emissions inventory for the area of the U.S. corridor segment, trade contributes the greatest portion in the Winnipeg-Fargo corridor (16% of mobile source PM-10 and 11% of mobile source NO_x). The high significance of trade-related emissions in this corridor is expected since it is relatively sparsely populated and has less domestic freight activity.

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. To estimate emissions impacts, the Baseline Scenario assumes a lifting of border operating restrictions for both U.S. and Mexican trucks. As described earlier, 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 end points. The fraction of maquiladora trade is assumed to remain constant.

Table 3 presents baseline trade-related emissions in 2020 for each corridor in kilograms per day and as a percentage of the 1999 levels. Due to the dramatic improvement expected in truck emission rates, and to a lesser extent rail emission rates, trade-related NO_x and PM-10 emissions drop to less than half of the 1999 levels in the Vancouver-Seattle and Toronto-Detroit corridor segments, despite a more than doubling of freight tonnage. In the Winnipeg-Fargo corridor, NAFTA-related NO_x and PM-10 emissions also decline, though the drop is smaller in part because of the large rail mode share and because of the strong expected trade growth. The reduction in trade emissions of NO_x and PM-10 is also smaller in the San Antonio-Monterrey corridor, partly because Mexican trucks are not assumed to benefit from low sulfur diesel and advanced emission controls.

Unlike NO_x and PM-10, trade emissions of CO and CO₂ will not benefit from the new emission standards. They are expected to increase two to four times compared to 1999, on par with the growth in trade. Trade-related CO₂ emissions grow most dramatically in the San Antonio-Monterrey corridor, to nearly 4.1 times the 1999 level.

Note that the 2020 Baseline Scenarios used to estimate future emissions are sensitive to assumptions about trade growth rates, and the growth in truck and rail traffic could be stronger than the rates assumed under the baseline. For example, 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, and trade-related NO_x and PM-10 emissions could exceed 1999 levels in some corridors.

MITIGATION STRATEGIES

The previous section illustrates how strict new standards are expected to dramatically reduce NO_x and PM-10 emissions from long-haul trucks. Yet rapid growth in freight transportation will offset much of the gains. In

addition, if the 8-hour ozone standard and PM_{2.5} standard 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 six such strategies: alternative fuels, reducing border delay, advanced truck emission controls in Mexico, reducing empty freight mileage, expanded use of longer combination vehicles, and advanced locomotive emission controls.

Alternative Fuels

The use of alternative fuels can play an important role in reducing pollutant emissions from the freight transportation sector. Most commercial vehicle 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 alternative 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. One of these, called the International Clean Transportation Corridor-3 (ICTC-3), follows I-35 in Texas, with effort to extend it to Monterrey.

Compared to today’s heavy-duty diesel trucks, CNG and LNG trucks offer lower emissions of NO_x, VOC, CO and PM-10, though the benefits are greatest for PM-10. In future years, the emissions benefits of natural gas will decrease as diesel trucks become cleaner, particularly in the U.S and Canada. In the U.S.-Mexico trade corridors, however, natural gas vehicles can provide significant 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. As shown in Table 4, PM-10 emissions from all trade-related freight are reduced significantly (10%) under this scenario.

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 were explored for the Vancouver-Seattle corridor. Border delay is significant at the Pacific Highway/Blaine crossing. In a recent survey of trucking companies, drivers reported average delay for loaded trucks in excess of 50 minutes (15).

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 (16). 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 40% (16).

To determine the impact of reduced border delay on emissions, we assume that average commercial vehicle delay drops from 37 minutes to 15 minutes. Compared to the 2020 Baseline this reduces truck idling emissions at the border by nearly 60%. Trade-related emissions of CO are cut by 2% across the entire corridor segment, while CO₂ emissions are cut by 1%, as shown in Table 4.

Advanced Truck Emission Controls 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 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. There is some indication that PEMEX, the national oil company, is considering introducing cleaner diesel fuels in high density corridors (4).

We calculate the emissions benefits that could be gained from providing low sulfur diesel fuel, and associated emission control technologies throughout the Tucson-Hermosillo 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 4, the emission benefits of this scenario are dramatic. Total NAFTA trade emissions of NO_x are reduced 36% and PM-10 emissions are reduced by 51%.

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. Less restrictive cabotage rules could provide Canadian and U.S. carriers making international trips with more flexibility in arranging for return loads. It is also believed that U.S. operating restrictions on Mexican trucks leads to excessive deadheading at the U.S.-Mexican border.

The potential to reduce empty mileage is more limited where large trade imbalances exist. For example, southbound truck flows at Laredo/Nuevo Laredo exceed northbound flows by over 40%. Corridor-level trade imbalance may be even greater for rail freight; southbound rail tonnage in the Vancouver-Seattle corridor is over four times northbound tonnage. 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.

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 (17). We calculate the impact of reducing the percentage of empty trucks to 10%. As shown in Table 4, trade-related emissions of NO_x and PM-10 are reduced by 3% from baseline levels in this scenario.

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 in this regard (4,18). 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, which makes it difficult to calculate the potential emissions benefits of reducing empty mileage.

Longer Combination Vehicles

The term longer combination vehicles (LCVs) generally refers to trucks that are both longer and heavier than the U.S. Interstate standard of 80,000 gross vehicle weight (GVW) or a 53-foot trailer. 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. Note that several serious non-environmental concerns have been raised regarding greater use of LCVs, such as their impact on traffic safety and pavement damage. Although these issues are beyond the scope of this study, they must be included in any assessment of changes to LCV operating restrictions.

Because they are the lowest common denominator, the U.S. regulations tend to govern the size and weight 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 (19).

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, which tends to limit their use in the corridor. In a 1996 survey, only 3.2% of trucks at the Emerson, Manitoba border crossing had more than

five axles (20). Analysis of commodity flow data suggests that only 10% of 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.

An increase in truck size and weight would effectively reduce trucking costs, and thus divert some freight from rail to truck. Several studies have examined the impact of changes in truck size and weight limits on the U.S. freight rail industry (21). 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.

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 (22). Table 4 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 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.

Advanced Locomotive Emission Controls

As described above, the baseline 2020 emission factors for locomotives do not assume adoption of any new emission standards beyond those that will take effect between 2002 and 2005 (Tier I and Tier II). If low sulfur diesel become widely available for locomotives as it will for on-road vehicle beginning in 2006, use of advanced control technologies could allow for far greater reduction in locomotive emission rates. We explored the impact of reduced locomotive emission rates, assuming the following:

- Low-sulfur (15 ppm) off-road diesel is widely available in the U.S. and Canada by 2010.
- New locomotive emission standards (termed "Tier III") take effect in beginning 2010. All locomotives built in 2010 and later are assumed to meet Tier III standards at the time of manufacture and each subsequent remanufacture.
- The new Tier III locomotive emission standards reflect the same level of improvement seen in truck emission standards made possible by the use of advanced emission controls and low-sulfur diesel. Thus, they are equivalent to base locomotive emission factors (uncontrolled) times the ratio of 2007 heavy-duty truck emission factors to 1990 heavy-duty truck emission factors.
- Base emission factors, Tier I and II emission factors, fleet turnover and relative fuel consumption by tier are consistent with EPA's 1998 *Regulatory Support Document* (12).

We applied these emission factors to the 2020 cross-border rail freight flows in the Toronto-Detroit corridor. Rail emissions of NO_x and PM-10 are 25% and 19% lower than in the 2020 Baseline Scenario. As shown in Table 4, total trade-related NO_x and PM-10 emission in the corridor are cut by 12% and 8%, respectively.

On a ton-kilometer basis, trucking still maintains an advantage over rail for NO_x and PM-10 emissions in this 2020 scenario. Rail emissions of NO_x and PM-10 per ton-kilometer are 50% and 30% higher than trucking, compared to 110% and 60% under the Baseline Scenario. Rail emission of CO₂ per ton-kilometer remain approximately 86% lower than trucking.

SUMMARY

This study examines the impacts on air pollution emissions resulting from the development of North American trade and transportation corridors. 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.

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. By 2020, due to the expected reduction in emission rates for trucks and locomotives, 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. However, emissions of CO_2 from NAFTA trade will grow by two to four times in all corridor segments.

A variety of mitigation strategies can reduce future trade emissions. Using low sulfur diesel and advanced control technologies to reduce emission rates of Mexican trucks or locomotives would have the greatest impact on criteria pollutant emissions. Use of natural gas in Mexican trucks would significantly reduce PM-10 emission in U.S-Mexico corridors. Strategies that improve the efficiency of freight trucking – reduced empty mileage or expanded use of LCVs – would reduce trade-related emissions of all pollutants, including CO_2 . Reducing truck border delay has only a minor impact on corridor-wide emissions, though a large impact on localized emissions of CO.

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TABLE 1: 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 ^a	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 ^b	219,471	219,471	438,942	13,792	8,831	22,623

^a Northbound flows are U.S. to Canada, southbound flows are Canada to U.S.

^b Southbound truck volumes at Nogales were not available, and were assumed to equal northbound.

TABLE 2: EMISSIONS FROM CROSS-BORDER TRADE, 1999

Corridor Segment	Commodity Flow (mil. tonnes/yr)	Trade-Related Emissions (tonnes/day) and Percent of Mobile Source Inventory					CO ₂
		NO _x	VOC	CO	PM-10	CO ₂	
Vancouver-Seattle	11.2	8.7 3%	0.6 0%	3.7 0%	0.4 5%	912	
Winnipeg-Fargo	9.2	5.2 11%	0.3 1%	1.7 0%	0.2 16%	448	
Toronto-Detroit	61.6	46.7 5%	3.5 0%	20.5 0%	2.4 7%	5,111	
San Antonio-Monterrey	26.6	25.9 8%	2.0 1%	10.8 1%	1.4 12%	2,511	
Tucson-Hermosillo	5.3	4.3 3%	0.3 0%	1.7 0%	0.2 4%	378	

Note: Emissions and inventory are for the U.S. portion of corridor segments only.
The emissions inventory was developed by the U.S. EPA at the county level.

TABLE 3: EMISSIONS FROM CROSS-BORDER TRADE, 2020

Corridor Segment	Commodity Flow (million kg/yr)	Trade-Related Emissions (kg/day) and Percent of 1999 Levels				
		NOx	VOC	CO	PM-10	CO2
Vancouver-Seattle	26,620 237%	3,664 42%	508 80%	8,257 225%	119 27%	2,137,038 234%
Winnipeg-Fargo	31,412 340%	4,148 80%	418 129%	5,473 320%	128 57%	1,478,987 330%
Toronto-Detroit	171,619 279%	21,022 45%	3,207 92%	54,188 265%	697 29%	14,102,189 276%
San Antonio-Monterrey	105,779 398%	24,854 96%	4,255 215%	39,843 370%	1,134 83%	10,227,511 407%
Tucson-Hermosillo	13,718 257%	2,561 59%	431 133%	4,215 254%	116 51%	1,083,415 286%

TABLE 4: IMPACT OF MITIGATION STRATEGIES, 2020

Mitigation Scenario	Corridor Segment	Change in Trade-Related Freight Emissions Compared to 2020 Baseline				
		NOx	VOC	CO	PM-10	CO2
20% Mex. Natural Gas Trucks	San Anton.-Monterrey	0%	-4%	-2%	-10%	1%
Reduced Border Delay using ITS	Vancouver-Seattle	0%	-1%	-2%	0%	-1%
Mex. Low-Emission HDTs	Tucson-Hermosillo	-36%	-42%	0%	-51%	0%
Reduced Truck Empty Mileage	Toronto-Detroit	-3%	-4%	-5%	-3%	-5%
Expanded use of LCVs	Winnipeg-Fargo	-4%	-6%	-7%	-4%	-7%
Adv. Locomotive Emission Controls	Toronto-Detroit	-12%	-3%	0%	-8%	0%

FIGURE 1: STUDY METHODOLOGY ROADMAP

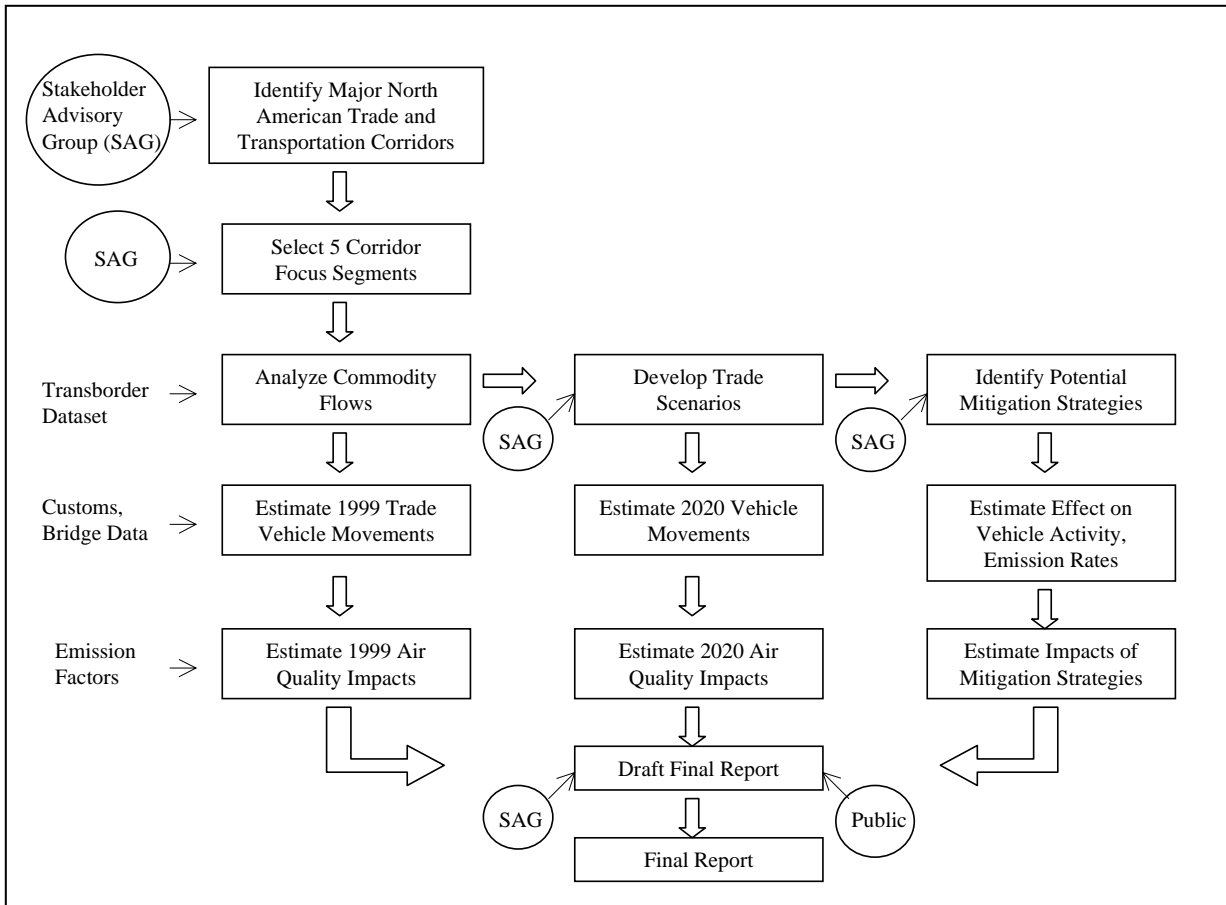


FIGURE 2: FULL NORTH AMERICAN TRADE AND TRANSPORTATION CORRIDORS

