



ALBERTA GHG OFFSET SYSTEM

Draft Quantification Protocol for Freight Modal Shifting



ABRIDGED DRAFT

Prepared on behalf of:

The Canadian National Railway Company



Prepared by:

The Delphi Group



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Introductory Note

The following document represents an abridged version of a draft GHG protocol developed by The Delphi Group on behalf of the Canadian National Railway Company for the Alberta GHG Offset System. The full version of the draft protocol was submitted to Alberta Environment following an expert technical review session held on November 5, 2007. As such, this document has been designed to reflect the specific requirements of the Alberta system and the general format of and precedents set by protocols that have already been approved in the system.

This abridged version has been prepared as a means of supporting a broader stakeholder consultation process. As such, this document should not be used as a quantification protocol..

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1 PROJECT AND METHODOLOGY SCOPE AND DESCRIPTION

1.1 Protocol Scope and Description

Companies that produce or aggregate goods requiring transport in or through Alberta ship to and from a variety of locations (herein referred to as “Origins” and “Destinations”) primarily by either truck or rail, and in a small percentage of cases also by marine and air. Where greenhouse gas emissions associated with the various potential transportation modes differ, shifting freight transportation from a more GHG-intensive mode to a less GHG-intensive mode will result in GHG emission reductions.

This protocol provides a method for calculating the GHG emission reductions that occur from shifting baseline truck freight transport to project rail freight transport in the Alberta context. This activity results in emission reductions given the significantly higher fuel consumption and associated GHG emission rates of trucks as compared to rail per amount and distance of freight shipped. The opportunity for shifting from truck to rail is considered strongest in the Alberta context for larger shipments traveling longer distances (e.g. east / west movements passing through Alberta; large bulk good; commodity and equipment movements into or out of the Alberta; etc.), versus smaller, more regional/local shipping. However, this protocol is not restricted to these types of shipments, and may be applied to all types of shipping that meet the applicability criteria presented in Section 1.1.2.

Since emission reductions from a single shipment of goods will be very small, this protocol is intended to be used for the aggregation of emission reductions from all shipments initiated by a particular producer or aggregator of goods such that the total emission reductions calculated and resulting offset credits that might be generated would justify the costs associated with quantifying the reductions.

Transport modes other than truck and rail, such as air or marine, are not considered within the scope of this protocol (and as such, shifting to or from these other modes is excluded from consideration).

Lifecycle diagrams for the project and baseline are presented in Figure 1-1 and Figure 1-2, respectively.

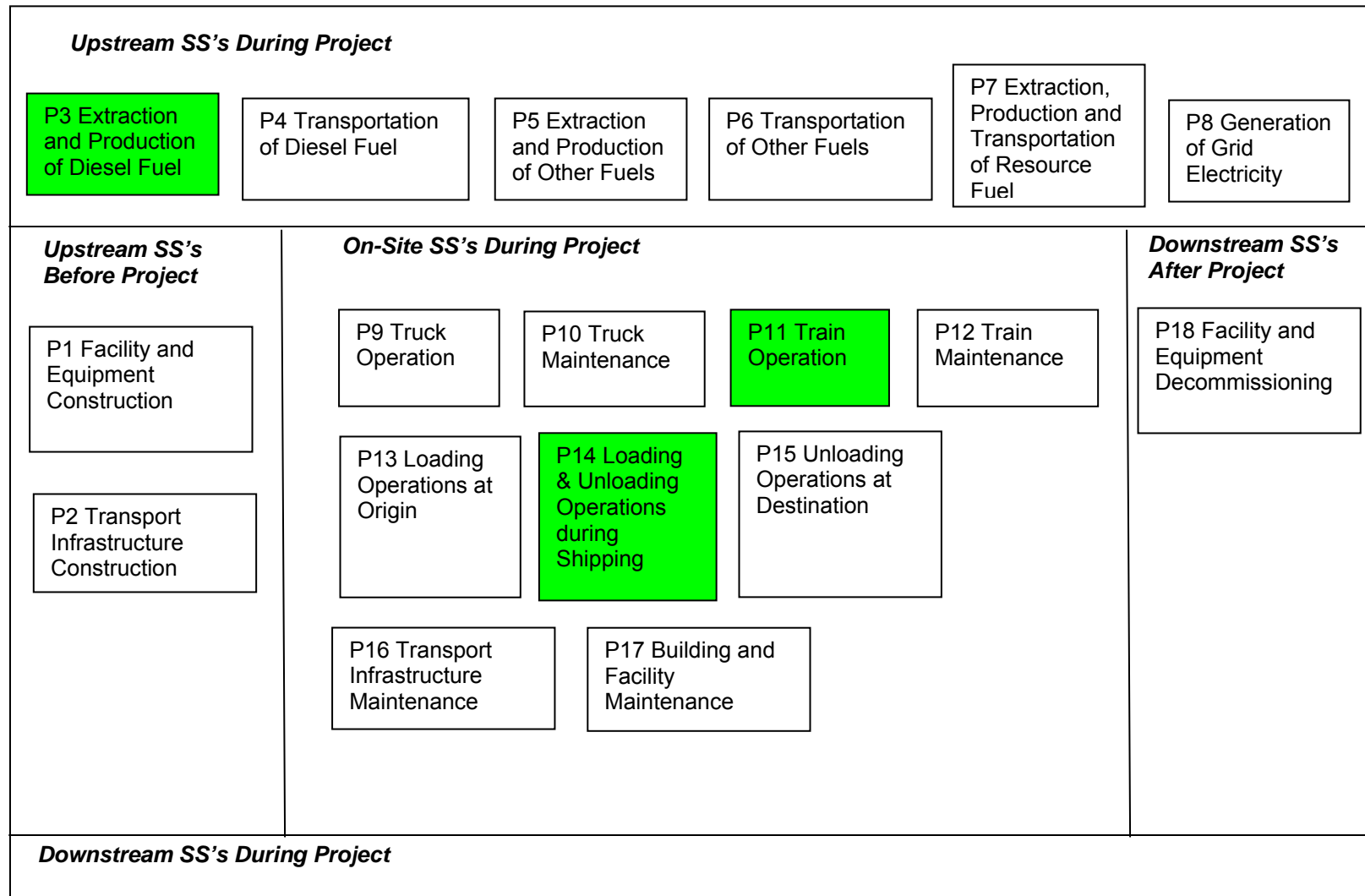


Figure 1-1: Project Lifecycle Diagram

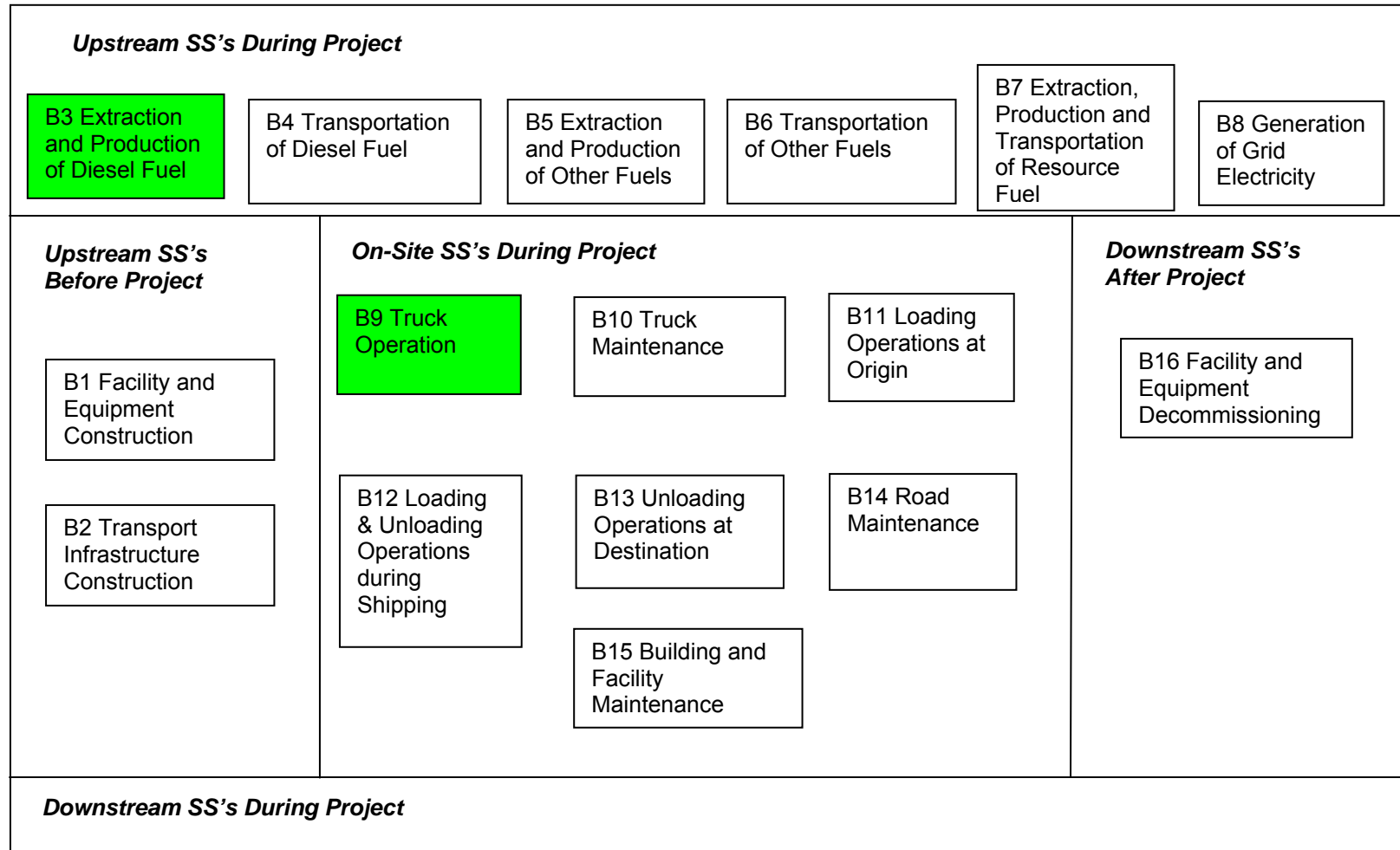


Figure 1-2: Baseline Lifecycle Diagram

* Sources and sinks selected for measurement and monitoring under this protocol are highlighted

1.1.1 Protocol Approach

In order to accurately compare GHG emissions of rail transport to truck transport, this protocol assumes a common project and baseline function of freight transportation, and a functional unit of revenue tonne-kilometers (RTK) shipped, representing the product of the mass of freight shipped and the distance over which the freight is shipped. The net increase in rail transportation / decrease in truck transportation due to the project is determined by comparing the proportion of freight shipped by rail and truck in the baseline to the project. More detail on how the net increase in project rail transportation is determined can be found in Appendix II.

In determining baseline shipping patterns, an historic approach is used where the average of project proponent shipping records from the three years preceding the start of the project is determined.

1.1.2 Protocol Applicability

This protocol applies where:

- the most likely situation in the absence of the project for rail freight shipments being included as part of the project would be the shipping of the same freight by truck (i.e. only freight shipped by rail that would have otherwise been shipped by truck is considered a part of the project, which means that some rail freight transportation used by a proponent may be excluded from the project).
- the goods being shipped as part of the project originate from a single producer or aggregator of goods (not necessarily a single location, but a single company), with this producer or aggregator being considered the project proponent. Note that this protocol cannot be used to quantify the modal shifting benefits of goods being shipped by multiple companies – such freight shipments from each individual company would need to be considered separately.
- the project proponent has shipped goods for at least three years (and thus has sufficient information with which to construct an historic baseline).
- the project meets the requirements for offset eligibility as specified in the applicable regulation and guidance documents for the Alberta Offset System. Of particular note, emission reductions must:
 - Result from actions taken on or after January 1, 2002
 - Have clearly established ownership based on Alberta system rules
 - Have occurred in Alberta (which in the context of this protocol means that freight shipments included as part of the project must originate, terminate, and/or pass through Alberta, and only the portion of the journey occurring in Alberta can be counted).

Users of this protocol need to clearly describe how their project meets these eligibility requirements in their Offset Project Plan.

1.1.3 Protocol Flexibility

Flexibility in applying the quantification protocol is provided to project developers in three ways:

1) Determining Project Rail Revenue Tonne-Kilometers (RTK)

Project developers may use one of two approaches for determining the amount of project rail RTK that resulted from a shift away from trucking in the baseline.

Option 1 – Simplified Approach

This option is for use where the proponent does not have access to detailed distance data for each shipment carried out during the project and baseline timeframes, and is only suitable for freight shipments that pass through Alberta east to west or west to east but that do not: originate, terminate, and/or switch modes within Alberta; or pass through Alberta to or from the North West Territories or the United States. For this option, a standard assumption has been made regarding transportation distances for truck and rail.

Option 2 – Detailed Approach

This option should be used where the proponent has access to detailed size (tonnage) and distance data for each freight shipment conducted during the project and baseline timeframes, and must be used for freight shipments that: originate, terminate, and/or switch modes within Alberta, or pass through Alberta to or from the North West Territories or the United States.

2) Trucking GHG Emission Factor

This protocol provides a default trucking emission factor for use (114 g CO₂e / tonne-km). However, where the proponent has access to truck transport emission factors specific to the fleet of baseline trucks and/or types of routes being used, or otherwise has trucking emission factors that are more suitable for the project, these factors may be used instead of the single default factor provided in this protocol. Alternative emission factors could include a single emission factor or a number of emission factors corresponding to different truck configurations, routes, etc. being used. Where the proponent decides to use their own factors, the appropriateness of these factors must be justified.

2 QUANTIFICATION OF IDENTIFIED SOURCES AND SINKS

Quantification of the reductions, removals and reversals for the sources and sinks selected for measurement and monitoring under this protocol will be completed using the methodologies outlined in Table 2-1 and Table 2-2, below. These calculation methodologies serve to complete the following three equations for calculating the emission reductions from the comparison of the baseline and project conditions.

$$\text{Emission Reduction} = \text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}}$$

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions}_{\text{Truck Operation}} + \text{Emissions}_{\text{Extraction and Production of Diesel Fuel}}$$

$$\text{Emissions}_{\text{Project}} = \text{Emissions}_{\text{Train Operation}} + \text{Emissions}_{\text{Extraction and Production of Diesel Fuel}} + \text{Emissions}_{\text{Loading \& Unloading Operations during Shipping}}$$

Table 2-1: Procedures for Measuring/Estimating Parameters for Calculating Project SSs

1. Project SS	2. Parameter / Variable	3. Unit
P11 – Train Operation	= (Eligible Project Rail RTK) X (Rail Fuel Consumption Factor) X (Rail Diesel Combustion Emission Factor)	
	Eligible Project Rail RTK (See Appendix II)	tonne-km
	Rail Fuel Consumption Factor	L diesel per tonne km
	Rail Diesel Combustion Emission Factor	tonne CO ₂ e per L diesel
P3 - Extraction and Production of Diesel Fuel	= (Volume Diesel Consumed by Train) X (1+ Correction Factor for Loading and Unloading) X (Diesel Extraction and Production Emission Factor), where (Volume Diesel Consumed by Train) = (Train Operation Emissions) / (Rail Diesel Combustion Emission Factor)	
	Train Operation Emissions	tonne CO ₂ e
	Correction Factor for Loading and Unloading (See Appendix III)	Unitless (%)
	Rail Diesel Combustion Emission Factor	tonne CO ₂ e per L diesel
	Diesel Extraction and Production Emission Factor	tonne CO ₂ e per Litre diesel
P14 - Loading & Unloading Operations during Shipping	= (Train Operation Emissions) X (Correction Factor for Loading and Unloading)	
	Train Operation Emissions	tonne CO ₂ e
	Correction Factor for Loading and Unloading (See Appendix III)	Unitless (%)

Table 2-2: Procedures for Measuring/Estimating Parameters for Calculating Baseline SSs

1. Baseline SS	2. Parameter / Variable	3. Unit
B9 – Truck Operation	= (Eligible Baseline Truck RTK) X (Truck Emission Factor)	
	Eligible Baseline Truck RTK	Revenue tonne km
	Truck Emission Factor	tonne CO ₂ e per tonne km
B3 - Extraction and Production of Diesel Fuel	= (Volume Diesel Consumed by Truck) X (Diesel Extraction and Production Emission Factor), where (Volume Diesel Consumed by Truck) = (Baseline Truck Emissions) / (Truck Diesel Combustion Emission Factor)	
	Baseline Truck Emissions	tonne CO ₂ e
	Truck Diesel Combustion Emission Factor	tonne CO ₂ e per L diesel
	Diesel Extraction and Production Emission Factor	tonne CO ₂ e per L diesel

Appendix I: Glossary of New Terms and Definitions

Table I-1: Glossary of Terms

Term	Acronym	Definition
Destinations	D	The ultimate destination for freight being shipped by the project. This is the location where the freight would be unloaded from a truck or train after having been shipped from project Origins.
Origins	O	Starting points for freight being shipped by the project. This is the location where the freight would be loaded onto a truck or train for ultimate delivery to Destinations.
Revenue tonne – kilometer	RTK	The product of the mass of freight shipped and the distance the freight is shipped. RTK excludes any non-revenue transportation movement (e.g. moving railway or other non-revenue materials, empty rail cars and truck trailers, etc.), and does not include the weight of the rail cars or truck trailers themselves.
Intermodal Terminal		A location where truck containers can be transferred to trains or containers on trains can be transferred to trucks.
Rail Hub		A more general term than intermodal terminal specifying a location where freight can be transferred between truck and rail.
Rail Spur		A rail line that is brought directly into a facility (origin or destination) such that transport by truck to or from an intermodal terminal is not required to ship by rail.
Producer		Refers to the company that manufactures the goods to be shipped.
Aggregator		<p>For the purposes of this protocol, ‘aggregator’ refers to a company or organization that collects the same kind of good (e.g. wheat, lumber, etc.) from a number of small producers, and acts on their behalf to ship the goods from a centralized location.</p> <p>For the purposes of this protocol, ‘aggregator’ excludes shipping companies and third party logistics companies that handle a wide variety of goods from many different producers and aggregators.</p>

Appendix II: Determining Eligible Project Rail RTK

Eligible Project Rail RTK represents the net amount of baseline truck transportation that has been shifted to rail as part of the project. To determine Eligible Project Rail RTK, the project proponent must determine the amount of rail transportation that they have used during the project time period, in units of RTK, that is due to a shift away from truck freight transportation in the baseline. Eligible project rail RTK

will be smaller than or equal to total rail RTK during the project time period since the proponent may have already been using a certain portion of rail transportation prior to the start of the project that would be considered part of the baseline and thus would not count as a project activity. This determination can be complicated because the amount of freight transportation conducted by a project proponent can vary from year to year due to various factors, including growth or down-sizing of business activity and associated freight transportation. As such, it is possible to observe, relative to a baseline case, a decrease in total truck transportation RTK without a shift to rail if total company shipping activity decreases, and conversely also an increase in total rail transportation RTK without a shift away from truck transportation if total company shipping activity increases.

Given the above, the following general approach is to be used for determining the amount of baseline truck transportation shifted to rail in the project:

A) Compare the percentage of rail RTK during the project time period (as a percentage of total RTK shipped by rail and truck combined) to baseline rail RTK. If the project rail RTK percentage is smaller than the baseline rail RTK percentage, then the project data does not show a shift from truck to rail (i.e. no relative increase in rail use has been observed).

B) Otherwise, if percentage rail RTK is increased and percentage truck RTK is decreased for the project relative to the baseline, then the data reflects a shift from truck to rail. In this case, the percentage shift is then calculated by subtracting the project percentage of transport by truck from the baseline percentage of transport by truck, as shown in the following equation:

$$\%Shift\ to\ Rail = \%RTK_{Truck, Baseline} - \%RTK_{Truck, Project}$$

Where,

%Shift to Rail = percent of project RTK that represents a shift from truck to rail

%RTK_{Truck, Baseline} = percent of total baseline RTK shipped by truck

%RTK_{Truck, Project} = percent of total RTK shipped by truck during the project timeframe

C) To determine the total RTK of baseline truck transportation that has shifted to rail in the project, multiply the total RTK shipped by the proponent by both truck and rail combined during the project timeframe by the percentage shift from truck to rail determined in B), above, as shown in the following equation:

$$RTK\ Shift\ to\ Rail = RTK_{Total, Project} \times \%Shift\ to\ Rail$$

Where,

RTK Shift to Rail = the amount of RTK, in units of tonne-kilometers, that has shifted from truck to rail as part of the project

RTK_{Total, Project} = total RTK shipped during the project timeframe, by both truck and rail

%Shift to Rail = percent of project RTK that represents a shift from truck to rail (determined above)

Two options have been identified for determining the percentage of total RTK freight transportation conducted by the proponent by rail and truck for the project and baseline.

OPTION 1 – SIMPLIFIED APPROACH

The simplified option is available only for freight shipments that pass through Alberta east to west or west to east using a single mode of transport (truck or rail), with both origin and destination outside Alberta.

Note: if the proponent wishes to seek credit for modal shifting for other types of freight shipments (e.g. shipments that originate, terminate, and/or switch modes within Alberta; or that pass through Alberta to or from the North West Territories or the United States), Option 2 – Detailed Approach must be used.

This simplified approach relies on the key assumption that it is reasonable, based on an analysis of the road and rail network in Alberta, to assume that the most direct (and thus typically the most economical) route for freight to travel through Alberta is similar for both rail and truck. Since there are two primary east-west rail corridors in Alberta: one across southern Alberta via Calgary (approximate distance of 540 km) and a more northerly route via Edmonton (approximate distance of 650 km)¹, and these routes correspond generally with the most direct road routes across the province, this assumption is considered appropriate. Assuming that the two routes are used equally, the average distance across Alberta is 595 km. However, since this assumption cannot be easily validated, a conservative estimate of 540 km (the lower value) will be used.

Using this average distance for both truck and rail shipments, project proponents need only track the tonnes of freight transportation by rail and truck (separately) across the province for both the project and baseline timeframe, and then multiply the total tonnage and average distance together to calculate total RTK shipped by each mode. Percentage RTK shipped by each mode for both the project and baseline is then easily calculated. For instance, in the case of rail RTK during the project timeframe, the following equation would be used:

$$\%RTK_{\text{Rail, Project}} = RTK_{\text{Rail, Project}} / RTK_{\text{Total, Project}} \times 100\%$$

Where,

$\%RTK_{\text{Rail, Project}}$ = percent of total RTK shipped by rail during the project timeframe

$RTK_{\text{Rail, Project}}$ = total RTK shipped by rail during the project timeframe

$RTK_{\text{Total, Project}}$ = total RTK shipped during the project timeframe, by both truck and rail

Resulting percentages are then used in the procedure described at the beginning of this note to determine total RTK shifted from truck to rail (i.e. Eligible Project Rail RTK).

For monitoring the total tonnage shipped by each mode, the proponent may use either the detailed tonnage monitoring approach outlined in the Detailed Approach, below, or use any other form of record that will be able to verifiably demonstrate during an audit that a given tonnage of freight was shipped by each mode across Alberta in the project and baseline case.

A project proponent must be able to verifiably demonstrate during an audit that the method selected for determining freight tonnage values results in accurate tonnage data, and that the approach gathers data from all freight shipments conducted during the project and baseline timeframes that fall within the scope of this protocol. All records of tonnage shipped must be permanent records that are company-approved or approved by a legislative authority.

OPTION 2 – DETAILED APPROACH

The detailed approach must be used when a proponent wishes to seek credit for modal shifting for shipments that originate, terminate, and/or switch modes within Alberta (given the range of actual shipping distances that could result from origins and destinations potentially located all over the province, an appropriate simplified approach was not identified for these types of shipments). A proponent may still choose to use the simplified approach for shipments passing through Alberta while using the detailed approach for all other shipments, or may use the detailed approach for all shipments.

¹ Distances estimated by measured road distances that followed the same route as the rail lines. All road distances were taken from google maps (<http://maps.google.com>)

The most accurate and transparent way to determine the percentage of total RTK freight transportation conducted by the proponent by rail for the project and baseline is through the use of detailed tonnage and distance data for each shipment made by the proponent, broken down by mode of shipment. For shipments that involve both truck and rail (e.g. shipping goods by truck to the nearest intermodal terminal, where they are then loaded onto a train), the distances for the truck and rail portions of the journey must be tracked separately.

For each shipment, monitored tonnage and distance values are then multiplied together, and then individual RTK values for each shipment made using a particular mode are summed together to give total RTK shipped by each mode. Total RTK shipped by both truck and rail combined can then be determined for the project and baseline by summing these mode-specific RTK values. Percentage RTK shipped by each mode for both the project and baseline is then easily calculated. For instance, in the case of baseline truck RTK, the following equation would be used:

$$\%RTK_{\text{Truck, Baseline}} = RTK_{\text{Truck, Baseline}} / RTK_{\text{Total, Baseline}} \times 100\%$$

Where,

$\%RTK_{\text{Truck, Baseline}}$ = percent of total baseline RTK shipped by truck

$RTK_{\text{Truck, Baseline}}$ = total baseline RTK shipped by truck

$RTK_{\text{Total, Baseline}}$ = total baseline RTK shipped, by both truck and rail

Resulting percentages are then used in the procedure described at the beginning of this note to determine total RTK shifted from truck to rail (i.e. Eligible Project Rail RTK).

Availability of the above detailed data, however, depends on project proponents collecting tonnage (or other load size) data and distance data for each shipment.

Detailed freight tonnage values can be determined in a variety of ways, including:

- Direct measurement using weigh-scales; or
- Estimation using a combination of other measures of load size (e.g. volume, number of units, linear measures such as board-feet for lumber, etc.) and average densities for the freight being shipped (e.g. tonnes per pallet, tonnes per 1000 board-feet, tonnes per box car, etc.).

Distances could be estimated using map distance tables, internet-based mapping programs (e.g. <http://maps.yahoo.ca>, <http://maps.google.ca>, <http://www.mapquest.ca>, etc.), or other distance databases (direct measurement of distances, e.g. using odometer readings, is not currently considered feasible unless the project involves a very limited number of routes). For project rail distances, estimates of distance would ideally be based on rail distances versus road distances. However, since the majority of distance data available to proponents will likely be in the form of road distance data, and road distances will both be less than and greater than rail distances depending upon the specific routes, use of either road or rail distance data is deemed acceptable for these estimates. Note that only distances within Alberta are to be considered. For shipments that enter or leave the province, only the Alberta portion of the journey is to be counted.

This tonnage and distance data could be tracked and recorded in a variety of ways, most easily as part of a proponent's invoicing or logistics system, either as part of invoicing for the shipping (e.g. where cost of shipping is based on load size and transportation distance), or invoicing for the sale of the freight itself (which would typically involve a quantity of goods sold and a delivery address, from which a shipping distance could be determined). Use of electronic invoicing or logistics systems would make the processing of monitored data easier, and, for ease of subsequent verification, it is highly recommended that a database of some sort be used to store and perform RTK calculations on all monitored data.

A project proponent must be able to verifiably demonstrate during an audit that the methods selected for determining freight tonnage values and distance values result in accurate data, and that the approaches gather data from all freight shipments conducted during the project and baseline timeframes that fall within the scope of this protocol. All records of tonnage shipped and distances (or proxies for distances used for distance estimates, such as the location of origins and destinations) for each shipment must be permanent records that are company-approved or approved by a legislative authority.

Appendix III: Estimating Emissions from SS P14 - Loading & Unloading Operations during Shipping

Emissions for SS P14 are to be quantified only for the net increase in loading and unloading operations expected during the project as compared to the baseline. Increases in project loading and unloading relative to the baseline would only be expected to occur for shipments involving intermodal terminals where goods must be transferred from truck to rail or from rail to truck, since this would not be expected to occur in a truck-only baseline shipment case.

Since it is impractical for project proponents to measure actual loading and unloading emissions occurring at intermodal terminals for each shipment, emissions for this SS will be estimated, as described below.

At each intermodal terminal, it is assumed in the worst case (from an emissions perspective) that goods would need to be transferred by crane twice: once to unload from the first transport mode and move to a storage area; and a second time to move from the storage area and load onto the second transport mode. The number of crane transfers (or lifts) required for a particular shipment (with a shipment in this case considered to be one standard shipping container) would therefore typically range from zero to four, depending on if a rail spur, versus intermodal terminal, is used at one or both ends of the journey (wherever a rail spur is used, no incremental transfers would be required as compared to the baseline since loading onto rail occurs at the origin/destination). Interestingly, in the Alberta context, no crane transfers would occur within Alberta for shipments passing through the province, and at maximum only two transfers would occur within the province where the origin or destination is outside of Alberta. However, the worst case of four transfers being needed still applies, and is considered further, below.

Considering the case of four crane transfers, associated emissions can be estimated. Diesel cranes are typically used for intermodal terminal loading and unloading operations (versus electrical or other fuel-powered equipment), and these cranes are have been estimated to consume on average 21.6 L diesel/hr and perform 12.6 lifts/hr according to a CN Rail study (CN Rail, 1999). Using these values, fuel consumption per lift can be estimated as:

$$(21.6 \text{ L/hr}) / (12.6 \text{ lifts/hr}) = 1.7 \text{ L diesel per lift}$$

Using a diesel combustion emission factor for a heavy diesel truck with moderate controls of 2757.53 g CO_{2e} /L diesel (Environment Canada, 2006b) as a proxy for a crane emission factor, associated emissions can be estimated as:

$$(1.7 \text{ L/lift}) \times (2757.53 \text{ g CO}_2\text{e /L}) = 4.7 \text{ kg CO}_2\text{e /lift}$$

In comparison, fuel combustion emissions expected from a train transporting a 15-tonne load 500 km, based on a 2004-2006 average train fuel consumption factor of 6.002 L diesel / 1,000 RTK (RAC, 2007; RAC, 2006) and a train emission factor of 3074.15 g CO_{2e} / L Diesel (Environment Canada, 2006b), would equal:

$$(6.002 \text{ L diesel} / 1,000 \text{ RTK}) \times (15 \text{ tonnes}) \times (500 \text{ km}) \times (3074.15 \text{ g CO}_2\text{e} / \text{L Diesel})$$

$$= 138 \text{ kg CO}_2\text{e / shipment}$$

Therefore, the worst-case estimate of incremental loading and unloading emissions for a single 15 tonne, 500 km intermodal shipment can be determined as:

$$(4.7 \text{ kg CO}_2\text{e / lift}) \times (4 \text{ lifts / shipment}) / (138 \text{ kg CO}_2\text{e / shipment}) = 13.6\%$$

While this represents a relatively large percentage of train operation emissions, this is equal to only 2.6% of the net difference between train and truck operation emissions, assuming a trucking emission factor of 114 g CO₂e / t-km and rail fuel consumption and emission factors noted above. See below for this calculation:

Worst-case loading and unloading emissions as a percentage of the difference between truck and train operation emissions

$$= 13.6\% \times (\text{Rail Emission Factor}) / (\text{Truck Emission Factor} - \text{Rail Emission Factor})$$

$$= 13.6\% \times (6.002 \text{ L diesel / 1,000 RTK}) \times (3074.15 \text{ g CO}_2\text{e / L Diesel}) / [(114 \text{ g CO}_2\text{e / RTK}) - (6.002 \text{ L diesel / 1,000 RTK}) \times (3074.15 \text{ g CO}_2\text{e / L Diesel})]$$

$$= 2.6\%$$

Of course, some shipments may be less than 15 tonnes and less than 500 km, which would increase the relative significance of loading and unloading emissions as compared to train operation emissions. However, on the other hand, lighter shipments would be expected to require less energy for lifts, and the potential for modal shifting is generally considered to be greater for longer routes. This bias to longer routes for modal shifting means that the worst case of four additional lifts, which would apply only to shipments with both an origin and destination in Alberta, is expected to occur only in the minority of shipments likely to be quantified using this protocol.

Therefore, emissions for SS P14 will be calculated as 14% of emissions associated with SS P11 – Train Operation, considered a conservative value in this case. This simplified approach is considered appropriate given that in the worst case presented above loading and unload emissions represent only a modest 2.6% of the difference between truck and train operation emissions.