AECOM

Appendix D

Rail Operations

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1.0 Railway Operations

1.1 Limitations and Scope

In order to provide a conservative approach, practical and proven technologies and processes form the basis of this operating report notwithstanding the recent innovations are discussed briefly and products that assist in the safe and efficient movement of trains are examined but at a preliminary design stage.

The key points of this section of the report are:

- Safety is paramount. Given that railways are the only land transport which needs to be able to “see” beyond the range of their driver’s sightlines, has driven a long history of pioneering safety systems which allowed for the safe movement of passenger and large freight tonnage at a relatively high speed. Railways, like airlines today, are governed by rules created after incidents which necessitated the need for the railway or regulatory body to develop a rule to prevent reoccurrences.
- The Railway is considered to be purpose built. That is, being new, and specifically designed to move a particular product, and notwithstanding it can move other commodities, it can incorporate the latest in technology and equipment to make it a leader as the safest and most efficient rail carrier.
- The supply chain is integrated. The project treats the movement of bitumen more as an industrial process than a traditional railway. From loading at one end to the unloading at the other the logistical processes are designed to move the product efficiently, taking into account other up-chain and down-chain operations.
- Designed to potentially accommodate multiple commodities and even passengers. While the railway is purpose built, it can still accommodate within those standards the movement of virtually any commodity that can be carried by rail. This makes it far more versatile than a pipeline.

Since this is a conceptual operation, limited by project scope, more detailed analysis cannot be carried out without additional base input data. If a preliminary design is progressed in the future with the necessary additional data, assumptions and principles will need to be reviewed and updated for compatibility and even optimization with any design changes.

Note that while Infrastructure and operating teams jointly acted in an interactive manner to select the equipment and alignment versus their costs, this conceptual stage are not optimized.

This conceptual study provides an indicative operating plan, meant to provide a realistic high level view of the necessary operational assets and processes required to deliver bitumen, based on conceptual designs with the limited available data underpinned by operating experience in the moving of goods by rail. When variances have been used in the absence of data, the rule of thumb was to error on the conservative side in order avoid the understating of requirements.

This provides a solid, first pass, basis to help derive typical operating costs in order to provide guidance as an indication of the economic impacts of this project.

1.2 Overview

1.2.1 Synopsis

A rail link from Alaska to the rest of the North American rail system has been under consideration in various forms, configurations and routes since the Alaska Railroad was started in 1914. Today, a renewed interest in resource deposits in Alberta, Alaska, Yukon, and British Columbia, as well as changing world markets, global trade dynamics and supply chains, has rekindled interest in that link. For example the interest in reaching Pacific ports with the Canadian and US agricultural production provides additional interest in freight movement across northern Canada.

Railways, just a few years ago, were often viewed as being transportation relics of the past. Now railways have re-emerged, largely because of new technologies and the ability to move large amounts of product safely, efficiently and reliably while allowing flexibility of destinations by interconnecting to the broader railway network. The substantial increase in trainload has brought the base operation costs of this mode down substantially over the past 15 years. And of course, railways can move virtually any commodity in both directions, giving them large potential to support broad economic development.

It is therefore important to understand the operational characteristics of this railway which enable potential future goods and people improvement. Crossing Provincial, Territorial, Federal and First Nations boundaries, and it will provide avenues directly to the North American rail network making it the first rail connection between Alaska and the lower forty eight states. Some of the potential rail connections are identified below:

- Fort McMurray area – CN to the southeast
- High Level, Alberta – CN to the southeast and north to Hay River
- Fort Nelson area, British Columbia – CN to the southwest
- Delta Junction area, Alaska – Alaska Railroad to Anchorage

This operating plan covers the movement of Bitumen and supplies carried by rail to support this product. For this level of study, indicative operations that are able to move the required product with a conservative yet practical approach have been used as a basis to determine the specifications for alignment, equipment and manpower. Derived from this are base asset numbers for use in the capital expenditure (Capex) and operating expenditure (Opex) calculations in this study. This has required a multiple disciplinary team to carry out both sequential and iterative processes to determine the final product.

Potentially the railway may haul any and all goods; this design is focused on moving bitumen efficiently from the Athabasca mining area in northern Alberta to Delta Junction in Alaska. It will operate the approximately 2,400 km as a single track, standard gauge, bi-directional, heavy-haul railway. It will operate 24 hours per day, using industry standards with the latest proven technologies for promoting both safety and efficiencies. The logistics of this movement requires the loading and unloading operations be designed and integrated into an overall operation to keep the bitumen moving. Briefly the proposed supply chain will load and move insulated rail tank cars from Athabasca Oil Sands area to Delta Junction, offload to a pipeline for furtherance to Valdez, Alaska, and loaded to ship to final destination. This will need to be confirmed both in terms of capacity and any required upgrades. There are also other options including:

- possibly negotiating the transfer of bitumen to the TAPS if this is agreeable to its owners,
- building a new alternate pipeline parallel to TAPS and a new marine terminal from Delta Junction to Valdez, or
- building a new alternate rail alignment from Tok to Glennallen, to move the rail terminal closer to a new pipeline to and new marine terminal at Valdez.

The base load of 1.0 mbpd barrels per day and secondary case of 1.5 mbpd barrels per day was used. The single track railway is not limited by this amount, but rather can be incrementally expanded to approximately 1.9 mbpd barrels per day by adding some passing sidings to facility more trains. Further, the railway can be incrementally expanded well beyond this capacity if double track is added. For the purposes of this study, given the capacity of the TAPS pipeline, the cases within this scope are limited to 1.0 mbpd and 1.5 mbpd barrels.

It is anticipated these volumes would be ramped up to the 1.0 mbpd barrels per day over a 3 year period once the railway is completed.

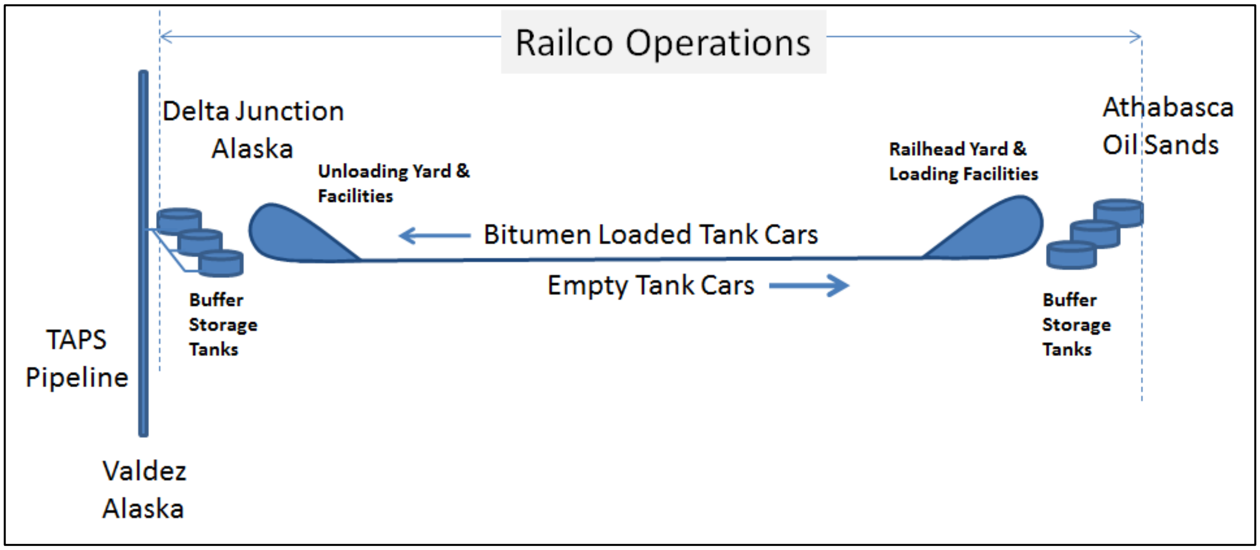


Figure 1 RailCo Operations

As indicated above, bitumen will be collected and brought to a state of the art loading area at the railhead yard where it will be loaded into insulated heated storage tanks. These tanks serve as a necessary buffer to permit the various bitumen producers as well as rail operations, to continue despite disruptions that periodically occur by any of the parties. The heated bitumen will be loaded into insulated tank cars for the approximate 42 hour trip to Delta Junction.

Loaded trains will be restricted to 80 km/h and empty trains to 100 km/h (Class 4 designation). While these are not the highest speed limits for heavy freight rail found in North America, nevertheless the trip will require only 6 train crews to take the train the approximately 2,400 km. These train crew legs are longer in distance than many North American freight railways, but the railway, with a purpose built design, a simple single track network, safety systems and uniform characteristics of the train performance, allows the railway to maintain better average operating velocity and typical on duty times of less than 8 hours per crew leg. This is covered in more detail in section 1.9.4 Train Crew Legs.

Typically loaded trains will be given priority over empty trains for 3 reasons:

- Loaded trains will be more time sensitive as the heat must be maintained to destination
- Empty trains will travel faster and therefore typically arrive at passing locations before loads. This permits:
  - Savings on fuel and brake wear for the heavier loaded trains
  - Savings on turnout maintenance at the passing sidings.

The railhead yard will also be the designated inspection location for the rolling stock maintenance facilities. The highly monitored railcar fleet will undergo regular maintenance to ensure equipment is in proper running order. This is made simpler by the fact the fleet is generic and the mileage accumulated routine. This is covered in detail in section 1.19 Rolling Stock and section 1.22 Rolling Stock Maintenance Plan.

At Delta Junction loaded trains will be unloaded into insulated tanks which will serve as the required buffer between rail operations and the existing TAPS pipeline operations.

The railway is designed to move bitumen in relatively large quantities safely and efficiently, around the clock. Reliability in moving the demand volumes successfully are achieved by integrating the loading and unloading operations into an overall operational plan. This is unlike a typical Class 1 railway where train services and commodities vary widely. This railway will have a singular focus and discipline in operations more in keeping with a production line than a traditional railway. It will be a scheduled and structured transit. The logistics of moving this bitumen will be coordinated from at the loadout railhead yard which will also serve as the operations control centre. The specific logistics for moving bitumen is covered in more detail in Section 9.6 Bitumen Logistics of the report.

Keeping the bitumen moving requires that all operations, or be they loadout, rail operations, including train operations, track maintenance, car maintenance or unload operations, be coordinated at all times. Of these, track maintenance is the key to a reliable operation and sustaining the necessary velocity of the railway. This translates into an important operating KPI for this railway in order to operate successfully: Zero Deferred Maintenance.

The cold climate and remote geography are not new to North American railways. These lessons have been taken and applied to this railway and the requirements for daily routine track maintenance requirements as well as the renewal of the plant under operation are identified. As such a significant number of operating days per year are dedicated to this effort. This is covered in more detail in section 1.24.1.4 Track Maintenance.

1.2.2 Length

The approximate 2,400 km (1,500 miles) railway alignment traverses Alberta, British Columbia, Yukon and into Alaska as is shown in Figure 2. The exact length cannot be determined until a final alignment is established including a fixed location in the Fort McMurray, Alberta and Delta Junction, Alaska terminals which is not within the scope of this study.

1.2.3 Regulatory

Since the railway crosses provincial boundaries it will be federally regulated by Transport Canada/Canadian Transportation Agency. Crossing into Alaska it will be regulated in the US by the Federal Railway Administration. This will not be onerous since North American railways are already relatively homogenous and cross border operations are common. In fact, the Federal Jurisdiction oversight on both sides of the border provides for a very well established and highly efficient regulatory framework. That being said, two distinct companies will be incorporated on either side of the border but the operations will be seamless. Transport Canada and the US Department of Transportation set the operating requirements for rail operations on their respective sides of the border.

1.2.4 Climate

This route encounters temperatures that have a range of 90 °C. While snowfall accumulation is not extreme, there is some accumulation to deal with over the winter months. The harsh winter conditions have to be taken into account in the design, maintenance and operation of the railway. This is detailed further in the Climate section 1.4.5 of Appendix B Hydrology.

1.2.5 Elevation

The railway starts at about 350 m in the east to finishes around 360 m in the west and would cross the continental divide near Finlayson Lake at an elevation of 1,020 m (3,350 ft.), making it the lowest crossing of the Rocky Mountains of any major railway in North America, which is important in terms of finding a well-engineered and cost efficient route.

1.2.6 Alternative Routes

A Southern route (via Peace River) as well as an alternative Northern option (via Fort Vermilion) have been also been considered. The route as shown below is deemed superior due to lower grades and shorter route overall.

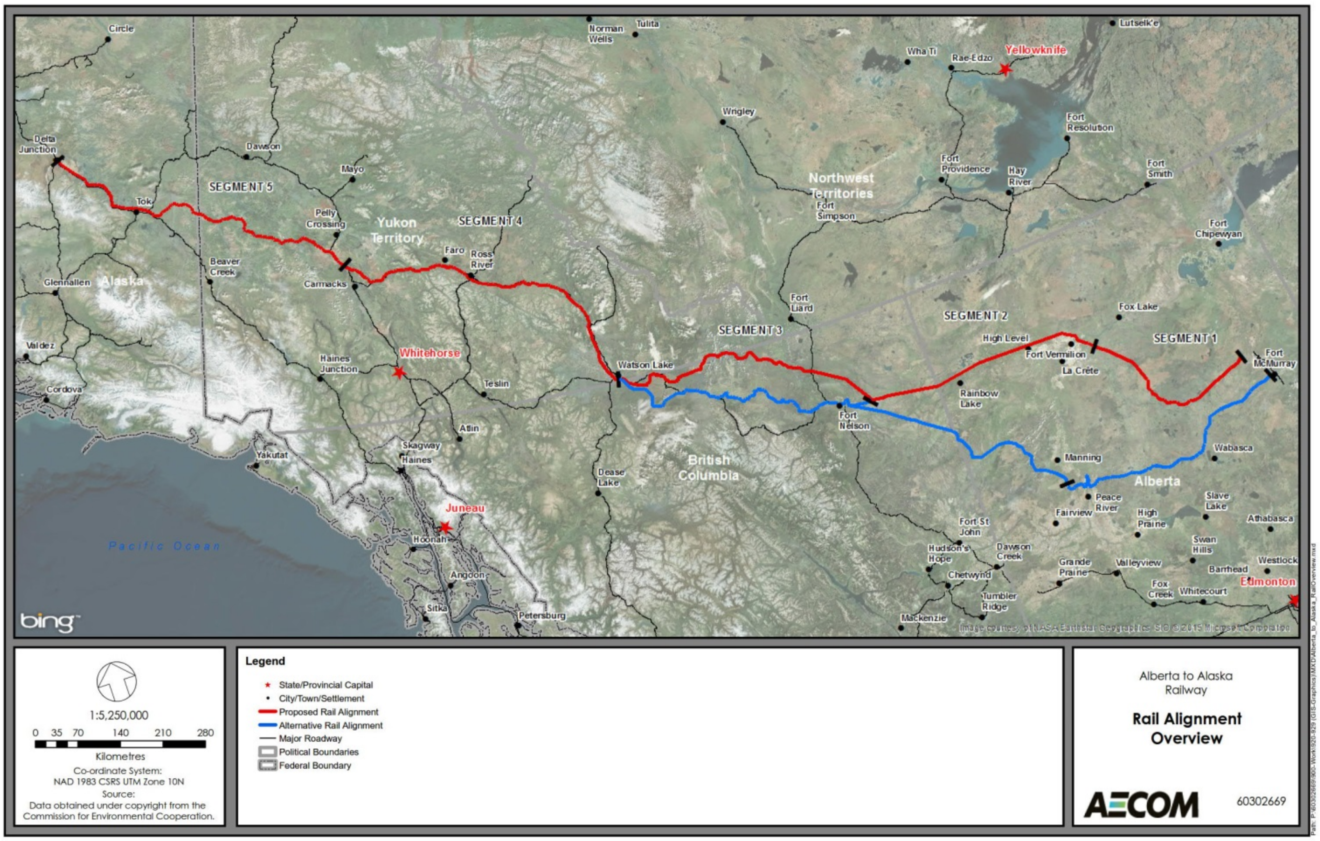


Figure 2 Rail Alignment in Segments (Google Earth)

The new railway provides the possibility to optimize the alignment spend, making intelligent trade-offs between traditional high cost conservative alignments and new operating technologies. The alignment of each segment of the railway can be adjusted to improve its function with design balancing operating characteristics with constructability while providing alignment geometrics to meet the project purpose. This optimization has not been carried out in detail as part of this conceptual study.

1.2.7 Potential Loading Terminal Locations

The Oil Sands cover a large area of Northern Alberta as depicted below (brown colored area) based on the Alberta Environment and Sustainable Resource Development website.[1] The areas presently under development or approved

[1] http://environment.alberta.ca/apps/osip/

for development are shown in green and blue, with the main development area running northwest from Fort McMurray.

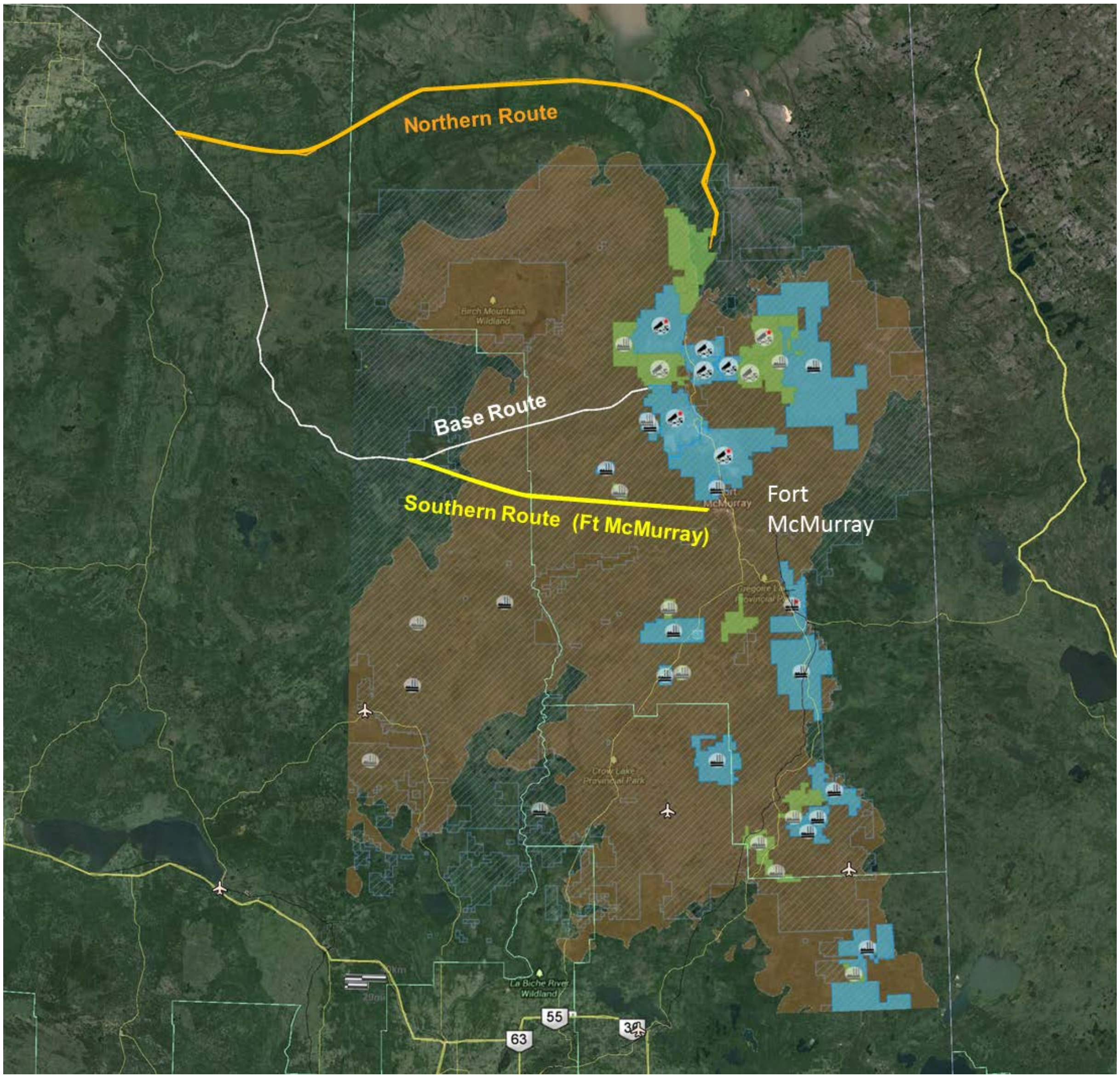


Figure 3 Loading Terminal Options **(Google Earth)**

Alberta to Alaska will have an advantage over other routes in that it will approach from the northwest and can access directly into the heart of this oil sands production area. The final location will be based on a suitable loadout terminal property area with good access to mines. There are several potential routes into the area and given the relatively large geographic footprint, no definitive railhead yard site has been chosen as yet.

As shown above, the Base route (white) is used for this study and enters the central northwest area of the oil sands and is the indicative route chosen for this study. Potential alternatives might include the yellow Southern Route which heads directly toward Fort McMurray with a possible connection with CN Rail. Another alternative is a more northerly route circumventing the Birch Mountains Wildlands area with its higher elevations turning south and then down the Athabasca River valley.

1.2.8 Potential Unloading Terminal Locations

There are several possibilities for terminal locations in Alaska. The chosen base route to Delta Junction with a rail connection to the Alaska Railroad. The others options are to either:

- Use the cut off at Tok and head south to Glennallen for a more southerly connection, or
- Proceed further south to Thompson Pass, or
- Investigate a new route via Chitina to a new port.

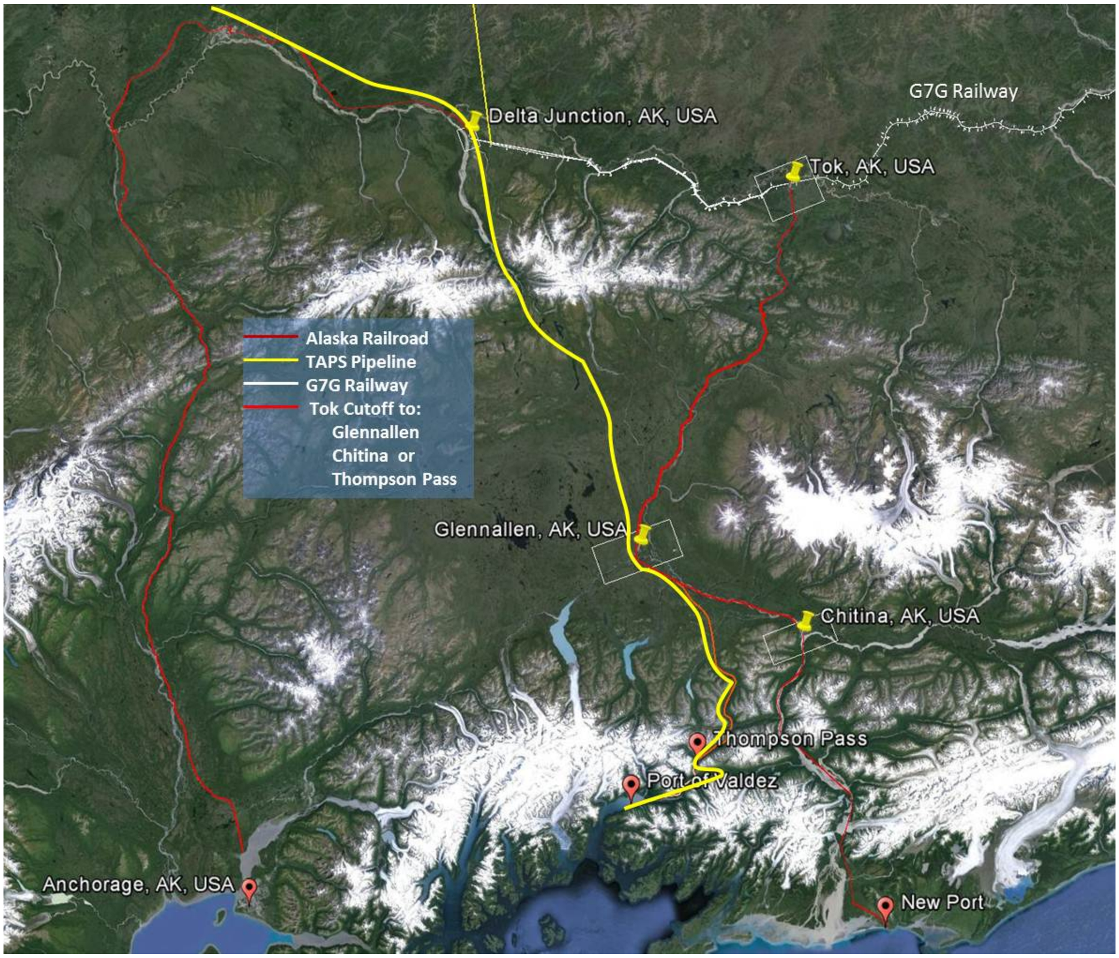


Figure 4 Unloading Terminal Options (Google Earth)

A comparison of each route option is contained in Table 1.

Table 1 Comparable Destination Alaska Terminal Options

Railway Leg	Km	Port	Via	Pros	Cons
Tok to Delta Junction	172	Valdez	Pipeline at Delta Junction	• Can connect with the Alaska Railroad and other railway business • Connect to TAPS or other pipeline	• Going away from Valdez: • 210 km further by pipeline • 175 km further by rail •
		Port	Alaska		• Alaska Railroad yet to be built to

		Mackenzie	Railroad		Delta Junction (about 95 km) • Port Mackenzie yet to be built • 850 km more on Alaska Railroad to port
Tok to Glennallen	219	Valdez or New Port	Glennallen	• Shortens pipeline use to 210 km • Land available for unloading station	• 50 km further by rail than to Delta Junction • 1 more mountain pass to climb •
Glennallen to Thompson Pass	110	Valdez	Thompson Pass	• Shortens pipeline by an additional 110 km • Downgrade to Valdez from Thompson Pass 43 km • Shorter pipeline	• 110 km new railway from Glennallen • • 1 additional pass to climb • Railway cannot descend past Thompson Pass (without very large capital cost - 2,300 ft. drop in elevation in 12 km) • High elevation and narrow valley for transfer station & inclement weather (very high snow fall)
Glennallen to a new port	273	New Port	Chitina	• Very good grades • No additional pass to climb • 200 km on previous narrow gauge alignment from Chitina to Tide Water	• 275 km from Glennallen • Rugged route along river. • Requires new port to be constructed at tide water (exact location not studied).

Given the above, Delta Junction appears to provide the most flexibility for the initial rail route with a possible connection to the Alaska Railroad, and the best route to the Port of Valdez. Therefore from a transportation infrastructure point of view the destination of Delta Junction serves as the base case for this study.

1.3 Railway Safety

In order to determine the configuration of tank cars into trains, it is necessary to review the key areas of technology that allow modern railways to operate in a safe and efficient manner.

For railways that are designed as purpose built, the safety and efficiency is increased substantially since such railways are essentially a closed system for these bitumen trains where railcars are not handed over to other railways but monitored and maintained in a highly predictable and regimented basis. Alberta to Alaska Railway is envisioned to be a leader in this area.

1.3.1 Safety in Design

Safety starts with the design of the railway. In the preliminary design stage, potential safety hazards are identified and designed out of the systems wherever possible. For those potential hazards that cannot be designed out, safety procedures and processes are identified and form part of a robust Safety Management System that is in compliance with all regulations of both the US and Canada as they apply to the railway operation.

All railway equipment will need to be incompliance with North American standards and regulations as contained in the AAR rules of interchange.

1.3.2 Wayside and Onboard Safety Monitoring Systems

A well maintained railway is a safe railway. Below is an indicative list of current monitoring systems that are available today to augment regular manual inspections and in total, go beyond current regulatory requirements to support a safe railway environment. The ability to continually monitor equipment both from wayside as well as onboard trains, provide the ability to respond to pending failures before they occur, providing an superior level of safety practice.

Safety System	Frequency	Spacing	Type of Inspection
Wayside Systems			
Hot Bearing Detector (HBD)	Continuous	25 km	Axle Bearing Health
Dragging Equipment Detector	Continuous	25 km	Under car equipment
Wheel Impact Load Detection (WILD)	Continuous	Terminals	Wheel condition
Signal System Continuity	Continuous	NA	Functionality of whole system
Switch Position	Continuous	NA	Confirmation of Switch position & continuity
Rail Break Detection	Continuous	NA	Electronic detection of rail continuity
Falling Rock Detection	Continuous	As required	Detect falling rock on track
Network Management System	Continuous	24/7	Detect health of signals/fiber/radio
Equipment Inspection	Train arrival	Each Terminus	Visual inspection of rail equipment
Various System Inspection & Maintenance	As Regulated	As Required	Test & Examine the system and record results/make corrections
High Water Detectors	As required	Specific	Prevention of derailment by washout
Wind Detectors	As required	Specific	Prevention of derailment by wind
Seismic Monitoring	As required	Specific	Prevention of derailment by earthquake
On Board Systems			
Driver Assist	Continuous	Each Train	Provides information on track, speed limits and current authorities
Air Brake monitoring **Electronically Controlled Pneumatic Brakes (ECP)**	Continuous	Each car/train	Detect changes in air brake pressure, individual car brake functions, (including air pressure at end of train)
Train Control	Continuous	Each Train	Provides driver overrides to ensure authorities are not exceeded
Engine Health	Continuous	Each loco/train	Monitor and report health of engines
Car Bearing Health	Continuous	Each car/train	Monitor and report health of car bearings
Rolling Stock mounted track inspection	Continuous	Two car sets	Continually monitor condition of track for any deterioration or change

1.3.3 Operating Trains

Below are more detailed outlines of four components which allow traditional railways to take advantage of their rail guided, superior low friction wheel to rail interface, to now move large volumes of product safely and effectively.

- Distributed Power
- Driver Assist
- Positive Train Control (or similar train control system)
- Electronically Controlled Pneumatic Brakes (ECP).

All are in use today to some degree on heavy haul railways around the world. The Alberta to Alaska Railway, being purpose built can incorporate these technologies within a closed system environment for maximum effect. These areas of train control are as shown below. It should be noted that railway being new, has a distinct advantage over existing railways in that there is no retrofit cost to deal with, since new equipment needs to be purchased and therefore will incorporate the most advanced and proven products that industry can supply.

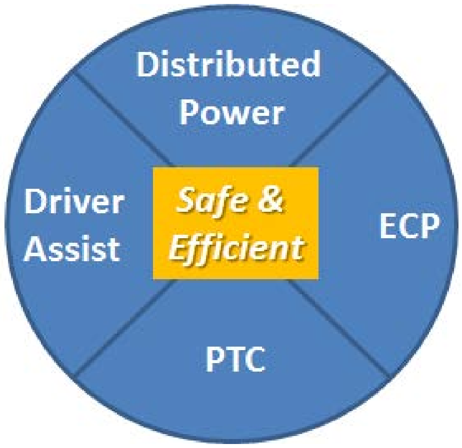


Figure 5 Keys to Safe and Efficient Train Operation

1.3.3.1 Distributed Power

Train load is a goal of freight railways. As with all modes, the more that is hauled in one load, the more efficient the transportation. Adding more locomotives to the front of a train will not automatically allow a heavier train to be hauled. The heavier the train, the higher the forces become throughout the train. In the face of extreme forces, the couplers between cars are designed to reach their strength limit prior to more serious equipment failures, such as broken car bodies or draft gear which could result in a train derailment. The couplers have knuckles which are replaceable if broken and therefore the couplers act as safety “fuses” within a train body when too much force is exerted. To add more tonnage and safely overcome this limit, distributed power technology is currently being used extensively within the heavy haul rail industry. Distributed locomotive power, also known as Distributed Power (DP), enables increased trainload by placing additional locomotives throughout the train which are remotely controlled. Distributing power allows longer/heavier trains which leads to fewer trains per ton moved and the following benefits:

- Improved line capacity
- Reduced risk of train incidents or accidents
- Fewer operating crews
- Less complex railway logistics and operations
- Improved fuel efficiency per tonne of bitumen hauled
- Reduced in-train forces
- Reduced wheel/rail wear
- Improved braking performance due to reduced air propagation time; and
- Improved operational efficiency where consists need to be split (i.e., for unloading)
- More time for track maintenance per ton moved.

Figure 6 Photo of Distributed Power in use within a Single Coal Train

1.3.3.2 Electronically Controlled Pneumatic Brakes (ECP)

Traditional heavy haul railways rely on a single air system to both charge the brakes and then apply them. This ingenious use of a single pipe for both charging and controlling brakes has drawbacks for the drivers.

- Conventional brakes take time to apply from the locomotive to the cars at the speed of the air reduction in the pipe as it moves down the pipe car to car. This causes delays in brake application on longer trains and causes in-train dynamics.
- Conventional brakes cannot be charged and applied brakes at the same time. If brakes are applied and then released it takes time to recharge the brakes again. If too many brake applications without allowing sufficient time to recharge the train must be stopped and then recharged.
- The brakes cannot be graduated off. They can only be applied more or released completely. This means if too much brake is applied, then making some release to make adjustment is not possible without full release. This seriously handicaps the ability to precisely maintain an optimum speed (too much brake or too little).

The Electronically Controlled Pneumatic Brake (ECP) is a braking system which eliminates the above problems. It has an electronically transmitted control signal via wire along the length of the train which activates the brake solenoid on each car pair simultaneously. The train wire can also be used to transmit other signals such as train integrity; train condition and train control information as well as being used to monitor individual car alarms. Similarly to a conventional brake system which relies on a charged pipe in the train to keep the brakes off, the ECP system relies on constant communication in the line or the train is brought to a safe stop.

An ECP brake is recommended for all rail equipment on the Alberta to Alaska Railway enabling superior braking performance than is possible with conventional air brakes based on the length and weight of the proposed bitumen trains. The ECP system has the following safety and operational benefits over a conventional air brake system:

- Instantaneous and uniform application and release of brakes throughout the train permitting improved train handling

- Graduated release of brakes (lessening of brakes already applied) versus conventional freight train brakes which only permit either increasing brake or a complete brake release
- Much improved and consistent in-train forces throughout the train enabling longer, heavier trains, thereby requiring fewer trains to reach the production targets and consequently greater flexibility in the rail system with less infrastructure and assets
- Elimination and/or detection of individual sticking brakes
- Reduced fuel consumption and improved cycle times
- Supports communication channels to monitor car alarms, providing location and type of alarm, enabling constant monitoring of all cars in the train.

1.3.3.3 Driver Assist

Driver assist software is a passive system used to provide information to the driver to assist in the safe handling of the train. Given the challenges of developing the large number of sufficiently well trained drivers to operate extremely heavy trains over the undulating alignment and in order to meet train production velocities in a safe manner, driver assist software greatly enhances the startup and operating excellence of this new railway.

Since fuel is a major operating expense of this railway, and the single track mainline requires trains to stop so others may pass, Driver Assist analyses train locations and their progress, imposing speed limits thereby reducing the “hurry up and wait” syndrome. The result is a substantial saving in fuel and improved train performance and handling.

1.3.3.4 Automatic Train Control (e.g. Positive Train Control - PTC)

This provides up to date information to drivers so they are constantly aware of limits of authority and not subject to looking for wayside intermittent indications. This in turns permits trains to be operated with a higher level of confidence due to consistency safe train handling.

Limits of authority, both for speed and location override the driver as required. This eliminates the risk of train collision by imposing overrides to stop the train if an unsafe condition is detected. This system is extended to protect track equipment as well as trains to ensure a safe operating of the entire network. There are several working systems in place today, and the final combination of systems would be specified at the detail design stage of this project.

While a PTC system may not be cost effective from a retrofit point of view for tens of thousands of existing railway miles, the Alberta to Alaska will require new control systems, therefore the cost for employing current technology is simply part of the design and an use of the best in-use technology an operating plus.

1.3.4 Security

Security and safety are often grouped together in light of heightened security awareness. While the responses require similar measures, the prevention is a risk assessment which requires a Security Management Plan. Given the remote nature of this railway and the advanced systems that will be put in place this is viewed as a low risk environment. Never the less, this subject needs to be addressed in any preliminary design process.

1.3.5 Risk

One of the difficulties with assessing safety risk is to separate the risk of accident from the impact. Events that happen with severe impact tend to get noticed far more than smaller accidents which may accumulatively have far more impact.

Risk is expressed in terms of probability and impact. For example the impact of the incident Lac Megantic was horrendous. But the risk of this type of rail accident is extremely low. In fact, this was the worst rail accident of its kind in Canadian history. This accident is non-typical of railway incidents to the extent that on average there are only 1.5 fatalities per year from derailments in Canada[2]. This is classified as a low risk-high consequence accident. Given the billions of ton-miles moved by rail in Canada, compared to other modes, the risk of a high consequence accident is extremely low. Through the Safety Management System and Plan, the railway will develop a comprehensive program designed to minimize risk and continually reduce injuries.

1.3.6 Incident Response

The ability of the railway to respond immediately should an incident occurs is paramount. Due to the isolation of the area, the railway must take a lead role in addressing all emergency issues. The coordination of any response will start with the operations control centre and be escalated as required to achieve the necessary remedies as outlined by the Safety Management System and Emergency Response Plan of any Federally Regulated railway.

Standby equipment and trained responders will be available 24/7 to respond to an incident, whether by road or in isolated locations by rail or air. In addition to the eight engineering locations on line, there will be three sites where major rail mounted response equipment will be staged: At Delta Junction, at Fort McMurray and at Liard River Crossing.

Disruptions cause significant impact to railway operations. These accidents or events are costly to rectify and if not handled quickly will cause the loss of productivity and can impact environment, communities and wildlife. Every effort should be made to avoid these situations. However unexpected disruptions do occur and require a well planned and executed emergency response. An Emergency Response Plan must anticipate the manner in which accidents and events should be handled. Then materials, equipment and personnel must be made ready and available to anticipate and productively respond to such emergencies when needed.

In the case of the Alberta to Alaska Railway, access to the railway by road is difficult in many areas. A trip between Unloading and Loading facilities over the roadways can take as long as 3 days. Given this difficulty an Emergency Response Plan should make best use of the railway or any other means to access an emergency response site. Responsiveness can be further enhanced by having assets and personnel strategically located along the railway network. Due to the potential environmental impact that a derailment could have, mobilization time will be the critical element in successfully containing and restoring a derailment site.

As such the main response equipment should be located at a central location, near Liard River Crossing for example, while two satellite response teams need to be positioned at both ends of the railway. That way any major incident still permits approach of equipment from both directions on either side, no matter the location of the incident.

The Emergency Response Plan will make use of Chemtrec and Canutec as a resource and will be a member of the ICM's responsible Care initiative. The plan must address:

- Readiness (prepared)
- Response (safe and timely)
- Restoration (repair and recovery).

[2] *TSB Rail Statistics 2010 http://www.bst-tsb.gc.ca/eng/stats/rail/2010/ss10.asp#t2*

1.4 Railways and Pipelines

The potential railway connections not only give Alberta to Alaska Railway direct access to supplies by rail, but the railway has the potential to open up this vast and remote hinterland area of Canada/Alaska to any and all products that need to be shipped. It will be classed as a common carrier and obliged to carry any and all goods and people tendered. The expected revenues this will generate that establish it as a Class One freight railway ranked rail operation joining just a handful of railways in North America.

Therefore the potential investment for this project has benefits when compared to a pipeline. As part of this, it is important to dispel the myth that railways are operationally less efficient than pipelines. By comparison, while the benefits of pipelines are well documented and considering their efficiencies, they have transportation limitations and drawbacks. The following table outlines a comparison of the value of operations inherent with a purpose built railway compared to using pipelines.

Table 2 Railways versus Pipelines

Values	Attributes	Alberta to Alaska Railway Alternative	Pipeline Alternative
Flexibility	Commodities	All rail transported products in bulk, container and other units	Extremely limited, with pre-emption by the selected petroleum product class
	Purity of Bitumen	Up to 30% more Bitumen per barrel moved	Diluent Added - up to 30% less bitumen per barrel moved
	Backhaul potential	Yes for the train consist if moving condensate diluent	No, one flow direction only
	Additional Handling	Limited, Only crude oil / petroleum compatible liquid materials	Significant, Diluent recovered and either transported back by rail or continually produced at source
	Choice of Destination	All rail served properties in North America	Limited to terminals along the pipeline route
		Modify destinations for product in transit and future shipments	Origins and destinations fixed
	Linked Transport Development	Supports full range of economic development	Narrow band of economic development at limited locations
		Commercial carrier transportation widely accessible to Industry	Bulk liquid product industries aligned with the selected product
	Maintenance	More flexible, performed under continuous operations	Less flexible, performed with operations shutdown
	Staffing	More robust and diversified workforce	Standardized with limited staff availability
	Delivery Contract	Typically shorter, offers more flexibility and better costs, particularly to smaller producers. Can be less beneficial to the railway if the market changes significantly.	Typically longer, fixed and doesn't take into account fluctuations in the market. Benefits pipeline as price is locked for a long duration and does not fluctuate with demand.
Risk	**Prevention**		
	Out of Sight Out of Mind?	Transparent (above ground)	Hidden (below ground)*
	Inspection & Detection	Unlimited	Limited to what fits inside the pipeline
	Wear Measurement	Continuous	Intermittent with limited field and operational verification
	Spillage	Limited, readily observable, compartmentalized by car	Small leak - undetectable but cumulative long term damage

Values	Attributes	Alberta to Alaska Railway Alternative	Pipeline Alternative
	Product Loss	Readily scalable response measures Less viscous, less contamination, the Estimated spill rate for crude oil moving by rail was 0.38 gallons spilled per million barrel miles moved[3]	Large Leak –highly viscous large potential contamination in short time Estimated pipeline spill rate of 0.88
	Elapsed time to response	Immediate	Delayed pending actuation of release detection and triggers
	Mitigation	Modify vertical and horizontal alignment	Horizontal route alignment pre-determines mitigation strategies
		Flexible and adaptable mitigation strategies	Mitigation strategies limited to pre-construction decisions
	Sustainable Assets		
	Normal depreciation	Verifiable through multiple detection strategies, scalable, continual renewal	Constrained in-situ techniques with limited detection techniques & scalability
	Accelerated depreciation	Detectable and scalable through multiple techniques	Limited detection with potential run to failure events
	Sustained Factor of Safety (SF)	SF status detectable and responsive to restoration & mitigation	Limited detection and measurement with potential run to failure events

Note: The bitumen will not require any diluent by rail, as the temperature will be maintained within the range of fluid viscosity throughout the trip. This translates into an actual product shipped which will be up to 30% more than found in a pipeline which requires diluent mixed with bitumen in order to flow. Refer to Section 9.6 Bitumen Logistics of the report.

1.5 Methodology to Determine Capex and Opex

In order to establish the requirements of the new railway operation, a series of steps is required taking information as provided as well as deriving conclusions based on knowledge of railway operation capabilities to generate outcomes which lead to a final operating plan which can meet service requirements with an estimated Capex and Opex.

Infrastructure:

- Establishing potential route(s)
- Setting railway alignment parameters
- Designing a preliminary alignment

Operating:

- Understanding the nature of the product to be moved, its characteristics and limitations
- Determining the right railcar for the product
- Determining size of train consist given the railway alignment parameters
- Application of technologies which permits safe and efficient operations
- Establishing cycle times of equipment
  - Determining train performance
  - Establishing crewing requirements

[3] *https://www.aar.org/safety/Documents/Freight%20Railroads%20Safely%20Moving%20Crude%20Oil.pdf*

  - Establishing loadout and unloading requirements
  - Establishing Network Performance (multiple train patterns)
- Establishing Total Rolling Stock Fleet Size
  - Establish Rolling Stock maintenance requirements
- Establish Required Infrastructure Maintenance
  - track, signals, power and bridge
- Establish an indicative railway organization to support the operating and maintenance of assets

From these, the Capex and Opex required for the moving the bitumen as well as the maintenance requirements in order to sustain their movement were developed. These are outlined in the following sections.

This process requires a strong integrated railway planning team with multiple disciplines to enable this work to be completed.

1.6 Moving Demand Volumes

1.6.1 Bitumen Demand

Once the standards are established and the route is selected, a confirmation of the demand to be placed on the railway was being established in order to determine the necessary equipment to meet demand. Railways operate based on tonnage, not volume, since the operating limits are usually prescribed by weight not volume for most commodities.

The following demand volumes are the basis for this study and both are within the capacity of a single track Alberta to Alaska railway as described below. The two volume cases are explored in this study:

- 1.0 mbpd barrels of bitumen per day
- 1.5 mbpd barrels of bitumen per day

1.7 Base Tank Car Specifications

While the railway could interchange with both CN and the Alaska railway directly and every other North American Railway indirectly, providing North American wide rail access, the dedicated cars carrying bitumen will be specifically designed to be part of the Alberta to Alaska Railway operating network, meeting or exceeding and taking advantage of the latest technology and working to the heaviest North American rail standards – 315,000 lbs. gross weight per car.

Product movement starts with choosing the appropriate tank cars. Due to extreme temperature variations, not only will the tank car design and construction be latest technology but the design must also address brake pipe system piping and the need for Electro Pneumatic brake system. Since every coupling of cars is a potential maintenance point, the least number of couplings possible is desirable. By using 3 railcars that permanently coupled into one unit, air hose as well as the ECP electronic couplings, are reduced by two thirds. The result is a recommended combination of 3-58 ft. tank cars together as a group called a 3-pak.

In order to carry heated bitumen from load to unload, cars will be heated and insulated. Heat loss is restricted by the insulation and in order not to have to reheat the bitumen during in the coldest extreme weather the loaded cars need to reach Delta Junction within 60 hours. While they will normally retain enough residual heat from the bitumen to be unloaded at destination without reheating, they carry the necessary piping to be reheated for unloading if they are unduly delayed en route for any reason. With the extreme winter temperatures experienced in the Alberta to Alaska

Railway route, the ability to heat cars at either end will support the logistics to ensure maximum volume is moved quickly and efficiently.

The general tank car specification is based as follows:

Table 3 Base Tank Car Specification

Tank Cars		
Multiple unit	Yes	3-pak (solid drawbars & air hoses)
Barrels of Bitumen per unit/car	638	Barrels (2.5% density allowance)
Length of individual tank car	58	ft.
3-Pak length	174	ft.
Insulated	Yes	
Heated	Yes	External Coils
ECP	Yes	1 control unit per 3 cars
Hot bearing sensors	Yes	onboard sensors for each bearing

1.7.1 Bitumen Volume versus Weight

The bitumen will be loaded into insulated heated tank cars. It is required to be heated to above 30 °C in order to flow freely. At 15 °C, which is assumed to be the usual temperature for commercial sale, the tank car will hold 654.1 barrels[4] at 100% of the loaded weight capacity of the railcar.

However In the winter months the heated temperature may have to be as high as 90 °C in order to reach Delta Junction and discharging without having to reheat the bitumen. This temperature requires room for expansion of up to 6.2% and the volumes increase to 664.8 barrels or 99.9% of the tank car capacity, even though commercially it is still carrying only 654.1 barrels.

Table 4 Basic Barrels per Rail Tank Car

	Density		Volume				Weight per Car					Load Allowance
Fully Loaded			**Fully Loaded**				**kg**	**tons**			**lbs.**	
temp °C	**g/cc**	**Density Variance**	**bbl**	**Litres**	**Gallons**	**% Full**	**Load Limit**		**Tare**	**Gross**		**0.0%**
15	1.016	-1.6%	654.1	104,024	27,480	93.8%	105,688	116.5	41	157.5	315,000	100.0%
20	1.012	-1.2%	656.8	104,435	27,589	94.2%						
31	1.000	0%	664.8	105,688	27,920	95.3%						
80	0.960	4.0%	691.3	110,092	29,083	99.3%						
90	0.954	4.6%	695.3	110,784	29,266	99.9%						
		Total Variance	6.2%									
In order to ensure safe weight and volumes allowances, a 1.5% reduction in average weight reduction is used. This also brings the volume capacity down to 98.4% at 90 °C. This translates into an average of 644.5 barrels per car at 15 °C.												

[4] ***Properties of Oil sands and Bitumen in Athabasca,*** *Hisako Mochinaga*Jogmec Trc, Chiba, Japan, et/al., 2006 CSPG-CSEG-CWLS Convention*

Table 5 Barrels per Rail Tank Car with Temperature Adjustment

	Density		Volume				Weight per Car					Load
Weight (- 1.5%)			**Weight**				**kg**	**tons**			**lbs.**	**Allowance**
temp ℃	**g/cc**	**Density Variance**	**bbl**	**Litres**	**Gallons**	**% Full**	**Load Limit**		**Tare**	**Gross**		**1.5%**
15	1.016	-1.6%	644.5	102,497	27,077	92.4%	104,137	114.8	41	155.8	311,580	98.5%
20	1.012	-1.2%	647.1	102,902	27,184	92.8%						
31	1.000	0%	655.0	104,137	27,510	93.9%						
80	0.960	4.0%	681.2	108,476	28,656	97.8%						
90	0.954	4.6%	685.1	109,158	28,836	98.4%						
Total Variance			6.2%									

Finally an extra 1% reduction in barrels per car is used in order to account for some carry back of product from the unloading point. This will vary by time of year and is viewed as a conservative number.

Table 6 Barrels per Rail Tank Car with Carry Back Adjustment

	Density		Volume				Weight per Car					Carryback +
With Carry back Allowance (-1%)			Weight + Carry Back				kg	tons			lbs.	Allowance
temp ℃	g/cc	Density Variance	bbl	litres	Gallons	% Full	Load Limit		Tare	Gross		2.5%
15	1.016	-1.6%	638.0	101,464	26,804	91.5%	103,087	113.6	41	154.6	309,266	97.5%
20	1.012	-1.2%	640.6	101,865	26,910	91.8%						
31	1.000	0%	648.4	103,087	27,233	92.9%						
80	0.960	4.0%	674.3	107,383	28,368	96.8%						
90	0.954	4.6%	678.2	108,058	28,546	97.4%						

In summary, based on a revenue barrel base (@15 °C), the heated bitumen at loading requires a volume which is at least 6.2% larger than the cooler volume to have retained sufficient heat for direct unloading at the other end of the railway. The proposed railcars have sufficient capacity to hold this additional volume. In addition for this purpose built railway, we assume a 1.5% average reduction in loading allowance plus a 1% carryback of product in order to provide reasonably conservative revenue barrels per car (refer to Section 9.6 Bitumen Logistics of the report).

As a result of the above assumptions, the actual revenue barrels per tank car are calculated as 638 barrels.

1.7.2 No Diluent Added

The goal is to use the railway to its advantage in that products move on wheels. Since the base product to be carried by rail is bitumen, this means that no diluent is required to be mixed into the bitumen as long as it is heated to the proper viscosity for loading/unloading. Since bitumen is heated to allow it to flow freely when mined it is a logical fit to move the heated bitumen directly to heated railhead storage tanks. Then the heated bitumen is loaded into insulated railway tank cars. Therefore the shipped product will be 100% bitumen and provide an additional increase in barrels shipped as compared to pipeline where diluent can be as much as 30% of its volume. So by using raw bitumen with no diluent, an increase in revenue barrels of bitumen as compared to pipelines (assuming a 30% diluent content) could be achieved, as such 1.0 mbpd barrels shipped by rail compares to only 0.725 mbpd in a pipeline. In addition the handling costs (production or recycling) of diluent are also eliminated.

1.8 Base Locomotive Specifications

A number of key requirements for locomotives must be considered in order to operate a heavy-haul line in Canada and the United States. These requirements are driven by factors such as:

- Climate conditions – extremely low temperatures during winter can impact on engines, product viscosity, track adhesion and brake pipes.
- Power output – total power output is a product of tractive effort required and speed. Tractive effort has been determined based on forces required to overcome friction, track curvature and grade and acceleration requirements.
- Adhesion – consideration of the track condition, particularly during winter, must be considered including friction coefficients for both wheels and brake pads for acceleration and deceleration requirements.
- Fuel tank capacity – total fuel capacity for each locomotive has been determined based on the total length of the line and currently available products.
- The design basis for the alignment is maximum 1.0% vertical grades, 2°30" curves, 2,400 km of track, 34 tonne axle load.

The major operating cost of this heavy haul railway will be fuel. Aside from diesel, a cursory review of the application of Liquefied Natural Gas (LNG) was undertaken and is not recommended at this point for various reasons found in Section 1.20.1. If tonnage and haulage reach a considerable volume then electrification of this line may be a viable alternative, depending upon the expected life of the railway and cost of sourcing the electric power. However, that alternative is beyond the scope of this study.

Therefore, at this early stage and to be conservative in our approach, we have assumed diesel-electric locomotive, using existing and proven technology. A locomotive with AC (alternating current) traction is preferred over a DC (direct current) locomotive for this application due to:

- Lower whole life cost due to greater fuel efficiency and lower maintenance costs; and
- Ability to travel against long grades at low speeds without overheating

Table 7 Train Specifications

Diesel Electric[5]	AC Traction
Fuel Efficiency	Tier 4
Weight Range	439,000 lbs. to 472,500 lbs.
Length between front and rear coupler pulling faces	Nominally 75 ft.
Cab configuration	Single cab at short hood end
Net Notch 8 tractive horsepower	4350 THP
Locomotive weight	219 tons (without fuel)
Maximum speed (fully worn wheels)	100 km/h
Minimum continuous speed at Notch 8	14 km/h
Starting tractive effort	132,000 lbs. force in all weather conditions
Peak braking effort	132,000 lbs. force in all weather conditions
Peak Braking Horsepower	5,200 BHP
Special Equipment	• Distributed Power (DP) • Driver Advisory System • WSP • AESS to be fitted, ensuring the engine does not power down in cold ambient conditions • Wired Distributed Power required with the capacity to control trains with up to 4 consists and 8 locomotives
Brake Equipment	Stand-alone ECP shall comply with AAR Section E
Fuel Tank	Fuel tank capacity to be at least 4,800 gallons.

[5] *Note: use of electric locomotives is beyond the scope of this study.*

1.9 Determining Bitumen Fleet Assets

1.9.1 Train Consist

A number of train configurations have been considered and a distributed power (DP) arrangement is considered more suitable than a head end power (HEP) arrangement as it minimizes in-train forces and maximizes coupler longevity. These improvements yield benefits in a reduction in the lateral force between wheel and rail. This reduces wheel-rail interface friction which, reduces wear and improves fuel efficiency. The table below summarizes the main advantages and disadvantages of DP and HEP.

Table 8 Train Configuration Comparison DP:HEP

Train Configuration	Advantages	Disadvantages
Distributed Power (DP)	• Reduced in-train forces (especially on front cars) • Enhanced carrying capability due to longer trains • Instantaneous brake application using same ECP brake communication system • Reduced component wear • Reduced fuel consumption • Reduced stopping distances	• Time required to break up the consist and add additional locomotives if necessary • Cost of equipping locomotives with suitable control system • Potential loss of signals requiring multiple fail-safe redundancies • Operational responsiveness to a failed locomotive at the rear of the train
Head End Power (HEP)	• Lower cost to implement (relative to DP) • Good reliability due to lack of dependence on electronic systems	• High in-train forces due to tank car bunching during deceleration • Slow brake propagation • Limited carrying capability

A typical schematic of a train operating under a DP and HEP arrangement respectively is provided below.

Distributed Power:

Head End Power:

Taking into account the railway alignment standards that are incorporated into this study, the proposed Alberta to Alaska bitumen train will make use of distributed power pending further study beyond this study scope, is as follows:

2 Locomotive + 96 cars + 2 Locomotives + 96 cars + 2 Locomotives

A suitable distributed power system capable of controlling trains consisting of the 192 tank cars and the 3 sets of paired locomotives (6 in total) is required. Communications between locomotives will be established using the ECP brake communications cable.

Table 9 Train Consist

Cars/train	192	
3-Paks per train	64	3-paks
Locomotive	4400	HP
Locos per train	6	locos
Train length	11,590	ft.
	3,530	m
Gross loaded train weight	31,500	tons (maximum)
Gross empty train weight	9,186	tons
Power to Weight Ratio	0.84	HP/Ton
Barrels per train	122,500	barrels

Locomotives are paired, back to back to provide the ability to exchange or replace at any position in the train. By pairing locomotives as a standard configuration the maximum flexibility and reliability in operations is gained. The symmetry of this consist arrangement also has some additional operational advantages covered in Section 9.6 Bitumen Logistics of the report.

For this level of study, given the preliminary nature of the alignment, in-train force simulations are not appropriate at this time. The use of ECP and distributed power will have a positive impact on greatly reducing such forces. However, the final alignment plays a critical role in shaping those forces. Therefore should a preliminary engineering design proceed, those simulations should be performed as part of the integral train/track dynamic design in order to optimise the alignment civil costs versus train operation performance requirements.

1.9.2 Cycle Time

In order to determine the number of train sets required to move the bitumen, cycle time of the equipment has been evaluated. The shorter the equipment cycle, then the less rolling stock is required to move a given amount of bitumen. Since the rolling stock represents a substantial cost of capital, the cycle times are an important consideration. In addition, based on previous calculations the transit time for loads needs to be kept within 60 hours under normal operations to permit the bitumen to arrive at destination with sufficient residual heat to allow unloading without reheating of cars.

Modelling this outcome was an interactive process, and required the close collaboration with the Track and Civil design teams as well as the other operating disciplines (rolling stock, signals, communications and track maintenance planning) to ensure robust model inputs were developed.

Factors affecting the final fleet requirements determine how productive each car is and therefore how many cars are required to move the demand tonnage. These 3 major time components include:

- Loaded and Empty Trains Transit Time
  - Train Performance
    - Train Consist Parameters
    - Mainline Alignment
    - Horizontal/Vertical Profile
  - Network Performance
    - Meeting other trains
    - Number of passing sidings
    - Spacing of passing sidings
    - Length of Sidings

  - Control Systems
  - Crew Changes
  - Fuelling en route
- Loadout Process Time
- Unload Process Time

Together these times form the basis for one cycle. In other terms, the faster the average cycle time, the fewer cars are required to deliver the demand. Therefore, to minimize fleet costs, the objective is to move the bitumen with the overall shortest cycle time in a manner consistent within the required railway safety standards and processes. In addition the optimisation of fleet costs must be balanced against the various asset capital and operating costs which affect this cycle time, namely the chosen alignment, rolling stock, selected control systems, fuel consumption, etc.

1.9.3 Train Performance

The length of the mainline of the railway is a key parameter affecting the cycle time of the railway. Two alignments, Southern (via Peace River) and Northern (via Fort Vermilion) have been assembled and simulated. The route through Fort Vermilion is the preferred route as it avoids a difficult crossing of the Peace River Valley and shortens the overall route. This alignment is approximately 2,400 km (1,500 miles) of single track with passing sidings (limits of loadout yard to limits of unload yard).

A key impact on transit time is train velocity. Mainline speeds are nominally set at 80 km/h (50 mph) for loaded trains and 100 km/h (60 mph) for empty trains which is consistent with FRA regulations for this class of product. As the alignment is refined further curvature may necessitate localized speed restrictions but at this stage the proposed alignment is generally very well laid out and any such future restrictions should not significantly impact overall train performance.

Train performance was modelled using Systra's RailSim software. Typical inputs into this software are:

- Vertical grades [6]
- Horizontal curves
- Speed limits
- Locomotive performance characteristics (tractive effort, braking, etc.)
- Rolling Stock (tank car) performance characteristics (bearing friction, air drag, weight, etc.)
- Power to Weight Ratio (HpT - Horsepower per Ton).

In order to be conservative, 100% fully loaded trains were used in the simulations. RailSim provided the following results for nonstop performance from end to end for bitumen trains:

Table 10 Train Performance Run Times

Non-Stop Run Times		
2,400 km	Loaded	Empty
Nonstop Hours	36.7	26.0
Average Speed (km/h)	66	93
Speed Limit (km/h)	80	100

[6] The basic design criteria for the alignment are found in section 3.2 of the report.

With a 0.84 HpT for loaded trains, the train consists provide sufficient power to negotiate the long route in the required time. Of note, this power exceeds the minimum requirement for moving the train over the territory. However it is not only required to meet the required loaded transit time, it is assigned to each train that in the event of one locomotive failure en route, the configuration permits the train to avoid stalling or requiring trade-off of locomotives from other empty trains that may be encounter are en route. This ensures a good overall performance given the remoteness of the areas travelled through.

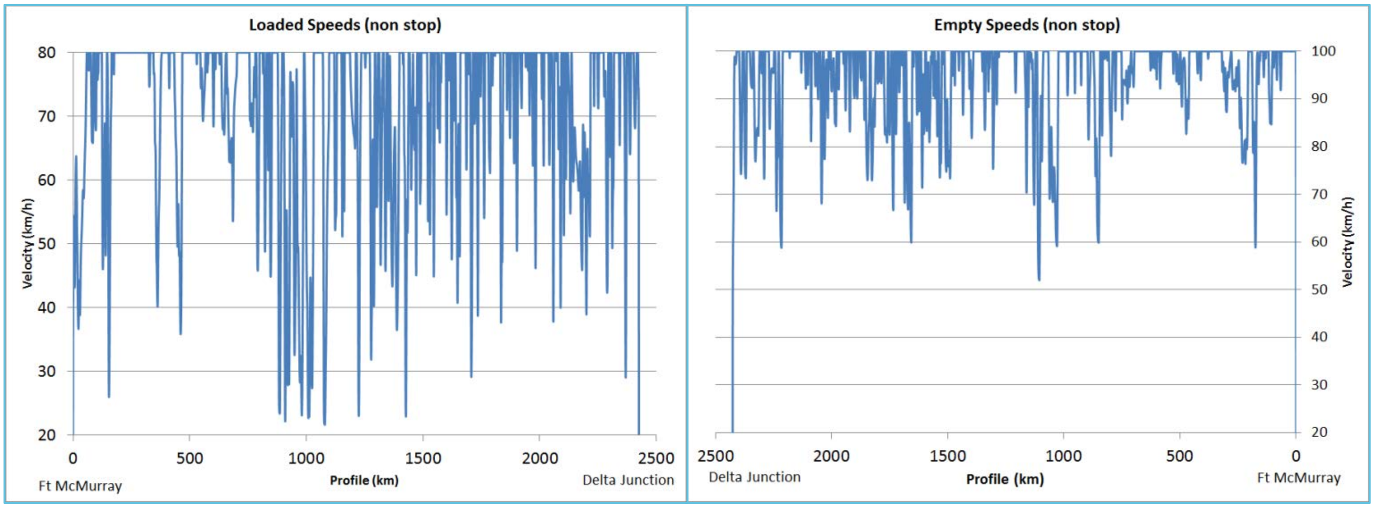


Figure 7 Train Performance Velocity

The transit times indicate that if it were possible to run non-stop a loaded train could reach Delta Junction in as little as 37 hours. The ability to reach the unloading facility in less than 60 hours provides the basis for the heated bitumen to be unloaded without being reheated even in the coldest weather conditions.

1.9.4 Train Crew Legs

Running non-stop is not possible; trains need to stop for crew changes even if nothing else impedes their progress. Since each train crew change off requires time to be added to the run times, an analysis of the crew times which are required to operate the trains was undertaken. Train crew requirement calculations were performed based on the following assumptions.

Note: in general terms, maximum on duty crew times must be less than twelve (12) hours as prescribed by Canadian Law and Transport Canada.

Table 11 Crew Assumptions

Detail	Assumption
Spare Crews	20%
Call at Home Terminal	2 hours
Call at Away from Home Location	2 hours
Average run times with train meets	8 hours or less
Maximum hours on duty	12 hours
Rest between trips at Home Terminal	16 hours
Rest between trips at Away from Home Terminal	8 hours
Time on Duty Before Departing	30 minutes
Time on Duty After Arrival	15 minutes
Buffer time per empty train crew leg (45 min)	4.5 hours

In order to provide a more conservative estimate, the 4.5 hours above represents15% empty transit time which allows for delays en route due to loaded trains taking priority, as well as the fleeting of loaded trains, as well as permitting empty trains delayed at unloading, or delayed while loading, to be able to regain the required cycle time.

The following table is the indicative crew legs for train crews (where they change) based on the preliminary alignment. Of first importance, these locations have good road access if possible. From this was derived run times and a set of 6 crew legs were established as shown below.

Table 12 Calculated Crew Minimum Run Times

Crew Legs		Distance (km)	Minimum Run Time (Hrs:Min)	
			Loads (read down)	Empties (read up)
Fort McMurray	High Level	430	6:16	5:26
High Level	Fort Nelson	400	5:26	4:58
Fort Nelson	Liard River Crossing	550	6:33	4:29
Liard River Crossing	Ross River	650	6:12	5:04
Ross River	Kirkman Creek	690	5:59	5:28
Kirkman Creek	Delta Junction	655	5:59	5:13

The following table is the recommended crew legs with modelled number of crews employed based at each home station based on 2 person crews. This is established on a conservative three (3) round trips per week per train crew plus 20% crews for relief, vacation etc. This is a higher percentage (more conservative) than average railways given the remoteness of the stations.

Of first importance, these locations split the overall route time into sections over which a train can travel each section within a nominal seven (7) hour window. Second, the crew at home locations should be, if possible, located where services and town sites already exist.

Table 13 Crew Locations and Requirements

Location		km from Town	Highway Access	Distance from Fort McMurray Loadout Yard km	Fuel	Home or Away Station	Crew Facilities	Train Crews including Spares	
								1.0 M Barrels / day	1.5 M Barrels / day
1	Fort McMurray AB	To be established	Yes	0	X	Home	Crew Office	18	28
2	High Level AB	At High Level	Hwy 35	430		Away	Bunkhouse	-	-
3	Fort Nelson BC	60 to Fort Nelson	Hwy 77	830		Home	Crew Office	36	56
4	Liard River Crossing BC	42 to Watson Lake	14 km to Hwy 77	1175	X	Away	Bunkhouse	-	-
5	Ross River YK	240 to Watson Lake	Hwy 4	1575		Home	Crew Office	36	56
6	Kirkman Creek YT	Rail access only	-	2005		Away	Bunkhouse	-	-
7	Delta Junction AK	To be established	Yes	2415	X	Home	Crew Office	18	28

Thus every other crew change point is an Away-From-Home Station. These stations are where crews from each direction turn back to their respective Home Station. The crews at Fort McMurray and Delta Junction work only one direction out to their to their Away-From-Home Station and return, while Fort Nelson and Ross River crews will work out of their Home Stations in both directions as required. Hence the crew's home stationed at Fort Nelson and Ross River are double those required at Fort McMurray or Delta Junction. It is assumed that a train crew will consist of two individuals, one Locomotive Engineer and one conductor. Crews will be trained as Conductors upon hiring and will over time be qualified as Locomotive Engineers.

Figure 8 Home and Away Stations for Train Crews on Selected Rail Route (Google Earth)

While trains would operate with two person crews, the terminal operations at both Fort McMurray and Delta Junction require yard crew assignments with three person crews. The reasons necessitating larger yard crews are discussed in Sections 1.9.9 and 1.9.10.

1.9.5 Network Performance

Network performance is a measure of service delivery by tracking the interaction of multiple trains, with their given individual characteristics, based on the fixed infrastructure including track alignment and for a single track railway, passing sidings.

1.9.6 Line Capacity

Alberta to Alaska Railway will be initially designed as a single track mainline railway. Capacity is largely a function of the number of trains that operate over the mainline compared to tonnage. As the number of trains increase on a single track, so do the number of train meets in the opposite direction. Sidings are the enablers for moving traffic in opposite directions on single track. If trains are significantly delayed then schedules are not met along with increased operating costs and bitumen demand is jeopardized. Even with 1.5 mbpd barrels per day, this railway will not exceed single track capacity. At that point the railway is approximately 75% of practical capacity, which is the optimum efficiency that the railroad as designed would operate.

As the main track fills with trains, the number of sidings is increased to handle the traffic, until a point where the sidings are so numerous that any additional sidings might as well be practically joined, turning the railway into a double track main track railway (one direction for each main track). In practice, the areas where trains travel the slowest (most congestion) are typically the first to be double tracked assuming the capital costs are acceptable. Once this occurs, meet delays are effectively eliminated and typically as a result, more than a tripling of train capacity is achieved. The use of in-train control technology increases trainload and as a result increases the railway's capacity.

Trains which have relatively uniform performance (similar power to weight ratios) tend to keep the traffic moving in a homogenous way, reducing conflicts. Given this is purpose built; the Alberta to Alaska Railway has very homogenous traffic and therefore benefits from these inherent uniform operating characteristics.

Siding placement is important not only to ensure there is always a sufficient number of pass points to keep trains moving ahead without undue delay, but also where train speeds vary by location due to grade differences, are placed so that the run times between sidings are roughly equal. Thus the train performance is used as the basis for the siding placement, with the trains in the slowest direction being used (typically the loaded trains). As a result sidings are based on train run times and not the more traditional average distance between the sidings, and need to be spaced apart as close as practicable by equal time segments.

The length of the siding is also important to keep the trains moving without excessive delay. The cost of the sidings is typically based on the length. Alberta to Alaska Railway sidings are designed to be at least 3% more than an average train length at 3,660 m (12,000 ft.). The operating systems of driver assist ensure safe and effective train handling, calculating the speeds for an optimum pass based on minimal overall fuel consumption.

Minimum siding requirements:

3,660 m (12,000 ft.) minimum

Alignment limitations (grades) or geographic impediments will cause the actual sidings to be moved up to 3 km from the ideal mathematical location based on running times in order to:

- Minimize major earthworks impacts
- Avoid tunnels by at least 460 m from portal
- Avoid additional bridges
- Avoid turnouts on curves
- Avoid grades greater than 0.5%.

Back Tracks would be also placed at each Passing Siding:

- 150 m length (for bad order car set off and track maintenance gangs)
- Minimum 75 m of level track – working area for emergency repairs to rail cars
- Double ended connect to the passing siding at both ends
- Placed at one end of siding as shown below, this configuration permits access in and out of the siding while still permitting trains to meet there.

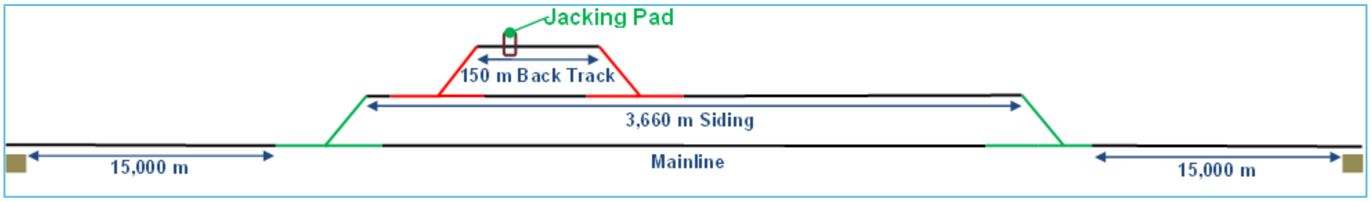


Figure 9 Indicative Passing Siding Configuration

Placed at 15,000 m from each end is standard wayside monitoring equipment to detect any in-train defects. The location permits the train to use the passing track to set off any defects should be occur, without having to reverse the train. A full description of these monitoring systems is found in Section 1.3.2 Wayside and On-board Safety Monitoring Systems.

Note that only with track and civil detail design can these sidings be very accurately placed. If this were a design project, this output would feed into sophisticated dynamic tools to model the interaction of multiple trains on the overall network to provide a network performance output. For this level of investigation, a spread sheet analysis is sufficient which took the nominal delays and wait standard times as trains meet and pass each other (single track), as well as the delays for load and unload at either end in order to produce a full cycle time for the equipment.

There is a trade-off between the number of sidings and the run times of a train in a populated network. As the run time between sidings increases the average wait time at a siding for an opposing train increases. Making recommendations of sidings location based solely on the minimum number of sidings with varying demands of bitumen did not answer the question of how these sidings, given they are optimized for each, can make a smooth transition from 1.0 mbpd barrels to 1.5 mbpd barrels without either rebuilding, wasting or changing locations of sidings as mitigation measures to protect future risks on increased demands on capacity due to issues such as:

- Increasing tonnage demands or
- Supply chain issues (upstream or downstream) or
- Final major alternative alignment changes affecting route run times or
- Less tonnage per train than anticipated or;
- Additional Alberta to Alaska train services

As their volumes fluctuate, many commodity railways have removed and then later reinstated passing sidings. Therefore a strategic network siding placement plan which protects a potentially expandable siding network prior to requiring any double tracking was undertaken. Sidings locations were based on:

- Dividing the run times of slowest (loaded bitumen) trains equally between sidings
- Avoiding alignment impediments

This approach enabled the identification of the least initial siding investment, while protecting future capacity incremental expansion. A network of seventy nine (79) potential siding locations with an average twenty eight (28) minute run time between them is the approximate limit for this single line based on tonnage and trainload. This could be staged with sidings built at forty (40) of these locations for 1.0 mbpd barrels per day and 61 to handle 1.5 mbpd barrels per day. As a result this provided a potential network of seventy nine sidings that could be incrementally expanded as necessary.

Based on the foregoing and the route information provided, the following passing sidings were designated to permit base calculations for train network performance measures. Where no location names were obvious, standard military alphabet and English names were utilized:

Table 14 Passing Sidings Functions and Location

Passing Sidings and Location from Fort McMurray						
Location/Name	**Function**	**km**		**Location/Name**	**Function**	**km**
Fort McMurray	Crew Home/ Terminal Load	0		John	Siding	1289.9
Alpha	Siding	35.9		King	Siding	1318.7
Bravo	Siding	71.9		Lincoln	Siding	1347.5
Charlie	Siding	107.9		Mary	Siding	1376.3
Delta	Siding	143.9		New York	Siding	1405.1
Echo	Siding	179.9		Ocean	Siding	1433.9
Foxtrot	Siding	215.9		Peter	Siding	1462.7
Golf	Siding	251.8		Queen	Siding	1491.5
Hotel	Siding	287.8		Roger	Siding	1520.3
India	Siding	323.8		Sugar	Siding	1549.1
Juliet	Siding	359.8		Ross River	Crew Home	1577.9
Kilo	Siding	395.7		Thomas	Siding	1608.5
High Level	Crew Change Away	431.7		Union	Siding	1639.2
Juliet	Siding	464.8		Victor	Siding	1669.8
Kilo	Siding	497.9		William	Siding	1700.5
Lima	Siding	530.9		Xerox	Siding	1731.1
Mike	Siding	564.0		Young	Siding	1761.8
November	Siding	597.1		Zero	Siding	1792.4
Oscar	Siding	630.2		Bob	Siding	1823.1
Papa	Siding	663.3		Carol	Siding	1853.7
Quebec	Siding	696.4		David	Siding	1884.4
Romeo	Siding	729.4		Eddie	Siding	1915.0
Sierra	Siding	762.5		Harry	Siding	1945.6
Tango	Siding	795.6		Ike	Siding	1976.3
Fort Nelson	Crew Home	828.7		Kirkman Creek	Crew Change Away	2006.9
Victor	Siding	857.5		Jim	Siding	2036.0
Whiskey	Siding	886.4		Kenny	Siding	2065.1
X-ray	Siding	915.2		Larry	Siding	2094.2
Yankee	Siding	944.3		Nancy	Siding	2123.3
Zulu	Siding	972.9		Oliver	Siding	2152.4
Adams	Siding	1001.7		Quincy	Siding	2181.5
Boston	Siding	1030.5		Sam	Siding	2210.6
Chicago	Siding	1059.4		Uncle	Siding	2239.7
Denver	Siding	1088.2		Vincent	Siding	2268.8
Easy	Siding	1117.0		Xavier	Siding	2297.9
Frank	Siding	1145.9		Yogi	Siding	2327.0
Laird River Crossing	Crew Change Away/Fuel	1174.7		Zachary	Siding	2356.1
George	Siding	1203.5		Steve	Siding	2385.2
Henry	Siding	1232.3		Delta Junction	Crew Home/Terminal Unload	2414.3
Ida	Siding	1261.1				

1.9.7 Fuelling

Initial fuel requirements identified from RailSim modelling indicate that refuelling will be required not only at the initial terminal but also a midway point along the route. The two graphs below indicate the typical range the throttle is found while traversing the route. Note the significant difference in throttle settings between the empty and loaded trains.

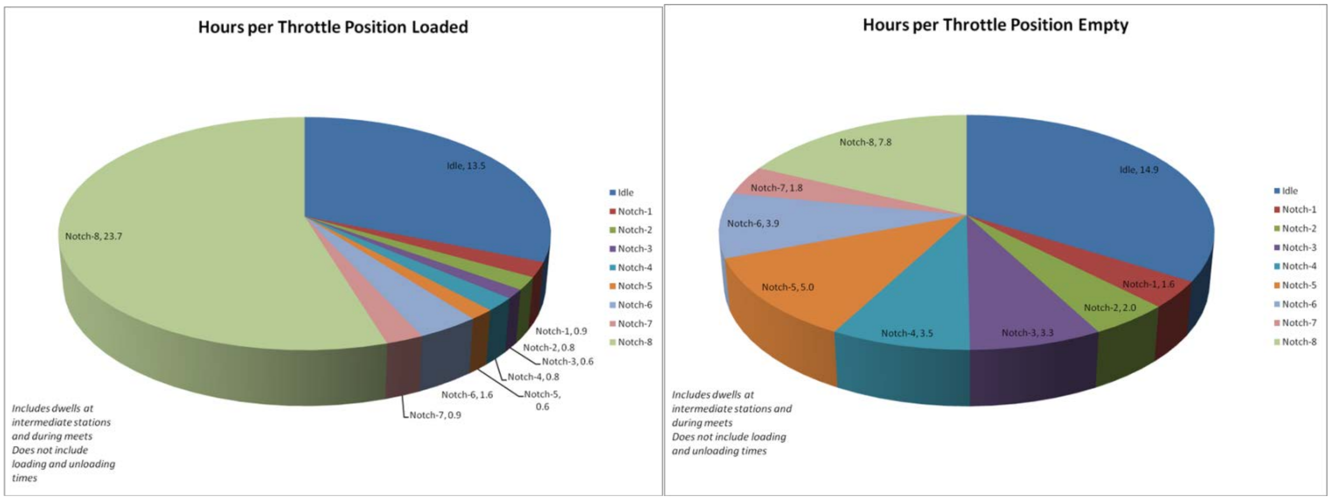


Figure 10 Throttle Settings for Loaded and Empty Bitumen Trains

Based on the storage tank capacity, diesel fuel will be provided for filling locomotives at three locations: the product loading area at Fort McMurray, a midpoint along the route, anticipated to be at the Liard River Crossing, and at the unloading station in Delta Junction. These could be accomplished as follows:

- Fort McMurray - at the trip service facility where all locomotives are inspected each round trip
- Liard River Crossing - fueling will be done at the crew change point at so that delays to the train are kept to a minimum. High speed sealed refueling units will be used at this location.
- Delta Junction - Fueling will be done on the unload tracks, locomotives to be split with rakes:
  - 1st and 2nd head end rake
  - 3rd tail end of second rake
  - 4th head end of third rake
  - 5th and 6th tail of fourth rake

The following table details daily fuel requirements per day by fuelling location.

Table 15 Daily Indicative Locomotive Fuel Requirements

Location	1.0 mbpd Barrels		1.5 mbpd Barrels	
	Gallons (US)	Tank Cars	Gallons (US)	Tank Cars
Fort McMurray	152,100	5.2	228,200	7.9
Liard River Crossing	242,200	8.3	363,300	12.5
Delta Junction	91,600	3.2	137,500	4.7

More than one storage tank is included in the event that one tank's stored fuel was to go off specification. The current conceptual design anticipates the centrifugal unloading pumps for tank car deliveries of fuel can be utilized for filling the locomotives through filling stands or tank trucks as determined in the future. A loading rack structure is anticipated at Fort McMurray and unloading racks at the Liard River Crossing and at Delta Junction. The design includes stair treads from the racks to the tank cars and manifold piping.

The existing concepts for Delta Junction could be readily modified to accept fuel deliveries to Delta Junction from other sources as well. Tank cars locomotive fuel could be loaded there as well tank cars for delivery to Liard River Crossing and Fort McMurray locations. The proposed operation at the midpoint would have a supply train setting off loads in the west end of the fuelling track, and on the return leg, lifting the empties out of the east end of the track. A car mover or shuttle car would first pull and spot the loads, then run around the cars, and once empty, push the cars to the east end of the fuelling track. This is covered in Supply Train Section 1.21.2.

1.9.8 Adjusted Run Times

The next step was adjusting train run times for calculating 1.0 mbpd and 1.5 mbpd bitumen demand levels. The travel times for each crew leg were totaled including 3 stop times for fuel at Laird River. The first to change crew and fuel head end locomotives and then the middle set and finally the rear set of locomotives (45 minutes total). It is planned that two trains can pass and fuel at the same time based on the track configuration as shown below.

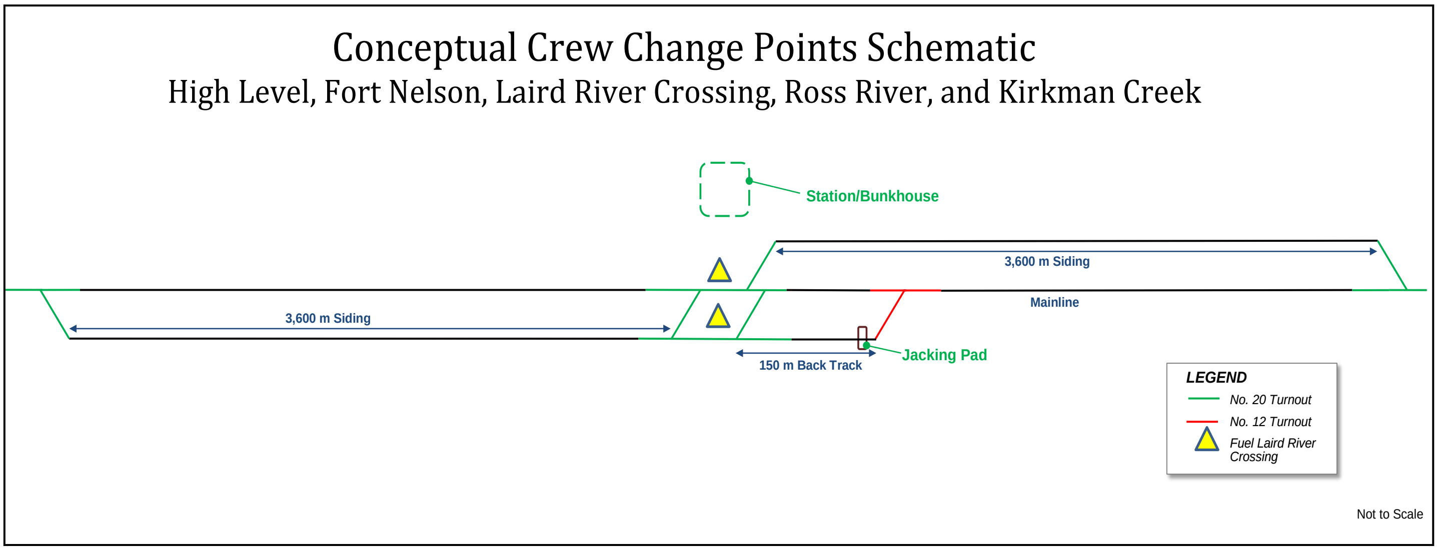


Figure 11 Conceptual Crew Change

Finally a penalty time was added to the segment run times for each meet where a train would be required to take the siding for an opposing train. Our calculations are based on 10 minutes for acceleration, deceleration, and switch or signal activation time. In addition to the 10 minutes a penalty was added based on the run times between sidings and the prioritization given to loaded trains over empties.

Table 16 Adjusted Run Time 1.0 mbpd Barrels

From	To	Sidings	Average Siding Spacing (miles)	Meets	Take Siding for Meet		Average Run Time (Adjusted Hrs:Min)	
					Load	Empty	Loads	Empties
Fort McMurray	High Level	5	45	4	1	3	6:42	7:58
High Level	Fort Nelson	5	41	4	2	2	6:41	6:07
Fort Nelson	Liard River	5	36	3	-	3	6:33	7:13
Liard River	Ross River	6	36	4	1	3	6:35	7:12
Ross River	Kirkman Creek	6	38	4	2	2	7:10	6:35
Kirkman Creek	Delta Junction	6	36	4	2	2	7:11	5:13
			Average hours in transit per crew				6:49	6:54

Sufficient additional passing sidings were introduced for 1.5 mbpd Barrels to keep the service levels for the bitumen within similar tolerances as follows.

Table 17 Adjusted Run Time 1.5 mbpd Barrels

From	To	Sidings	Average Siding Spacing (miles)	Meets	Take Siding for Meet		Average Run Time (Adjusted Hrs:Min)	
					Load	Empty	Loads	Empties
Fort McMurray	High Level	8	30	6	2	4	7:04	7:43
High Level	Fort Nelson	8	27	6	3	3	6:51	6:17
Fort Nelson	Liard River	8	24	5	1	4	6:52	6:45
Liard River	Ross River	10	23	5	2	3	6:59	6:24
Ross River	Kirkman Creek	10	24	6	3	3	7:17	6:43
Kirkman Creek	Delta Junction	10	23	5	2	3	6:46	6:34
Average hours in train per crew							6:58	6:44

Note this is well within the train crew 12 hour on duty limit and given the precision this railway will operate under these times, the crew legs appear to be well distributed. In addition, should loaded trains or empties be designated as priority, there is sufficient time to change which train will take the sidings and still be within normal crew on duty limits.

Given the performance of the empty trains and their ability to regularly clear in the siding waiting loaded trains (slower) to pass, as well as the uniformity of the trains, not only will meets work with better regularity than a typical class one railway, but the fleeting of trains will also operate well if multiple trains are required to operate in a group after a work block, etc. Thus these times are seen as conservative. The transit times for the loaded and empty trains are shown below. These transit times will account for almost 96% of the entire cycle of the bitumen cars. The remaining components comprise the loadout and unloading operations.

Table 18 Basic Transit Time Parameters

Barrels (M) per Day	**1.0**	**1.5**
Loaded Trains	8	12
Total Trains per day	16	24
Number of Passing Sidings	33	54
Loaded Transit Time	43:22	44:19
Empty Transit Time	43:54	42:55
Tank Cars	1,538	2,307
3-Paks	513	769
Loaded Trains	8	12
Revenue Barrels per Train	**128,501**	**128,501**
Revenue Barrels Per day	**980,007**	**1,470,011**

1.9.9 Terminus Train Operations

As a key part of the cycle of the bitumen cars, the Loadout Yard complex is proposed to be located at the eastern terminus. This serves as the Railhead Yard Facility for the Alberta to Alaska Railway. All major operations activities are coordinated from here, including the Railway Operations Control Centre.

The physical transfer of bitumen into and out of a single train typically occurs within a single transfer shed. Four loadout tracks are required to make one complete train consist. Each track has room for one rake (set of cars). Each rake of cars is sixteen 3-paks (48 cars) and is paired with a center load island similar to that shown below. Thus one island with 2 tracks can handle 96 cars or half of a train, two islands per shed.

Figure 12 Paired Loadout Tracks

It is important to note that both loadout and unloading yards will receive multiple trains per day. For this reason, the design is streamlined and processes established for a uniform, repetitive and factory production like environment. Given this work effort and the almost constant exposure to inclement environment in the winter, canopy buildings extend the full 850 m length over each of the four tracks, providing shelter from wind and precipitation as illustrated below.

These sheds are of significant importance and while no locomotives are stored within them, generous ventilation and lighting will form a key part of the design. Accumulated snowfall is not that significant at either Fort McMurray or Delta Junction, nevertheless they have to be designed to avoid heavy snow fall accumulations on the roofs and drifting of snow in the working areas.

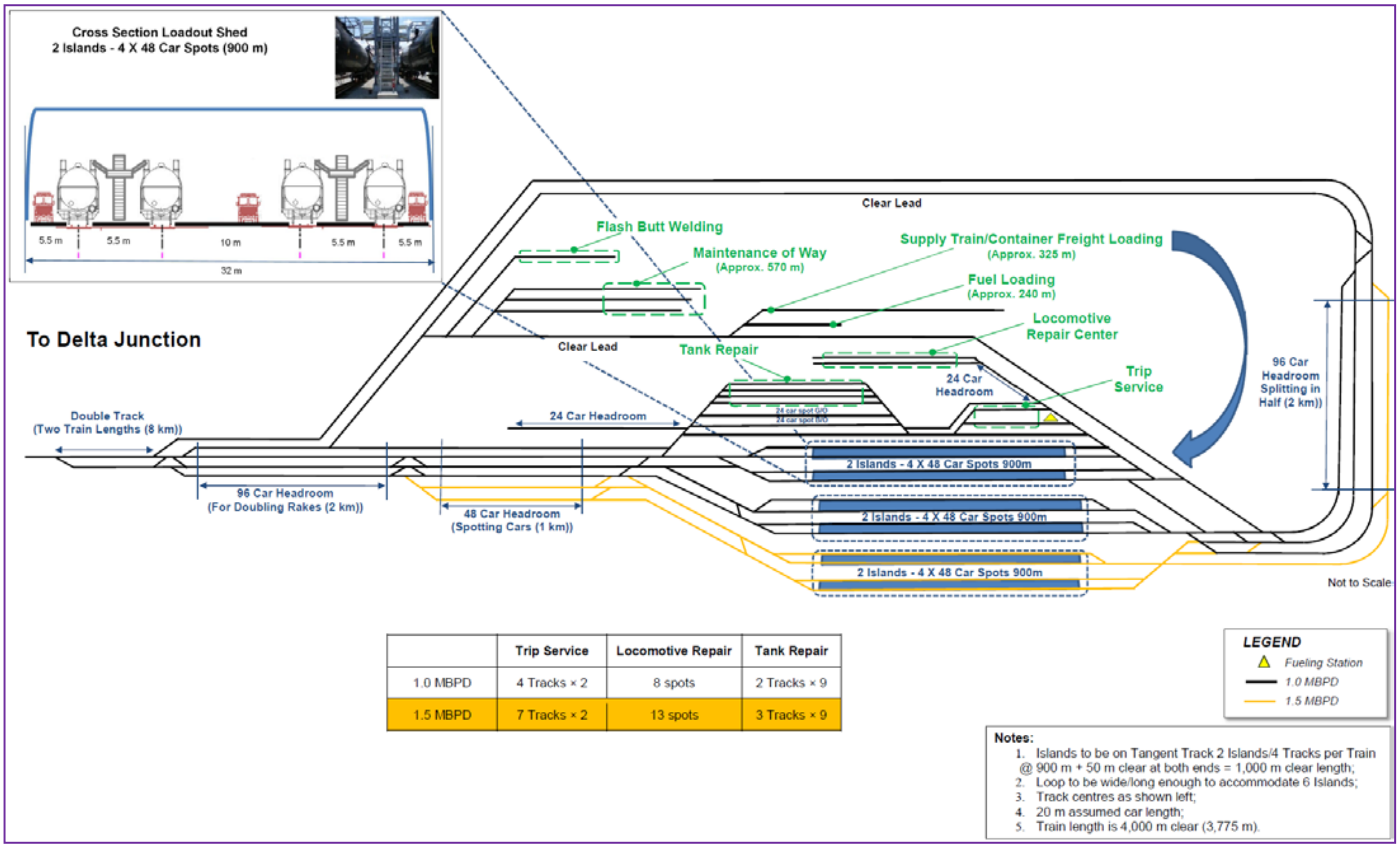
There are two 3 person yard crews anticipated to be on duty round the clock at the yards as operations warrant. The crew will have 1 road van vehicle with a driver, so that yard crews can move independently around the yard to be able to move locos in single direction trips and move to the next location by vehicle as required without any delays.

1.9.9.1 Fort McMurray Loadout Train Operations

Referring to the operating schematic below, the loaded train is loaded into 4 equal rakes of 48 cars each. The empty train arrives and is split in two ahead of the center 2 locomotives, with the help of a yard crew. The train crew then pulls first half of the train through one load track, spotting the rear quarter of the train and then doubles the headend quarter portion into the other track. The train crew then takes the lead 2 locomotives to the trip service facility and goes off duty. Thus the headend half of the train is spotted into 2 load tracks.

Similarly a yard crew then cuts off the rear end locomotives with the assistance of the 3rd yard crew member. The yard crew then moves the rear half of the train into a second set of loadout tracks, pulling through and spotting the rear quarter and then cuts off and doubles the headend quarter into the other island load track (just as the train crew did with the headend. The middle set of locomotives is taken to the trip service facility for fueling and servicing by the yard crew. The 3rd yard crew member, who is on the 3 set of locomotives, moves to the trip service. Thus the train is now positioned in 4 load tracks, loading in parallel and 2 sets of paired locomotives have been moved to the trip service.

Heated bitumen is then loaded at appropriate temperature between 60 °C and 90 °C into insulated heated tank cars. The loading hours each train is estimated at less than 3 hours. This will improve slightly in summer as compared to winter since empty cars may have to be pre-heated prior to loading the bitumen to ensure free flowing of the product into the tank cars. This is covered in more detail in Section 9.6 of the report.



	Trip Service	Locomotive Repair	Tank Repair
1.0 MBPD	4 Tracks × 2	8 spots	2 Tracks × 9
1.5 MBPD	7 Tracks × 2	13 spots	3 Tracks × 9

Figure 13 Schematic Loadout Yard Fort McMurray

The number of loadout sheds in the facility is based on the loadout time per train. This includes the arrival, switching the train into the sheds, loading and reassembly after unloading.

Table 19 Loadout Units

Barrels (M) per day	1.0	1.5
Loadout Sheds(4 tracks)	2	3
Train Loading (Hrs:Min)	2:43	2.43
Train Departures Every (hrs.)	3	2
Capacity used with 1 Shed	91%	136%
Capacity used with 2 Sheds	45%	68%
Capacity used with 3 Sheds	30%	45%

As the ramp up of bitumen occurs, sheds are increased from 1 to 3 sheds in order to maintain no less than 45% excess loading capabilities should changes in daily operations warrant. Note as well that sufficient space will need to be designed within the loop to add additional loadout units as required if demand for loading increases.

1.9.9.2 Delta Junction Unload Train Operations

The physical transfer of bitumen from the railway to the landside infrastructure will occur at the unload yard facilities. The unload yard is nearly a mirror image of the loadout yard as far as handling bitumen is concerned. The cars will arrive with the bitumen at a temperature which permits unloading directly into insulated pipes and heated holding tanks. Sufficient holding tanks are assumed that sufficient holding tanks will be available to unload the bitumen on arrival at Delta Junction.

If a loaded train is delayed by more than 24 hours in extreme cold temperatures or should some heating be required to return the bitumen temperature to a point for satisfactory unloading, heating will be available at both the loadout and unloading facilities.

The intent of this terminus is to keep any rolling stock maintenance servicing to a minimum. Although trains do have to be broken into 4 sections for unloading, only emergency maintenance on rolling stock is performed here. Otherwise, locomotives are refueled while attached to the cars which are being unloaded. Similar to the loadout yard, 4 tracks comprise of the unload unit for each trainload as shown below.

The process of splitting rakes into four is a very repetitive operation. This is the key to handling changing conditions and making sure the proper equipment and personal are at the right location on each train arrival. An example of this streamlining of process is found in the following procedures referring to the operating schematic below. Each loaded train arrives and is split in 2 (between of the centre 2 locomotives, with the help of a yard crew). The train crew then pulls first half of the train through one load track, spotting the rear (quarter of the train) and then doubles the headend quarter portion into the other track. The train crew then goes off duty. The yard crew then moves the rear half of the train into a second set of loadout tracks, pulling through and spotting the rear quarter and then cuts off and doubles the headend quarter into the other island load track (just as the train crew did with the headend). Thus the train is positioned in 4 load tracks and all locomotives are moved in pairs to the trip service.

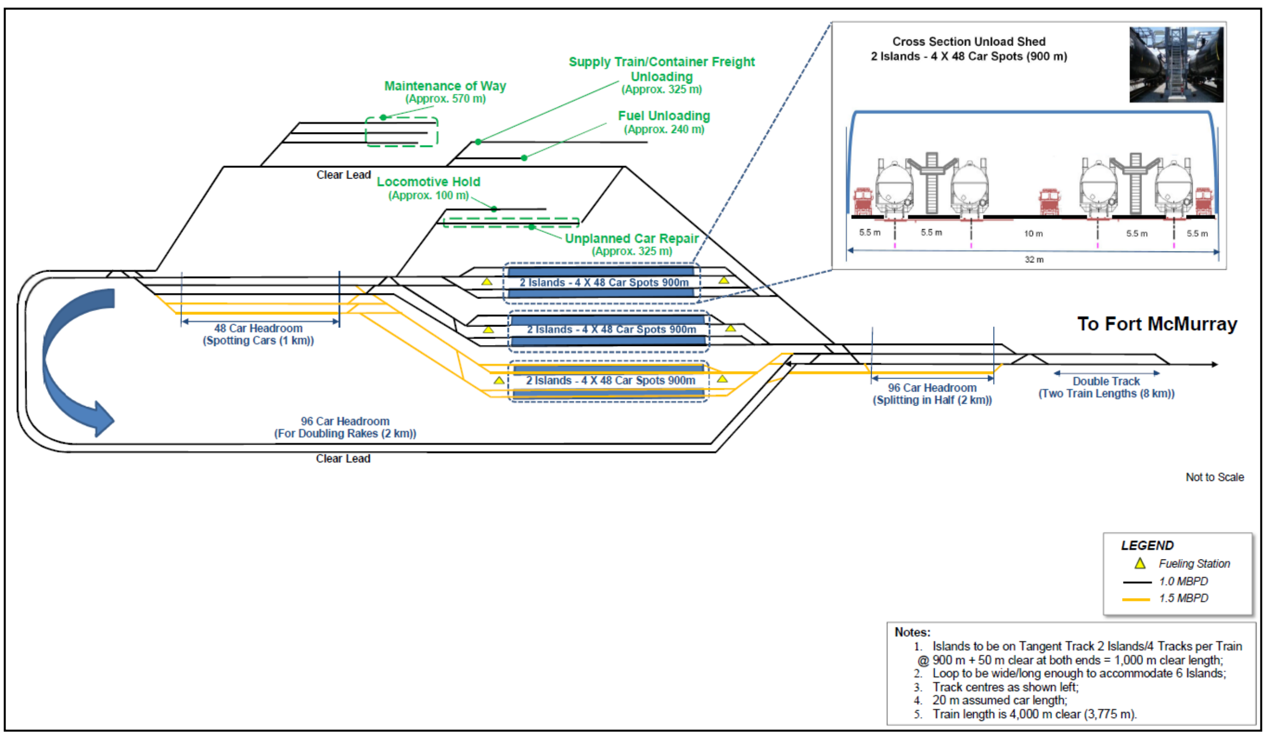


Figure 14 Track Schematic of Unload Yard Delta Junction

The difference at the unloaded versus the loading of bitumen is that locomotives are split between the middle two units, so that each rake of cars that is unloaded has at least one locomotive attached at all times which maintains air in the brake pipe at all times – saving time later to recharge air lines. Therefore all locomotives are secured and fueled on site in the unloading tracks, but actually sit just outside the shed.

Once unloaded the trains are doubled over onto a departure lead without yard crew assisting the train crew. After the prescribed brake test the empty train departs.

Note the loop arrangement can be used to turn any fleet or maintenance equipment as necessary. At least one loop track is normally kept clear unless 2 trains are doubling over at the same time for departure in parallel.

As ramp up occurs, should it be required, is will be sufficient sheds to provide no less than 37% excess unloading capability should changes in daily operations warrant.

Table 20 Unload Units

Barrels (M) per day	1.0	1.5
Loadout Sheds(4 tracks)	2	3
Train Unloading (Hrs:Min)	2:13	2.13
Train Arrivals Every (hrs.)	3	2
Capacity used with 1 Shed	74%	111%
Capacity used with 2 Sheds	37%	56%
Capacity used with 3 Sheds	25%	37%

Further details on the handling of bitumen are found in Section 9.6 of the report.

1.9.10 Bitumen Fleet Size

With the full calculation of one full cycle time now compiled, the necessary fleet of railcars can be determined. The following is a summary of the major cycle time components with corresponding fleet requirements that drive the corresponding fleet size to deliver the daily bitumen as shown below. Rolling stock maintenance does require time for repairs, both planned and unplanned. Therefore an additional 5% locomotives and 2% tank cars is assumed above the base fleet requirements.

Table 21 Fleet Size Requirements

Cycle Time per Train	1.0 mbpd	1.5 mbpd
Loadout Time (Hrs.)	2:43	2:43
Transit Time Loads (Hrs.)	40:52	41:49
Unloading Time (Hrs.)	2:13	2:13
Transit Time Empties (Hrs.)	41:24	40:25
Total Cycle Hours (Hrs.)	92:12	92:11
Total Consists (Trains)	31	47
Locomotives with Spares (5%)	208	309
Bitumen Tank Cars	6,072	9,205
Fuel Supply Tank Cars with Spares (5%)	196	196

1.9.11 Annual Bitumen Delivery

The actual operating days per year dictate the amount of bitumen moved annually. For the purpose of this study the railway will start with 365 normal operating days per year in which to run trains. However the railway will lose part and whole operating days due to both planned maintenance delays as well as unplanned delays. This will vary with the number of daily trains and the level of congestion experienced on the rail network. Lost days are based on full 24 hour periods of delays and are averaged out to include smaller hourly impacts as well as periods of more than 24 hour disruptions.

Planned maintenance is assumed to be around 5% of the total operating days and this topic covered in more detail the Track Maintenance Section 1.17.

It is assumed 3% of the total operating days are lost to unplanned delays. This is fairly consistent with similar remote high tonnage mining operations that are in constant operation based on confidential studies. While remote terrain is typical for many resource railways, Alberta to Alaska also experiences very large temperature 90° C swings (+30 °C to -60 °C). Winter weather operation is challenging and can result in train delay. Fortunately snow fall is not significantly high throughout this route.

Given the local nature of most unplanned delays and the fact they do not disrupt the entire flow of the railway, allows for recovery from many of the minor train delays enroute by adapting schedules with techniques such as fleeting of trains. This in turn can cause some congestion in either terminus which is addressed by building sufficient excess capacity at both loading and unloading yards of the railway.

The additional capacity available as identified in Figure 14 indicated 25% above demand loadout capacity and 37% above demand for unload capacity which adequately covers these situations.

Furthermore, sufficient storage tanks buffer is assumed to be in place at both ends to handle peaking variances in bitumen deliveries to railhead at Fort McMurray as well as covering TAPS pipeline interruptions at Delta Junction. This specific topic is covered below in Section 9.6 Bitumen Logistics of the report.

For the purpose of this study it is assumed the actual operating days on this railway are 329 as summarized in the following table.

Table 22 Annual Operating Days

	1.0 mbpd		1.5 mbpd	
	%	Days	%	Days
Planned days lost	7%	25	7%	25
Unplanned days lost	3%	11	3%	11
Total lost operating days/yr.	10%	36	10%	36
Total operating days/yr.		329		329

1.10 Supply Trains

Given the remoteness of the proposed rail route, it is envisioned that most supplies will be delivered by rail. Tentatively a supply train consisting of 96 fuel cars, plus additional cars of assorted supplies, both for the railway and for facilities on the rail line. As such, a supply train will be required every 7.1 days for 1.0 mbpd barrels and 4.7 days for 1.5 mbpd barrels.

One of the potential rail connections identified earlier in this report will likely bring the diesel fuel to this railway unless diesel is available at Fort McMurray. Pending the identification of sourcing the diesel, the fuel requirements are a major factor in scheduling supply trains. With 2 trains per week, a fleet of 196 diesel tank cars including 4 spare tank cars is required. Specific track arrangements for diesel unloading tracks will need to be designed in conjunction with storage tank conjuration, locomotive fill station layouts and the specific operational requirements for unloading the tank cars.

1.11 Railway Support Facilities

On-going maintenance of the Rail buildings and facilities will be the responsibility of Alberta to Alaska Railway Operations. The Facilities Management Strategy for the performance of this work, whether outsourced or performed in-house, will be determined in the future.

As a basis for the cost for maintenance for buildings and facilities were divided into two categories: operations costs and sustaining capital costs.

The operations costs include labour, supplies and services for routine maintenance of buildings and facilities.

The sustaining capital costs include for scheduled replacements or overhauls for architectural, industrial, mechanical and electrical equipment as a preventative maintenance program for the buildings and facilities. Further detail on the maintenance of buildings and facilities can be found in the above mentioned Operating Cost Estimate (Opex) and Sustaining Capital Cost Estimate.

1.12 Operations Control Center (OCC)

The control center will have staff co-located in one secure facility. The control center co-ordinates all aspects of railway operation. This includes dispatching of trains and train crews, as well as coordinating equipment readiness and ongoing infrastructure maintenance, monitoring wayside detection, onboard monitoring systems, signal and communications repair response.

The control center is not just a railway control center, but an integrated bitumen Logistics nerve center with responsibility to ensure delivery by coordinating movement of bitumen beyond rail, from forecast to actual plan for bitumen arriving into the storage tanks at Fort McMurray to the movement from storage tanks to the pipeline at Delta Junction.

By focusing on moving the product, the best operating plan can be executed, taking advantage of coordinated maintenance planning as well as overall asset use. While emphasis will be on regular and repeated operational execution and measurement of same, at the same time, weekly forecast plans moving to an executable 24 hour plan will ensure the flexibility to gain maximize return on assets while protecting service delivery.

1.13 Railhead Yard Facility (RYF)

The entire railhead yard consists of the railcar staging yard, train arrival yard, car and locomotive repair facilities, engineering track maintenance and loading track facilities. All rail activities are coordinated by the Railhead Yard Coordinator. Every movement is planned and timed, just as assembly line. As the plan progresses updates are continually fed into the plan.

On arrival, empty trains will be inspected prior to arriving at the yard. Empty trains are spotted into the loading sheds as previously described.

All regular rolling stock maintenance is carried out on a preplanned basis. Empty tank cars which require routine maintenance are switched to the tank repair tracks. Railcars needing unplanned repairs are removed from the rake and switched to the shop and such cars are replaced with good order cars back into the empty rake. Yard crews are available around the clock to do any necessary switching and moving of locomotives to and from the load track area.

Should there be any loadout failures due to tank car problems with valves, such cars will be switched out after the loadout is completed by a yard crew, who will then replace the missing loads with other tank cars loaded in other loadout tracks. There is flexibility in this design since various loadout tracks (between loadout units) can be combined into a single train, in this way production is maintained.

Fort McMurray is the home station for train crews who operate from there. This ensures a constant supply of train and yard crews is available. Outbound train crews will report for duty at the Trip Service facility. The outgoing crew of a loaded train is ordered to be on duty at the trip service with sufficient time to go through an on-duty (fit for duty) registration process, and if necessary be taken to the lead locomotives if they are not at the trip service for any reason. The train will be pre-assembled, brake tested and then the train crew will depart with the loaded train.

It cannot be emphasized enough that this process will go on every 3 hours for 1.0 mbpd barrels a day or every 2 hours for 1.5 mbpd barrels per day. Therefore the work is repetitive, measurable and predictable and therefore will be high reliable.

1.14 Trip Service Facility (TSF)

After every return trip, the locomotives require re-fueling, and other routine inspection and servicing. This activity is referred to as trip servicing, and is carried out at the fixed location facility. Fluids can be replaced as required. Locomotives that require more comprehensive service and repair or periodic inspections (such as the Regulatory 90 and 180 day inspection) will be directed to the locomotive repair center (LRC) within the RYF. The lead track to the LRC is immediately adjacent the Trip Service Facility for ease of access.

The facility consists of an enclosed building with two through service tracks each with an under track inspection pit, capable of servicing a pair of locomotives. The track layout provides for building expansion. The facility has been located to provide for minimum locomotive run time, after uncoupling from the empty cars, then return after servicing to pick up the loads. The track layout includes crossovers to provide for multiple parallel routings to minimize conflicts, and facilitate empty train assembly in minimum time.

1.15 Locomotive Repair Centre (LRC)

The Locomotive Repair Centre is located adjacent to the north of the Car Repair Centre within the main Rolling Stock Maintenance Centre. The LRC includes ancillary manual wash and wheel truing facilities. The main repair facility includes four single locomotive bays, with the provision for a fifth bay.

*Access to the LRC is via an independent lead track connecting to the main y*ard corridor adjacent to the Trip Service Facility. A storage track is provided for storage of spare locomotives and locomotives awaiting access to service. The center, including Wheel Truing and wash, are protected from unauthorized access by means of catch points and lockouts under the control of LRC personnel.

1.16 Car Repair Centre (CRC)

The railhead yard is also the location where empty bitumen trains are reassembled and prepared for loading. As a part of this process, any bad order (need of repair) car is shunted from the rake of cars and replaced with a repaired car. Cars are inspected before arriving at the railhead yard by camera and wayside detectors which flag wheel and car body fitness.

Bitumen car and general freight car repair service is provided in the Car Repair Centre (CRC) within the Rolling Stock Maintenance Centre. Two repair tracks are provided. There is provision for expansion to a third line in the future should it be needed. The facility is served by holding tracks for both inbound cars requiring repairs (bad ordered) and outbound repaired cars (good ordered) with lockout features to isolate maintenance operations from regular train operations.

In addition to this rail infrastructure there are separate storage tracks for general freight and fuel delivery as well as for storage of rail maintenance equipment.

1.17 Track Maintenance Facilities (TMFs)

1.17.1 Railhead Yard Facilities

The Railhead Loading Yard located at Fort McMurray is where the main maintenance facility will be located for all maintenance forces. The facility will consist of offices, storage space for materials and equipment, as well as a maintenance shop. The principal maintenance facility will be responsible for supplying the smaller maintenance facilities and will have the ability to reship to line point maintenance sites or distribution trains for track material along the line.

It is anticipated that the building at this location will also house the OCC staff for the railway. Consequently the track maintenance management can collaborate easily with the operations staff to plan and coordinate the required planned track maintenance work blocks.

A storage facility or stores building will consist of an indoor location for weather effected supplies and small items and an adjacent out door secure facility primarily to store rail, ties and all other non-weather dependent items. Storage will be required for tools and material as well as for a flash butt welding operation. This equipment shop will maintain and repair all of the track maintenance equipment and be used for the storage of equipment that is not in use as well as provide signals with a light repair shop for their electronic equipment. This whole complex will be serviced by sidings to receive and ship materials by rail along with on track machinery access to the shop area.

1.17.2 Online Facilities

For the online maintenance sites are expected to be significantly smaller than those at the terminal yards. However these facilities will be considered multi-use facilities and serve as storage facilities for track and signal material as well as have the capacity to do some minor equipment maintenance.

The S&C maintenance crews will be located at the same location as the track maintenance crews. In this way they can support each other’s work and consolidate on housing and storage needs.

1.17.3 Train Crewing Facilities (TCFs)

There are 7 locations that crews report for duty as indicated below:

Table 23 Train Crew Reporting Locations

Location	Home or Away Station	Crew Facilities	Location
Fort McMurray AB	Home	Crew Office	Trip Service Facility
High Level AB	Away	Bunkhouse	Bunk House
Fort Nelson BC	Home	Crew Office	Crew Office
Liard River Crossing BC	Away	Bunkhouse	Bunk House
Ross River YK	Home	Crew Office	Crew Office
Kirkman Creek YK	Away	Bunkhouse	Bunk House
Delta Junction AK	Home	Crew Office	Admin Office

The reporting locations require an office to report on/off duty, a computer, phone, lockers, washrooms and waiting room.

At the 4 home terminals a simple reporting office, with communications, desks and sufficient room and chairs to hold 3 crews (6 chairs) is required. Supplies as required for the crews from time to time are to be picked up here as well.

At the 3 away from home terminals these facilities will be collocated at the bunkhouse. The bunkhouse contains typical hotel type environment with bedrooms with a washroom and shower, lounge/TV room, games room and the booking in office as the same as at the home terminals.

1.18 Handling of Bitumen

1.18.1 Basic Operating Considerations

The following figure, shown earlier in the report, is a representation of the freight movement for bitumen from the Fort McMurray area to Delta Junction. The number of trains loaded, transported and unloaded in a day, together with the empty return runs, creates a true industrial supply chain. The supply chain's individual components affect the overall system performance. The report now identifies the individual components and their linkages.

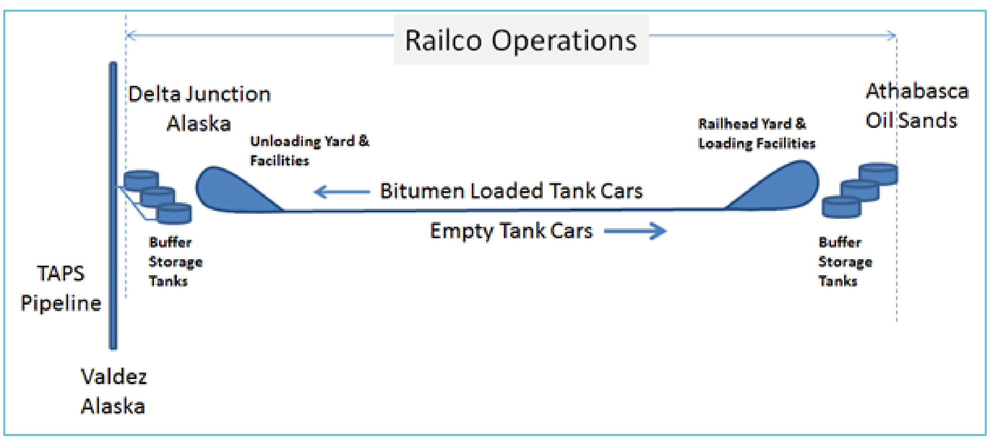


Figure 15 Logistics Flow in this Study

One key characteristic of bitumen as a liquid product is the relationship between viscosity and temperature. The graph below indicates the bitumen flows much more readily as the product temperature increases.[7]

[7] **Properties of Oil sands and Bitumen in Athabasca,** Hisako Mochinaga*Jogmec Trc, Chiba, Japan, et/al., 2006 CSPG-CSEG-CWLS Convention

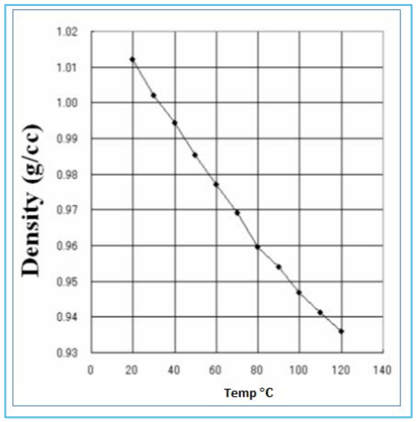


Figure 16 Bitumen: Density vs. Temperature

Based on the tank car specifications, the anticipated decrease in temperature during transport is approximately 20°C base on the transit hours. The planned loading temperature would not exceed 90°C in order to keep the product temperature below the boiling point of water to protect against any heel of water found in the empty tank cars. However, the ambient outside temperature ranges widely. In order to examine the degree of temperature required to heat the bitumen, the average lowest temperatures and the historical variance in low temperatures from either Fort McMurray or Delta Junction (which ever was colder) were plotted and used below.

To estimate a specific unloading temperature on arrival at Delta Junction, the graph below provides two examples of the relative loading temperatures required to support unloading temperatures of: 50°C (shown by the blue boxes - red dotted line variation) and 40°C (shown by the brown boxes - black solid line variation).

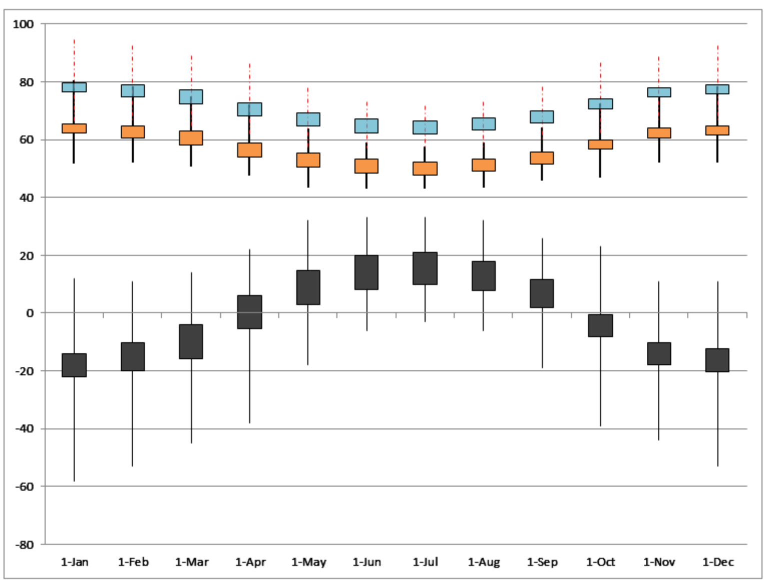


Figure 17 Variance in Load versus Constant Unload Temperatures

Thus, as demonstrated above, there is no case where more than a 78 °C loading temperature is required for even the coldest days to maintain an arrival temperature of 40 °C, well above the minimum 30 °C at which bitumen will freely flow. The graph illustrates to two important conclusions:

- There is room to heat the bitumen a higher temperature if necessary for operating reasons. This includes longer transit time or bitumen with more viscosity. Therefore our assumptions are conservative
- There is likely a significant buffer to reduce heating of the bitumen, still meet viscosity targets thereby saving energy costs during much of the year. In the summer months a loading temperature as low as 50 °C may be all that is required to maintain an unloading temperature of 40 °C. The extent of savings is undetermined but can be optimized in preliminary design.

The loading and unloading will be heat traced and insulated to maintain and enhance product movement during cold temperature periods. The time and product flow rates involved for loading cold tank cars will enable the insulated tank car to gradually raise the equipment temperatures as the product fills the tank car. As the cars are emptied there may be an increased amount of "clingage" to the walls and heel in the bottom of the tank cars in the colder months. The residual product will absorb heat during the next loading cycle and therefore the effect will not accumulative.

1.18.2 Tank Car Loading

The alignment of rail cars will see the empty train positioned in two strings of 96 tank cars for loading through 48 loading spots. In effect, the tank car string is repositioned after the first 48 cars are loaded.

The sketch of the two-sided tank car loading rack is shown below, with a plant road for access between and adjacent to each loading rack pair. The loading rack is configured with a top loading arm system that connects through a manway on the top of the tank car. It is anticipated subsequent orders for additional tank cars will be homogenous so as to match loading and unloading control systems. The loading and control features are anticipated to be within the range of commercially proven technologies.

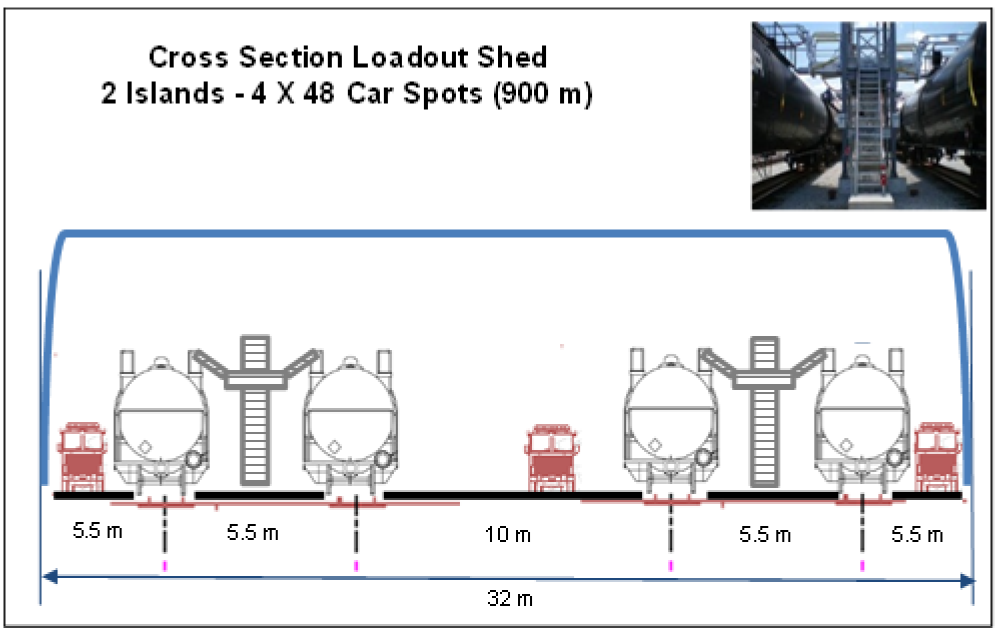


Figure 18 Typical Proposed Loadout Shed Arrangement

Design adaptations may be made where the unique features of the product, supply chain attributes and overall velocity of freight movement present an advantage to the planned operations. One example may be in the pipe diameter for the bottom connection for the tank cars. Today, the connections and fittings are designed at 2" to 3" ø, consistent with the overall tank car fleet and general terminal practices. The dedicated nature of the freight service, together with the project freight velocity may present the design team with the opportunity to increase the piping diameter and increase tank car loading and unloading rates, thereby reducing the handling time per tank car. Increasing the diameter from 3” to 6” enables three times the flow due to the larger cross-sectional area.

The Fort McMurray receiving tank farm will consist of storage tanks to receive inbound product from multiple sources, generally consistent with a typical API 650 storage tank seen in the petroleum industry development in northern Canada. The storage tanks will be connected to manifold(s) with piping and valve control to the tank car loading racks. The project was approached making use of a standard 250,000 barrel tank car (39,750 CM). A total of 36 storage tanks were planned for the storage of bitumen, 18 at each end of the rail corridor. Subsequent design efforts will address the absolute number of tanks and configuration once future conditions are examined and decisions are made regarding the use of existing assets, specific supply chain movements, individual customer requirements and related operational decisions.

The operational approach to the tank car loading and unloading is based on manifold piping to separate piping connections aligned with each individual tank car. The loading sequence will use centrifugal pumps in a manifold configuration connected to multiple tanks and loading islands. The pumps will be driven by motors energized by medium range voltage three-phase power. The final connection will include a loading and unloading arm respectively. The oil product movement takes place in unit trains, approximately 12,000 feet in length, with 192 tank cars incorporating standard insulation.

As reported earlier, the tank cars are joined in triple car sets. The minimum 15°C pipeline specification will be maintained. There is an estimated 20°C heat loss in transit. As a result, product will be loaded at not more than 90°C for the estimated 44 hour trip. The design anticipates steam traced pipelines and pumps, as well as fittings to make steam available in the event some trains arrive cold for unloading. The distributed power, 2-2-2 locomotive distribution, will augment local power shifting of the tank cars consistent with operational and readiness requirements for the equipment.

The tank car loading arms will be designed with manually assisted spring counterbalances allowing for the weight of the product in drop tubes. The technology is commercially available with a demonstrated applications and operating history. Generally, the equipment will require a single operator to position and initiate product flow then can be left to complete the filling while remotely attended. Automatic shutoffs and filling step down pumping rates will mitigate potential overfills and spills from the loading process. The operator returns to finalize the filling operation and disconnect the loading and control equipment.

1.18.3 Tank Car Unloading

Tank car unloading is essentially the reciprocal of the loading sequence with the pumping rates at the same level, this time using the bottom fittings of the tank car to aid the hydraulic movement of the oil. The unloading pumps are anticipated to be positive displacement pumps in a manifold configuration, scaled up to unload product at 900 gallons per minute per location. Positive displacement pumps provide greater unloading hydraulic capacity and can work well for higher viscosity products, a condition that may arise in the colder temperatures encountered with the Alberta to Alaska Railway.

The tank car unloading arms will be designed with manually assisted spring counterbalances allowing for the weight of the product in the connecting arms for the reach below the tank cars. The technology is commercially available with a demonstrated applications and operating history. Generally, the equipment will require a single operator to position and initiate product flow then can be left to complete the emptying while remotely attended. The operator returns to finalize the emptying operation and disconnect the unloading equipment. An individual operator may be able to access multiple tank cars to close the dome after unloading.

The schematic for the unloading rack schematic is shown below.

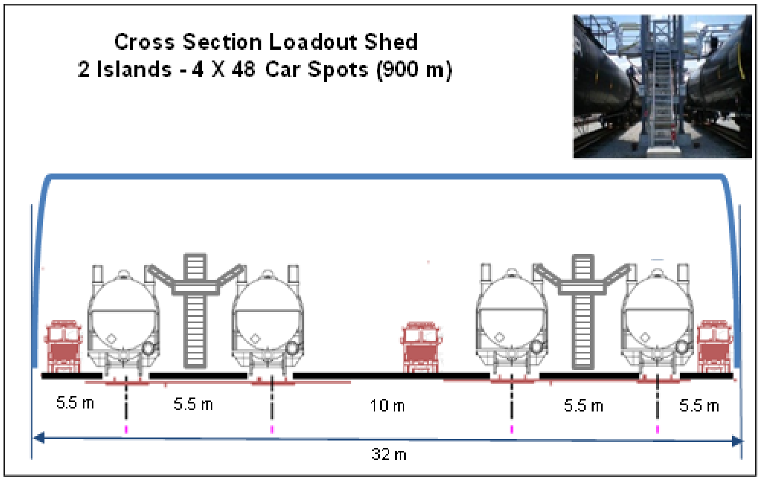


Figure 19 Typical Proposed Loadout Shed Arrangement

The 18 by 250,000 barrel storage tanks at Delta Junction are anticipated to accommodate the balancing of crude bitumen arrival and discharge to a pipeline and pumping station, as well as any outbound product movements that may arise in future development.

1.18.4 Product Handling Infrastructure

The pumping rates for loading and unloading are anticipated to be the same, leading to similar loading rack configurations for both product movements. The estimated arrival times for the unit trains, together with the anticipated one hour variation in schedule times, result in the need for a minimum of three loading islands at Fort McMurray and Delta Junction. Each island will be double sided with 48 spots on each side. In effect, the train will be split in half, twice resulting in one quarter train length sets.

This capacity of loading and unloading can be expressed as follows:

Table 24 Capacity of Loadout and Unloading Islands

		Loadout		Unloading	
Barrels (M) per day		1.0	1.5	1.0	1.5
Train Load/Unload (Hrs:Min)		2:43		2:13	
Train Departures Every (hrs.)		3	2	3	2
Sheds	Islands				
1	2	91%	136%	74%	111%
2	3	68%	102%	56%	84%
	4	45%	68%	37%	56%
3	5	38%	57%	31%	47%
	6	30%	45%	25%	37%

Therefore, in order at this early stage to be conservative, use of four islands will allow for the handling of additional operational variances in the railway operations. For example over the course of twelve hours the number of train arrivals indicate that the infrastructure will permit the first arriving train to be finished with approximately 3 hours to spare before the fourth train arrives for the design of the 1.0 million barrels per day facility. In addition six islands are proposed for 1.5 mbpd barrels until further optimizing and refinements can be developed at the preliminary engineering stage.

For the purposes of design at this stage of the program development, it was determined to allow for four loading islands at the Fort McMurray and Delta Junction locations (1 complete shed). The additional island was introduced as a reasonable allowance to accommodate program start-up and have a position available for accommodating clustering of train arrivals/delayed departures and the occasional provision of heat to cold trains that may arrive.

1. Storage Tanks

As an integral part of a larger bitumen supply chain, the Alberta to Alaska Railway will be able to properly interface with the bitumen at both Fort McMurray and Delta Junction. Inefficiencies are more likely to occur at the interfaces between modes since capacities and throughputs of upstream and downstream modes generally do not match. This results in a lowest common denominator, and the overall supply chain is limited by the weakest link. The traditional solution in a bulk materials supply chain is to build a buffer between each mode in the form of additional holding tanks. These large heated, insulted holding tanks are also useful for the blending of product but for this study perspective a single product is being transported on the railway.

The presence and size of holding tanks will determine how well the supply chain will be able to operate during various outages before, during and after delivery, and also the extent to which the system will be able to recover and recover after these events. Bitumen will be stored and heated up to 90 °C in large tanks waiting for loading into the rail cars. This report assumes the presence of sufficient holding tanks at the port for both ends of the Alberta to Alaska Railway to handle normal variations in railway delivery as well as upstream or downstream normal interruptions in the supply chain.

The industrial plant footprint for storage tanks, tank car loading racks, product and heating systems layouts and other product handling infrastructure such as roads and fire protection, are yet to be clearly defined at this early stage of development. The generalized arrangements undertaken for the product loading and discharge facilities are presumed to be in line with the types and layouts of facilities typically seen in petroleum product terminals and loading / unloading systems.

Actual conditions may vary based on site topography and land use ownership that are still to be determined. Some portions of the facilities may be shifted or separated without a material effect on estimated prices at this time. For example, loading racks may be situated more end to end with runaround tracks rather than in parallel without an adverse impact on capital costs and operations at this stage. The approach and estimate are based on neutral conditions experienced in the industry, attempting to avoid uniquely advantageous and constraining conditions with an excessive impact on present and future designs.

Terminal operations may need heat provided to storage tanks at one or both locations depending on the commercial relationships actually in place at the time the project is loaded or unloaded. The design at this stage is based on incorporating one boiler system inclusive of three boilers and piping, together with diesel fuel storage. Two tanks are anticipated to mitigate potential disruptions to the source and supply of fuel relying on a single tank. Diesel fuel was selected to minimize the number of alternative energy products carried on the rail line.

Preliminary engineering, including value engineering exercises and a more finalized set of commercial conditions, may shift in the final design. Three 750 boiler horsepower units were sized and selected for the design. The units provide the estimated capacity in a staged manner for current heat demand, together with resilience for maintenance and repairs. The heating system may be based on glycol as the heating fluid to reduce the volume changes as steam returns to its liquid state. Also, the use of glycol as the heating medium mitigates the icing effects of steam condensate if the steam or condensate lines were to leak. A return line is anticipated to the boiler house.

The plant labor for the operations will involve individuals that combine the typical skill sets associated with railroad workers together with those of the petroleum industry. Bulk liquid terminal operators have the training to manage the operations associate with liquid products such as crude bitumen in terms of temperature, pressure and product characteristics. The MSDS sheets for crude bitumen are the baseline descriptions for these product characteristics. The remote locations will also necessitate the effective cross training of personnel. The level of activity, as well as the 24-7 operations, will add to the importance of the workforce training and appropriate training certifications. The combination of tasks is similar to those in rail served petrochemical terminals yet differs in the magnitude of the contributing pieces.

Vehicles and equipment are anticipated for use by the plant operators, in part to cover the distances associated with storage terminal and the long train lengths. A mix of vehicle sizes was estimated to provide mobility for the distribution of personnel and to accomplish periodic material lifting and transport operations. Vehicles would also be used for the transfer of tools and operating materials.

1.18.5 Adapting Operations and Recovery for Disruptive Conditions

The volume projections, and the operations and infrastructure to support those projections, are based on the need to load and move crude bitumen tank cars in a scheduled and disciplined manner, as well as unload and return empty tank cars. The supply chain loop crosses a significant distance as well as incorporates a multitude of complex and interdependent activities. When service interruptions occur, due to human and natural events such as crew availability or weather, it will be essential to return to normally scheduled activities as soon as possible. The combination of infrastructure and operations in this crude bitumen supply chain must enable that recovery to take place. In effect, the built and operating systems must mitigate “domino effects” while accommodating the short term events to return to planned activity.

Business Resumption Plans would be designed in advance to handle all standard types of disruption. For example, should the track become blocked from snowfalls or equipment breakdowns, the trains on the line would begin to see the respective tank cars drop in temperature during the winter months. If the outage is long enough, it may become necessary to adopt a short term operating scenario to recover. Trains downstream of the blockage could continue to Delta Junction where a net accumulation of empty trains would begin. It may be most effective to return some loaded trains to Fort McMurray to reheat the tank cars and resume operations with newly loaded empty trains and depart them to Delta Junction. The balancing of the infrastructure at Fort McMurray and at Delta Junction would enable this to take place. Loading and unloading cycles would be managed to incorporate reheated trains as they become available.

The ability to recover for disruptions is an additional reason to incorporate a fourth loading and unloading island. The return of some loaded trains to this fourth island provides the capacity for recovery and offline maintenance, challenges to tight scheduling over long distances, while supporting the focus on the sustained arrivals of loaded trains. The “Railroad” will need to integrate operations and supply chain management in a very responsive manner, tied into operations and maintenance, through an integrated logistics center.

One final aspect is that of safety and risk. The unique long train configuration, while within the technical and operation capacities for freight transportation infrastructure, does introduce unique elements for consideration with the load/unloading operations. Visual and communication clearances may necessitate operational and infrastructure considerations to sustain safety and protection for personnel, property and equipment. The long loading racks will have multiple stairways to ground level so that the loading platforms can be evacuated if necessary. Fire protection and cooling hydrants would necessitate a similar assessment. The design for the infrastructure and operating systems for the crude bitumen handling and storage are within available technologies, equipment and operating histories. The magnitude of the applications in the Alberta to Alaska railway project will require a separate safety and health evaluation to fine tune the technical applications. As the subsequent stages of design unfold an assessment of the corresponding impacts between the industrial plant and equipment with the personnel facilities will need to be undertaken as well.

1.18.6 Innovations in Technology and Applications

Recent technical and commercial petroleum product handling applications have been proposed that focus on high volume loading and unloading. Higher pumping rates and larger diameter equipment have been designed with select applications and a limited number of vendors. The designs have included approximately 15 minutes per load, with ±10 minutes for filling and ±4 minutes for repositioning to the next railcar for the next filling cycle. Robotics and feedback imagery have been used for automation control and linked to a car indexer as seen in the mining and other bulk freight industries. The Schurzer System makes use of co-axial tubes with diffusers and a vapor return stream via an annular ring in one approach. At this stage of development, the high flow applications have been limited in numbers and operated fewer hours per day. The careful identification for commercialization risks of new technology was beyond the current study. New technology and continued development of new sites may evolve technology over the next 2 to 5 years that will demonstrate a higher volume handled for a sustained operating period.

1.19 Rolling Stock

North American AAR (American Association of Railroads) standards have been applied when specifying technical requirements including couplers and brake equipment as well as the general design of the locomotives such as loading gauge. The pertinence of these standards is demonstrated by international recognition of AAR standards as rail industry benchmark guidelines and by the project location (Alberta to Alaska).

Environmental conditions of the operation are:

- Extremely low, sub-zero ambient temperatures during winter
- Snowfall
- Substantial vertical grades.

1.19.1 Tank Cars

All tank cars for this project must be capable of discharging bitumen at a workable temperature after travelling over a long distance. As such, the thermal insulation capabilities of tank cars have been investigated in order to determine an optimal configuration suitable for the project application. In addition to this, heating coils will be incorporated into the design specification to enable re-heating of product in cases where the bitumen has cooled to a non-workable state following an extended period of idling. North American AAR and Federal Railroad Association DOT standards have been applied when developing the tank car specification.

1.19.1.1 Thermal Properties of Bitumen

For the bitumen to be unloaded efficiently it must be at a workable viscosity. This implies that the temperature of the hot loaded product must be maintained to prevent it falling below its pour point. It is envisaged that two external environmental factors which are expected to be detrimental to this goal are:

1. The extremely low ambient temperatures experienced in Canada particularly during winter (approx. -58 ºF); and
2. The length of the alignment between the bitumen source in Alberta and Delta Junction (approx. 2,400 km).

The combination of these two factors implies that the tank cars will be exposed to extreme cold for a prolonged period of time thereby increasing the risk that product will arrive in an un-workable state.

To negate this risk, the tank cars have been specified with an exterior coiled heating system and a level of insulation in accordance with the requirements stipulated by the Department of Transportation (DOT) through the Federal Railroad Administration (FRA). These requirements are:

- Minimum 4” thick approved insulation; and
- Maximum overall heat transfer coefficient of 0.075 BTU per hour per ft^2 per ºF (across all intended operational temperatures)

The reduction in temperature of the bitumen over time has been predicted based on the above parameters, and a worst case ambient temperature of -20 °C.

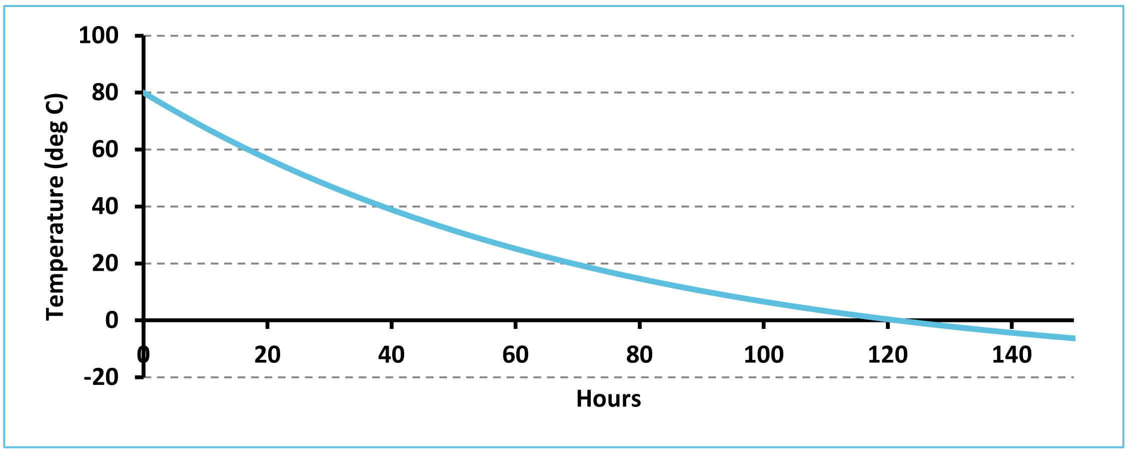


Figure 20 Temperature vs. Travel Time

Based on a journey time of 43 hours (34 mph average speed; 1,500 miles one-way), the graph indicates that the bitumen will remain well above 30 °C for the duration of the trip if loaded at no less than 80 °C. Therefore, taking into consideration the expected temperature fluctuations based on seasonal weather variations in Canada, a loading temperature of 90 °C has been assumed to prevent the temperature of the product falling below its pour point. Note the tank car can safely be loaded with bitumen up to 99 °C. This permits an extra heat allowance which may be very useful in extremely cold temperatures.

The graph below indicates that the viscosity of the bitumen will increase over the journey as it cools but will remain workable.

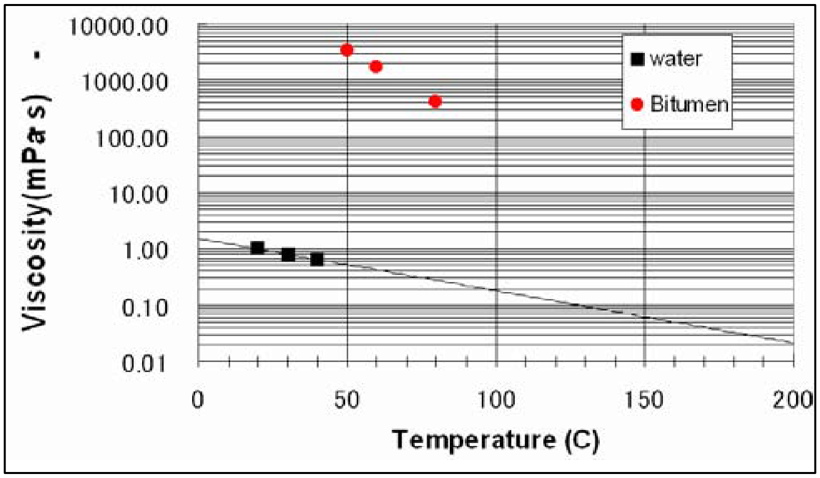


Figure 21 Viscosity vs. Temperature

1.19.2 Capacity and Configuration

Tank cars will be permanently coupled as 3-pack units to minimise coupler maintenance and eliminate unnecessary coupling/uncoupling processes when splitting trains for unloading activities and maintenance

A capacity of 29,300 gallons has been specified in order to achieve annual product output requirements. Though not a typical off-the-shelf design, it is expected that this bespoke tank capacity can be justified by the fleet size requirement and the resulting economies of scale.

Should an increase in annual output be sought, the operator may opt to increase the frequency of services or increase the length of the train through addition of extra tank cars. It is envisaged that this exercise would incur less cost than ordering higher capacity tank cars which would also increase track wear and associated maintenance costs.

Figure 22 Insulated Tank Car with Coil Heating

1.19.2.1 Condition Monitoring of Tank Cars

An on-board condition monitoring system will be implemented to provide real-time feedback on tank car running gear in addition to dynamic behaviours relating to in-train forces and product temperature.

1.19.2.2 Hot Axle Detection

Each axle will be fitted with a hot axle detector to provide early warning of any instances of overheating bearings which could lead to fire, axle seizure or derailment. The hot axle detectors will integrate with the ECP diagnostics system to enable reporting of hot axle events to the driver display.

1.19.2.3 Train Brakes

Wheel temperature sensors are capable of providing data which can be analysed to identify brake system faults. An excessively hot or cold wheel in comparison to others in the consist indicates over-braking or under-braking respectively, potentially due to a fault within the air braking system.

1.19.2.4 In-Train Forces

By providing feedback on coupler forces, a condition monitoring system is capable of identifying excessive braking or acceleration practices to develop improved driving strategies, to reduce the risk of derailments and the costs of replacing components worn at an unnecessarily accelerated rate.

1.19.2.5 Product Temperature

Product temperature sensors will be linked to the condition monitoring system to provide locomotive engineers and the network control centre with valuable information regarding the temperature of the product to allow potential heating procedures at the destination to be scheduled if necessary.

1.19.2.6 Hand Brake

Hand brake specifications are largely influenced by AAR standards; however, provision should be made for the installation of automatic spring applied park brakes (SAPB) to prevent runaways when brake air pressure fails.

Previous studies conducted into the application of SAPB to freight cars have identified real cost savings and potential increases in revenue generated through:

- A reduction in tare mass compared to existing tank cars resulting in greater load carrying capability and lower fuel use
- An increase in reliability resulting in reduced cost of maintenance
- An increase in operational safety.

In addition, SAPB allow trains to be stopped for an extended period of time without the need for a constant supply of air pressure to apply air brakes. During tank car loading and unloading processes, this feature would allow locomotives to be dispatched to maintenance facilities if required without added operational risk.

1.19.2.7 Cost

Following consultation with a number of tank car manufacturers, it has been determined that the approximate cost of procuring each tank car designed to the aforementioned specification would be USD $150,000 (2013 $).

1.19.3 Locomotives

Taking into consideration the requirements and options discussed, all analysis and modeling has been completed based on the Tier 4 GE ES44AC locomotive equipped with dynamic braking. An alternative is Electro-Motive Diesel SD70AC which is capable of performing in line with the operational requirements described. Whichever is selected it is prudent to pick one supplier for ease of parts inventory and repairs.

Figure 23 GE ES44-AC/EMD SD70AC

Some specific features of the locomotives that need to be specified are provided below.

1.19.3.1 Locomotive Fuel Tank

The proposed Alberta to Alaska railway line is long in comparison to traditional heavy haul lines around the world. Therefore, in order to reduce the need for refueling, the largest currently available fuel tank 18,200 liter (4,800 gallons) is deemed appropriate for locomotives.

A complete round trip is not possible on one tank of fuel so refueling will be required en route. The location of this refueling point will be to extract maximum use from the tank's capacity without introducing the risk of fuel starvation. The process of refueling is detailed in Section 9.6 in this report.

It could be possible to eliminate refueling by implementing an in-line fuelling system. This would involve positioning a diesel-laden tender car between each locomotive pair capable of delivering fuel to each attached locomotive throughout the journey, increasing the total fuel capacity of the train. The downside of in-line fuelling is the limitation it imposes on the total carrying capacity as the additional tender cars increase the total mass of the train which is compensated for by a potential reduction in tank cars.

This option is not considered worth pursuing at this stage of the study.

1.19.3.2 Electronically-Controlled Pneumatic (ECP) Brakes

ECP brakes compliant with AAR standards will be employed in order to minimize in-train forces and draft gear wear associated with hauling long, heavy consists with un-even brake applications. This system enables uniform, and instantaneous release of brake pressure in all brakes along the train which reduces stopping distances, improves the trains responsiveness to brake application and release and the risk of derailment due to tank car bunching. Another benefit of ECP brakes is the reduction in fuel use through the ability to apply graduated braking, eliminating the need to use power during prolonged braking on varying grades to achieve a target speed. ECP brakes also reduce the risk of coupler failure and increase their maintainability as peak loads through the coupler rod are reduced along the train.

The communications system associated with ECP brakes is a conduit along the train which acts as an enabler for the operation of a distributed power train system, has the potential to augment a Driver Advisory System and can be readily adapted for the transfer of train condition data to assist the engineer and the maintenance staff of any technical problems with the train.

The braking system must also be protected from the impacts of the cold climate in Canada. Condensation within brake pipes may accumulate and freeze resulting in cracked pipes and a loss of air pressure. This risk can be mitigated by designing straight brake pipes with minimal bends to prevent condensate wells occurring and the introduction of air dryers.

1.19.3.3 Driver Advisory System (DAS)

A Driver Advisory System will be provided to optimise train performance and reduce fuel consumption. This system provides real-time advice to drivers in order to identify optimal engine power and brake positions depending on the route and conditions along each journey. Such systems are commercially available such as Trip Optimizer or LEADER.

1.19.3.4 Wheel Slip/Slide Prevention (WSP)

The locomotive will be equipped with a microprocessor controlled WSP system in order to detect and prevent wheel-slide during braking or wheel-spin during acceleration. The system can be linked to the vehicle sanding system to achieve even greater levels of adhesion and prevent excessive slip or slide.

1.19.3.5 Automatic Engine Stop-Start (AESS)

An Automatic Engine Start / Stop (AESS) system compliant with AAR standards will be provided to reduce idle fuel use. The AESS system is capable of shutting down the locomotive engine when the unit has been at idle for a period of time and other conditions have been met. Once shut down the system monitors locomotive status and restarts the engine when necessary.

The AESS system must be able to maintain reliable locomotive operation during extreme cold weather as expected in Canada. Furthermore, the locomotive engine must be compatible with cold weather diesel mixes to sustain its reliability throughout the operating calendar.

Finally AESS should be able to remotely shut down units on empty trains when the horsepower is not required to make schedule. This allows the remaining locomotives under power to use fuel more efficiently.

1.19.3.6 Condition Monitoring of Locomotives

An on-board condition monitoring system will be fitted to the locomotives to provide real-time telemetry data from brakes, traction motors, running gear, auxiliary electrical systems and the geographical location in order to record the health and welfare of assets. The long-term aim of condition monitoring is to predict wear on components and to identify components experiencing consistent defects in order to develop targeted maintenance regimes to increase mean-time-between-failure (MTBF) and reduce mean-time-to-repair (MTTR). In this way, availability and productivity of the assets can be optimised to prevent failures occurring en route and the total maintenance cost can be reduced. The systems architecture for enabling communications between the on-board computer and the network control centre should be specified according to AAR standards relating to Locomotive System Integration and Advanced Train Control Specifications.

1.19.3.7 Cost of Locomotives

Preliminary research into costs for the ES44AC and SD70AC locomotives discussed, based on R1 reports produced by benchmark operators in North America, indicates an approximate purchase price of USD $2.5M (2013 $). Based on prior experience, it is proposed that an additional USD $0.5 million be provisioned for changes to the design to address local conditions, bespoke operational features, commissioning, spares and shipping, this results in an indicative unit cost of USD $3 million per locomotive.

1.20 Alternative Power for Locomotives

The single largest non-labour operating cost for most railways is the cost of diesel fuel to power trains. Alternatives such as Liquefied Natural Gas (LNG) or even Overhead Electric should be examined in more detail during future studies. The scope of this project does not include investigating these; however a short synopsis of using LNG is provided below.

1.20.1 LNG Locomotives

The viability of using LNG as an alternative to conventional diesel to fuel locomotives has steadily gained momentum over the past two decades due to technological advancements by the main locomotive manufacturers. Increasing costs for diesel have encouraged heavy haul railway operators to identify alternative means of running locomotives which provide a potential technical opportunity for this study. LNG locomotives have been investigated to determine their impact on the economic feasibility of the proposal and their ability to reduce operating costs.

1.20.1.1 LNG Fuel (Tender) Car

It has been noted that a 96,528 litres (25,500 gallon) LNG fuel/tender car could support a range of approximately 3,540 km with two locomotives per tender however this would be dependent on the alignment, terrain and the total mass of the train. Comparatively, the LNG-fuelled locomotive provides greater range than a locomotive fuelled by diesel alone but this benefit is largely due to the addition of the fuel tender car to augment the existing on-board diesel fuel tank and there will be the same impact on the amount of load that can be carried.

1.20.1.2 Status of Trials

One of the most successful trials of LNG fuel to date was completed by Burlington Northern Railroad from 1988 to 1995. The trial locomotive operated on diesel fuel when idling and through to Notch 2 and LNG was used from Notch 3 up to Notch 8, with a 95% of the fuel as natural gas. Currently, it is known that a number of heavy haul operators are investigating LNG technology including BNSF, CSX, Norfolk Southern and Union Pacific. CN has been testing in the Edmonton – Fort McMurray corridor.

1.20.1.3 Fuel Consumption, Efficiency and Equivalents

In 1994, GE published a technical paper on a test engine it developed called the “H-process” engine. The paper presented data only for full power (Notch 8) operation.[8] The results of the tests demonstrated that LNG has lower energy content than diesel – 73,100 BTUs versus 128,100 BTUs per gallon respectively, or roughly 1.68 to 1 gallons for equivalent energy content. Therefore, assuming typical yearly average diesel consumption of 400,000 gallons per year for line-haul locomotives, this gives equivalent annual LNG consumption of 672,000 gallons. For this project, a pair of LNG locomotives without a tender car would require refueling approximately every 1,500 km or 1.7 times per one-way trip, however this would vary depending on alignment grades and train consist mass.

Refueling LNG locomotives can pose problems due to operational flexibility and cost. Refueling stations must be located in close proximity to natural gas pipelines and liquefaction plants must be built to process the natural gas into its liquid state. The high cost of establishing these refueling facilities unless they are found en route, such as in the Fort Nelson area, as well as the challenge of locating them near existing pipelines, are a significant cost barrier to developing this option for the Alberta to Alaska Freight Railway.

Figure 24 LNG Locomotive with Tender Car tested by Canadian National Railway

1.20.1.4 Power Output

Due to its lower energy content, a comparison of an EMD SD60 powered by diesel and powered by both diesel and LNG shows a reduction in Tractive Brake Horsepower from 3,800 to 3,000 respectively. Therefore, an increased number of locomotives would be required to haul the same consist which would result in greater capital expenditure. Furthermore, engines running LNG fuel must be de-rated or inlet air into cylinders must be cooled to prevent engine knocking, and reduce wear on valves, and piston rings.

[8] *B. D. Hsu, G. L. Confer, and R. E. McDowell, “The H-Process Dual-Fuel Diesel Engine,” Natural Gas and Alternative Fuels for Diesel Engines, ASME ICE-24, 25-30, 1994*

Despite the high octane, a number of natural gas, spark-ignited engines require a lower engine compression ratio (to avoid pre-ignition of fuel) compared to compression-ignited diesel engines, and this in turn contributes to the lower efficiency. In addition, the use of a throttle to control load results in a decrease in efficiency, especially at lower loads, typical of switch engine operation.

1.20.1.5 Emissions

Based on technical investigations conducted by the AAR[9], it has been determined that nitrogen-oxide emissions are essentially equivalent for LNG locomotives and standard diesel locomotives. However, all other emissions including hydrocarbons, carbon monoxide and particulate matter are observed as higher for LNG locomotives. This is particularly significant, given the recent renewal of the memorandum of understanding (MOU) between the Railway Association of Canada (RAC) and the Canadian government to limit greenhouse gases and monitor air emissions from locomotives operating in Canada through 2015. Under the MOU, RAC members are encouraged to voluntarily further reduce emissions. In addition, tests show LNG can meet present Tier 3 regulations but the more stringent Tier 4 regulations come into effect in the US in 2015 leaving more research to be done on this fuel.

1.20.1.6 Cost

As LNG is still a relatively immature technology, new locomotives are sold without dual fuel capability. Operators wishing to use LNG must convert these locomotives at a cost of approximately USD $1 million in addition to the capital cost of the base unit. In addition, new locomotives with spark-ignited engines – a requirement for LNG systems – carry a premium of approximately USD $1 million. An approximate cost for the tender car required to fuel the locomotives en route is USD $1 million but may vary depending on capacity.

Considering all of these values, the total cost of producing one LNG locomotive could reach USD $5 million in addition to the cost of tender cars. For reference, the estimated cost of converting one EMD SD40-2 locomotive under the Southern California LNG Line-haul Loco Project (2004) was USD $1,719,265.

1.20.1.7 Benefits of LNG versus Diesel

Table 25 Benefits and Concerns of LNG versus Diesel

Benefits	Concerns
• Reduced fuel cost based on $/km • Increased range from tender car	• Procurement cost • Risk of transporting flammable gas • Location and cost of establishing refuelling stations • Greater emissions compared to standard diesel locomotives

1.21 Locomotive Conclusion

Whilst there are some significant benefits from the use of LNG, it is considered that the technology of this application is too immature and presents many unanswered questions to the project to be considered an option worth pursuing at this stage of the project's development.

The technical and functional capabilities of locomotives for this project have been developed based on environmental conditions, alignment length and dynamic performance requirements. It is recommended that locomotives are configured in a distributed power arrangement, each with a 4,800 gallon fuel tank and a variety of electronic safety systems to achieve operational objectives.

[9] B. D. Hsu, G. L. Confer, and R. E. McDowell, "The H-Process Dual-Fuel Diesel Engine," Natural Gas and Alternative Fuels for Diesel Engines, ASME ICE-24, 25-30, 1994

1.21.1 Work Train Fleet

The work train fleet consists of rolling stock required for track maintenance and facilitating yard movements. Track maintenance is an integral part to successfully maintaining track tolerances. To conduct the required track maintenance, efficiently and effectively, track maintenance vehicles are essential. Typical work trains for track maintenance will include:

1. **Mobile flash butt welders -** these are road rail vehicles with the ability to weld track where there are broken rails or when new sections of rail are installed;
2. **Ballast cars** – these transport ballast between a number of supply quarries along the rail alignment and temporary and permanent stockpiles which will be established as part of the track maintenance strategy for the rail network. Car hoppers will be top loaded using front end loaders. Operator controlled discharge will be through bottom mounted doors;
3. **Mainline and switch tampers** – these are used to realign or adjust the track geometry with the aim of returning it to an acceptable level. The difference between a mainline tamper and a switch tamper is that a switch tamper is fitted with movable workheads and extra lifting capacity to enable the tamping of switches;
4. **High speed rail grinders and switch grinders** – these are used to re-profile the rail head to remove irregularities from worn rail track to extend its life and to improve the ride comfort of the rolling stock;
5. **Ballast regulators** – these are used to regulate the ballast by raking and ploughing fresh ballast to spread it evenly around the rail, sleepers and shoulders;
6. **Ballast cleaners** – these are used to remove worn ballast, screen it and replace the worn ballast with fresh ballast;
7. **Dynamic track stabilisers** – these are used after the tamping process to stabilise the track and are generally used in conjunction with a ballast regulator;
8. **Continuous welded rail train** – this is a train that consists of a number of modified flat cars designed to transport continuous lengths of rail to areas where track needs to be replaced; and
9. **Track geometry car** – this is an automated track inspection vehicle used to test and record several geometric parameters of the track without taking possession of the railway so normal operations are not affected. As an alternative, tank cars could be modified to carry the same equipment, further reducing the impact on the operation

Yard movements are facilitated using shunting vehicles which are used to move rolling stock around maintenance facilities, depots and stabling yards. Shunting vehicles are important for the purposes of moving any bad order cars out of the consist and replacing them with good order cars. The selection of the shunting vehicle will be based on capital cost and the minimum requirement to shunt up to 48 empty tank cars. A number of vehicle options are available for these purposes:

1. **Car movers** – these are road/rail vehicles which provide greater flexibility when moving around the depot reducing the time taken for rail movements;
2. **Diesel shunter** – this is a small locomotive used strictly for assembling trains with low power but high tractive effort;
3. **Full scale locomotive spare** – capital costs may be reduced by using a spare locomotive to perform shunting duty provided it is in an optimal location to minimise process time; and
4. **Diesel hybrid** – this is a small hybrid locomotive similar in size to a regular diesel shunter which provide the added benefit of minimising environmental impact and fuel costs.

1.21.2 Supply Trains

The transportation of supplies and waste between the Alberta and Alaska rail terminals and any intermediate points will require the provision of mixed freight cars capable of operating as part of a dedicated freight service or transiting as part of a tank car train consist.

Flat cars can be used to transport secured containers and will be sized based on the average product load. Larger items may require the use of well cars which have greater carrying capability than flat cars.

1.21.3 Accommodation Cars

Accommodation cars for transportation of staff along the route may be required. The factors for consideration in determining this requirement are:

- Periodicity and duration of track and signals maintenance and maintenance crew size – this will determine the quantity and size of accommodation cars provided maintenance crews are not permanently located at set intervals along the alignment
- Unit specification – depending on the size required, an off-the-shelf unit may be suitable and would reduce capital costs
- Compatibility with train systems – the accommodation cars must be capable of being integrated with the train condition monitoring system.

As an alternative a regular diesel multiple-unit could be used.

1.21.4 Emergency Response Trains

Emergency response trains will be available as required by the Incident Recovery Plan. To augment the incident response capabilities of the train, a railway crane and emergency hi-rail 4WD vehicles will also be available.

The Core Response Plan should include but is not be limited to the following equipment:

- Excavators
- Bulldozers
- Hi-Rail rotary dump trucks
- Bull dozers with side lift capacity
- Track mounted Burro Crane
- Site restoration equipment
- Mobile incident Command centre
- Satellite communication equipment
- Specialized rail cars equipped with sleeping and eating facilities
- Hi speed mobile rail crane
- Flat cars with track panels
- Depressed flat cars with excavators
- Fuel, food, generator sets and water supply
- King vacuum Hazmat Response trucks (by flat cars)

Mainline blockage response teams should carry absorption pads, containment drums, pumps and all other suitable recovery systems. Specialized equipment (as mentioned above) should be stored centrally to provide the quickest response time.

Additional equipment including a remote command centre and standby helicopter service will be used in the unlikely event of a major incident.

One advantage to hauling bitumen without diluent, as compared to a pipeline, is that any spill will be restricted both in quantity (carload compartment) and size since higher the higher viscosity results in less permeation into ground or watersheds.

1.22 Rolling Stock Maintenance Plan

Rolling stock maintenance intends to provide safe, reliable and available rolling stock for use as production trains, freight trains and track maintenance trains.

Fundamentally there are three aspects of rolling stock maintenance:

- Trip servicing
- Routine maintenance
- Component Exchange and Overhaul.

Trip servicing encompasses topping up of fluids, fuel and general cleaning. Generally, these tasks are undertaken by semi-skilled personnel. This part of the operation occurs 24/7, with a traditional three shift deployment system. Daily inspections of the tank cars should also be conducted by this team.

The routine maintenance activities for both the locomotives and the tank cars are conducted by multi-skilled personnel who can complete mechanical and electrical tasks.

1.22.1 Maintenance Programs

This is an indicative plan, meant to provide a realistic but high level view of necessary maintenance based on the conceptual design at this point. Obviously, if detailed design is progressed the assumptions and principles will need to be reviewed and updated for compatibility and even optimization with any design changes.

Generally speaking, the maintenance programs for all rolling stock will follow prescribed programs produced by the equipment manufacturers. However, condition based monitoring techniques will be used to drive a maintenance optimization process which has the overall aim of reducing the Total Cost of Ownership of the equipment. Additionally, DOT §180.509 states that inspection of tank cars transporting materials not corrosive to the tank must occur every 10 years and is applicable to the tank and service equipment such as filling and discharge equipment and venting, safety, heating and measuring devices.

1.22.2 Definition of Levels of Maintenance

Rolling stock maintenance is performed using a tiered approach with multiple levels of maintenance activity and intensity. These levels, based on those adopted by benchmark operators, are:

Level 1 Maintenance – Trip Servicing

Trip servicing involves provisioning and preparing rolling stock before each journey. Activities include general cleaning, re-fuelling, emptying the toilet if necessary and checking fluid and sand levels. In addition, any technical faults that have arisen during the previous journey will be corrected.

All Level 1 activities are completed in the yard and targeted based on specific components following input from the condition monitoring system.

Level 2 Maintenance – Periodic Preventive Maintenance

Periodic preventive maintenance includes inspections every 3 months supplemented by a series of examinations that occur sequentially at annual intervals.

The 3 monthly inspections will generally include change of engine oil, brake blocks (if required) and filters, wheel inspections and turning along with a general inspection and performance check.

The sequential annual inspections consist of a set of core servicing, inspection and testing activities.

Defects that are not service critical will also be repaired during periodic planned maintenance. Defect rectification will often require more skilled labour, either for performing or validating the repair activity.

All Level 2 maintenance is undertaken in the rolling stock maintenance facility.

Level 3 Maintenance – Component Change Out (CCO)

Component change out covers the exchange of repairable equipment for overhaul. Equipment will be sent to the locomotive supplier or a third party for overhaul off site, minimising the number of skills required for railway maintenance staff. Level 3 maintenance occurs within the main rolling stock maintenance facility.

Level 4 Maintenance – Overhaul and Heavy Repairs

This maintenance level includes the rebuilding and refurbishment of the locomotive. Engine and locomotive components will be dismantled and repaired/replaced. Major system upgrades will also be performed when necessary.

1.22.3 Standard Rolling Stock Maintenance Equipment

To facilitate rolling stock maintenance, specialised equipment will be required including:

- Wheel lathes and mills – these are used to re-profile worn wheels. An above ground machine requires wheelsets to be removed from bogies whereas an underfloor system is capable of performing re-profiling while the wheel is in place.
- Bogie drop pit – Single unplanned wheelset changes can be made using a drop pit system. In this system, the consist remains connected during the change out and a dedicated drop pit must be excavated at some point under the track in the maintenance facility. The defective (bad order) tank car is moved over the drop pit and the connections attaching the wheelset to the vehicle are unfastened. The wheelset is then lowered into a pit using a lifting system and transported to another road for maintenance. A new wheelset is then lifted into place and fastened onto the bogie. The drop pit system also caters to loaded tank cars as no tank car lifting is involved. This gives the system greater flexibility in terms of responsive wheelset repair.
- Cranes – overhead gantry cranes are used for lifting heavy components for CCO activities. Lifting capacity will be specified based on the maximum mass of any single rotable.

1.22.4 Indicative Rolling Stock Maintenance Layout

Based on the number of tank cars and locomotives required to achieve the total output targets in addition to the reliability performance expected of the fleet, the following indicative maintenance layout has been developed.

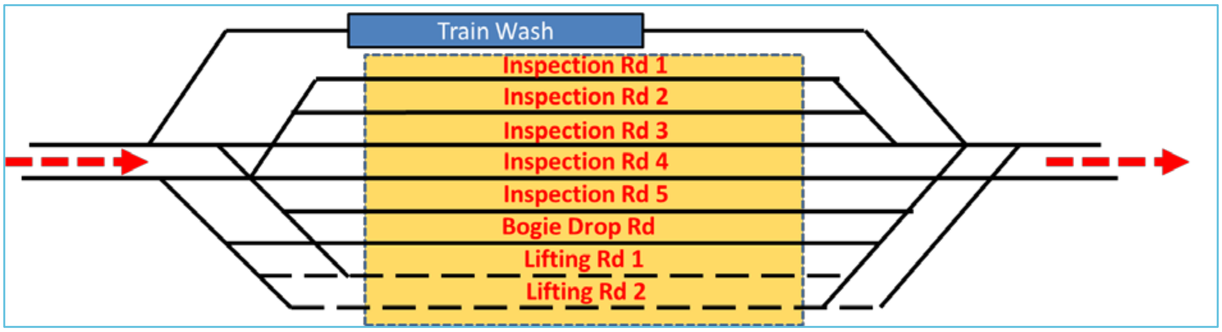


Figure 25 Indicative Rolling Stock Maintenance Layout

Multiple turnouts provide good access for trains accessing the facility and for transitioning between maintenance roads in case of work escalation. Consideration should also be given to road access and hard standing areas for the delivery of large items and supplies including rotables.

All locomotive cleaning will occur on the wash track with adequate space given for locomotives to be parked for interior cab cleaning. Toilet servicing is expected to be co-located with trip servicing facilities within another area of the yard, closer to loading and unloading terminals.

The length of the maintenance shed should be defined such that 2 three-pack tank car sets can be accommodated back to back on one road to maximise process efficiency. Each track will be pitted to provide full undercar access. A through-running layout has been designated as it reduces the need to reverse trains out of maintenance roads which can be a time-consuming process requiring careful coordination. The viability of this layout for this project would be dependent on land availability and relative track construction costs to achieve a complete loop through the maintenance facility.

1.22.5 Average Maintenance Periodicities

Based on industry benchmarks and regulatory laws, the maintenance periodicities for all levels of maintenance defined are as follows:

Table 26 Maintenance Periodicities

Maintenance Level	Maximum Periodicity
Level 1 – Trip Servicing	Each one-way trip
Level 2– Periodic Preventive Maintenance	3 month inspection 6 month inspection
Level 3 – Component Change Out (CCO)	1 year service
Level 4 – Overhaul and Heavy Repairs	4 – 5 years

1.22.6 Modern Maintenance Concepts

With the increase in demand by rail operators for higher reliability and availability targets, new maintenance concepts are consistently being developed to achieve these objectives utilizing the latest technology available.

Comprehensive Wayside Site

A comprehensive Wayside Super-Site brings together all available wayside surveillance equipment in the most economical way in a strategic location, including:

- Brake block wear measurement
- Wheel profile measurement
- Bogie alignment tracking
- Bogie wedge-height measurement
- Coupler security inspection
- Broken /misplaced spring detection
- Acoustic Bearing Monitoring.

The ultimate aspiration for a comprehensive wayside site should be to facilitate the elimination of the trip servicing inspection phase.

In-Train Wheelset Removal

This involves using a mobile lifting jack rated to approximately 50 tonnes or as required relative to tank car empty weight, mounted beneath the tank car coupling to raise the bogie and release a single wheelset for removal and replacement. As a result, wheelsets can be exchanged from tank cars without splitting trains, ultimately reducing downtime. A forklift is required for removal and replacement of wheelsets. The main objective of implementing the lifting jack method is to minimise train delays and yard dwell times due to bad orders and eliminate the movements necessary when replacing a bad order car with a pool fill car.

Another motivation behind the implementation of the lifting jack system is the operator's inability to service multiple tank cars at any one time due to the confines of the maintenance facility. A mobile service system enables multiple jacks and forklifts to be deployed simultaneously, increasing servicing productivity and reducing bad order down time.

Underfloor Wheel Lathe and Mill

Underfloor wheel lathes increase the productivity of a maintenance program as they remove the time-consuming requirement to remove and transport heavy wheelsets to a separate wheel turning facility for re-profiling. Furthermore, an underfloor wheel lathe eliminates the need to lift the train for wheelset removal which requires the installation of costly lifting jacks. Similar in principle to the wheel lathe, the wheel mill uses a rotating cutting head to re-profile the surface of the wheel which stays stationary.

Automated Maintenance Facility

The automated facility consists of automated machines and robotic systems capable of:

- Bogie disassembly
- Axle set disassembly
- Wheel turning
- Axle turning
- Axle/wheel assembly
- NDT
- Bogie assembly and automated bogie to tank car assembly.

This type of facility is constructed for large operators wishing to achieve the greatest productivity through low downtime and operator input and high accuracy and reliability.

1.22.6.1 Condition Monitoring

Condition monitoring of rolling stock is a growing aspect of fleet management. It is used extensively in the transit arena, but is also becoming more common in freight as reliability and availability become increasingly critical to maximizing operational efficiency and minimizing costs. Some typical aspects of rolling stock condition that are monitored are provided in the table below.

Table 27 Rolling Stock Condition Monitoring

System	Typical Condition Data
Electric Traction	Motor current, supply voltage, transformer input, output voltages
Diesel Traction	Compressor inlet/outlet pressures, exhaust pressures, fuel consumption, oil temperature and pressure, motor current
Compressors	Motor currents, output pressures
Fuel Tank	Fuel level (litres remaining)
Gearboxes	Vibration, oil temperature
Air Conditioning	Output temperature, Motor current, pump pressure
Utilities	Sand levels, washer wiper levels, toilet levels

Adoption of condition monitoring, when used as an integrated part of the fleet and operational management process, can have a positive impact on:

- Reliability
- Unplanned maintenance time
- Mean time to repair
- Fleet optimization
- Provisioning of locomotives.

The condition monitoring process generally proceeds as follows:

1. Condition data and event data is continuously monitored and stored on the locomotive;
2. Data is categorized. Urgent data is transmitted via mobile or WLAN networks to a central control system. Other data is collated and transmitted through WLAN at a provisioning facility;
3. For urgent information, for example a critical fault to the engine which requires it to be shut down, an urgent notification (email or text) is sent to the train control so appropriate action can be taken. All other data is collated, analysed through dedicated algorithms, and transformed into useable information. For example work orders can be automatically generated for a depot to take action in a defined period of time

Wayside and on-board condition monitoring equipment will detect failures; alert maintenance teams, and allow the scheduling of repair work. By the time the loaded cars have arrived at the Delta Junction yard, information will have been compiled for a list of potential bad order cars and, to a degree, the particular defects requiring repair.

Upon receipt of the data, repair staff will make judgments regarding which cars are to be cut from the consist and which can be repaired while the car is stored on one of the in-line repair roads. To complete in-train repairs on the outbound track, the required equipment will be positioned and resources pre-planned at point of arrival in the yard to minimise impacts on train cycle time.

1.22.7 Maintenance Schedules

1.22.7.1 Maintenance Program for Tank Cars

The tank car maintenance program will be based on:

- Level 1 - 30 days (undertaken on the mainline departure track)
- Level 2 - 9 months, wheel re-profiling (360,000 km)
- Level 3 - 3 years, bogie overhaul.

The tank car specification will describe three pack sets such that each set is permanently coupled with a rotary coupler at each end and fixed couplers in between. With the exception of mainline failures that must be addressed on the road, tank car maintenance will occur within the main rolling stock maintenance facility.

The principle of keeping the rakes intact as much as possible will apply:

- To minimize the risk of generating new problems by unnecessary uncoupling and recoupling of tank cars; and
- To avoid shunting costs and excessive time. Single bad order tank cars will be repaired in-train, except where repairs absolutely require a shop or the number of repairs exceeds the permissible time allotted for the outbound train.

The strategy for maintenance focuses on reliability, reduced downtime and parallel inspection/repair processes which minimise train turnaround times at the terminal yards.

1.22.8 Maintenance Program for Locomotives

The locomotive supplier will provide a maintenance schedule for each locomotive. This will include:

- Trip servicing: visual inspection and provisioning after each trip to the mine
- 3 month inspection (92 days): change engine oil and filters along with general inspection and performance check
- 6 month inspection (184 days): thorough check-up and follow-up repairs
- Component Exchange as required for major component change outs on bogies, brakes, power assemblies and possibly the engine/alternator packages
- Mid-life overhaul.

The maintenance will be undertaken either at the servicing facility or the locomotive workshop, both of which have been provisioned sufficiently to undertake the maintenance.

1.23 Signal and Communications Infrastructure (S&C)

The development of a comprehensive set of signals, Train Control and Communications System will include eight systems which separately or in concert provide the required safety system which controls the movement of trains according to regulations, in a failsafe manor. These various systems make certain that train movement is authorized in a timely fashion, ensuring trains remain safely spaced, are authorized to occupy discrete portions of the track network exclusively and in a safe manor. These systems also provide a constant monitoring of the track network, any equipment on the track and to identify all failures of any system or equipment before such failure creates an incident out of this unsafe condition. These detections of potential failures are reported in real time and protect trains, equipment and employees.

For the mainline track between main terminals, the functional operating systems required are the signals and train control system in combination with the communications system. This enables the signal system to effectively function and change as requested by the Rail Traffic Controller (RTC). The signal system works in conjunction with the switch control system and verifies the switch positions prior to revising the signal system as requested by the RTC. In addition and in an overlay position are Wayside Inspection Systems (WIS) such as the Hot Box Detector (HBD), Wheel Impact Load Detector (Wild), Dragging Equipment Detectors. These systems monitor the performance of the rail car axles, bearing, and other equipment on the cars to determine if they are functioning within allowable tolerances, flagging any discrepancies.

In concert with this, the required radio system provides continuous communications for Data and Voice between the train, employees and the RTCC. This radio communication system is a vital link in maintaining the continuous locations of the train and the monitoring of compliance with the rules and instructions set out for the train. There are a number of proposed radio systems available for this task.

The Network Management System monitors the health and functioning of the signal, fiber optic and radio networks and provides a 24/7 monitoring and response service to these systems so they are kept operational at all times. This is the same for the power supply system as it is needed to operate and service the power needs of the switch, signal and radio systems.

At each main terminal there is a similar set of systems which manage and service the rail activity in the terminals called the Yard Control System. This system monitors and controls the movement of trains and other equipment within the yard as they pass through power and manual switches and into and out of the Load/Unload systems. A Yard Controller manages these operations and issues authority for each train or track equipment movement.

For the interface between the roads and railway at level crossings there will be a level crossing protection system in place which will warn the road traffic about on coming trains and provide the required level of protection at each crossing.

1.23.1 Train Control Systems

The primary historically proven system in North American for authorizing rail movements over busy main tracks is a centralized traffic control (CTC) signal system. Newer systems like Positive Train Control (PTC) in North America, or European Rail Traffic Management System (ERTMS) are presently under development. Since this railway is new infrastructure, it has the distinct advantage of being able to in incorporate the latest proven systems technology and apply them to the design.

1.23.1.1 Traditional CTC - Wayside Based Fixed Block Signals

Fixed Block systems are a traditional method of train control which divides up the track into discrete portions (blocks) by means of connecting the track by wire to the control bungalows (buildings) which make up the wayside part of the overall control system. The system will detect if a given block is occupied by a train other equipment, or if there is a failure of the rail or switch not lined. Wayside signals traditionally are used protect the entrance to each block. The system then confirms that this occupancy is in agreement with the authorized occupancy or not and reports such to the Rail Traffic Controller (RTC) for further response.

This type of system has been in use for almost 100 years and is a very, very reliable system. The wayside signals themselves are hardwired to prevent unsafe indications should turnouts not be property lined or blocks occupied. They not only protect train movements, but also respond with stop signals in the case of loss of power or short circuits. They are designated as failsafe and will provide stop signals and in addition to electro mechanical also use reliable backup methods (traditionally with battery and even gravity and today with computer voting) to ensure they function properly. Block occupancies and key signal indications are displayed at the RTC's console. The RTC can control routing of trains at junctions by lining of switches remotely or hold trains at other key locations by wayside signal. The RTC can control each switch individually in order to route trains past each other. It verifies each instruction given by the RTC to move a switch position and is checked by computer to certify that the change of positions has been successful and is ready for the signal system to be revised to reflect the change in the switch. This system also monitors each switch and provides a separate means of checking the condition of the track network in that area.

This system is typical of what is in widespread use throughout North America (NA). The design, construction and material supply is well known and can be provided by a number of service providers. The regulatory environment in is familiar with this type of train control and their regulations are set up to approve and monitor such a system once it is in operations. Operationally it can be easily supported in the training of employees to operate, maintain and use this system.

This system relies on the competency of the RTC computer system to check and recheck prior to each new instruction being input. Once these new instructions are accepted, then it relies on the field personnel to understand and comply with the rules and operational instructions issued by the signal system and the RTC.

Cab Based Signals

Cab Based Signals (signals in the driver's locomotive cab) has traditionally been an overlay system of fixed wayside signals which repeats the indications of those wayside signals inside the cab. It was introduced where wayside vision can be restricted, such as valley areas where fog is often present and provides advance warning of the signal versus simple waiting until the signal comes into a driver's line of sight. The system also typically emits a sound in the cab if the signal indication changes. These systems rely on human response to understand the rules and to follow them correctly.

Automatic Train Stop

For a few freight railway routes in North America that were extremely busy, automatic train stops were built into the wayside signals in order to apply brakes to a train that inadvertently passed a signal that was displaying stop due to driver inattention or distraction. This technology has been in use over 70 years and while this did afford some protection, these wayside systems are rather unsophisticated, using mechanical arm to break (trip) a train's air brake line on the lead engine, thereby stopping a train by applying the brakes in emergency mode which is not a recommended technique to stop trains, especially long heavy freight trains. This technology is still found in many transit systems around the world today and works very well as an added safe guard to prevent collisions on these closed systems.

1.23.1.2 Positive Train Control (PTC)

The current technologies are rapidly changing as the latest progress in computer, data radio and satellite communications continue to evolve. The newest PTC systems under development are computer based and track train movements, authorizing not only a trains to occupy certain portions of the track, but provide overall speed requirements, track geometry and other temporary restrictions to the operator in the locomotive cab. With the size of today's freight trains, having up to date information well in advance provides not only better train handling information, but efficiencies with fuel use, less brake wear, etc.

The system also monitors the actual driver's performance and intervenes when the driver does not follow the recommended speeds and can bring the train to a safe stop using appropriate braking techniques. This type of system is also overseen by an RTC at a central location. For this railway application this would be managed from the central Operations Control Centre.

Further, this technology also has the ability to be upgraded to a moving block system which would enable greater capacity on this rail corridor in the future by allowing trains to follow each other based on their current operation, not on a set of fixed blocks.

US railways are mandated to employ PTC technology for those main tracks that handle both freight and passenger trains, under an act of Congress. The technology will likely be adopted in Canada once the systems are fully designed and tested. This railway should seize this opportunity to incorporate the latest and proven systems under the umbrella as a part of the design of the train control systems which would lower the risk inherent in any new systems development.

PTC in the US will be primarily placed on lines currently using fixed block systems and thus the PTC is being developed as an overlay system to the standard fixed block wayside signal system. Some European systems under development on the other hand do not require track circuits to detect train movement. Given:

- The advantage track circuits have in detecting rail breaks
  - Especially with heavy train consists and
  - A climate with a very wide range of temperatures stressing the rail
- The regulatory approvals are geared to North American train operations.

Therefore a PTC with fixed block circuits has been used as the start point for the conceptual design for this project pending detailed evaluation.

1.23.2 Yard Control Systems

A Yard Controller will be responsible for the train authorities to move about the yard and protect against other track movements. Given the time sensitive nature of the bitumen movements from the loading site to the unloading site, the yard controller at each end of the railway will play a very important role in the expeditious handling of each train. The yard control operations will use separate radio channels for various needs such as train activity, wayside staff and train load or unload operations staff. More detail on these operations is found in the Loading and Unloading of Trains sections (above).

For the major yard track network proposed at Fort McMurray and Delta Junction, each location will be connected to the mainline and will provide traffic control movement into the yard and through the load or unload facilities. In addition there will be some auxiliary trackage which will require access to from time to time for service and track maintenance equipment along with car and locomotive maintenance and repair requirements. All of these tracks will be under management of the yard controller, who will control and operate the switches leading into and out of these areas. These switches can be controlled by power for key routes or manually for less used routes. For example, switches which are part of the key loading and unloading of bitumen or the trip service tracks will be power operated.

1.23.2.1 Yard Control Design

For each terminal, there will need to be a set of operating rules governing the movement of trains through the Yard under direction of a Yard Coordinator (YC) managing these movements. These operating rules will set out the plan for how a train is moved between the line and the load/unload facility and what activates will be undertaken between these two end points on this trip. In addition the rules will cover all other possibilities for the standard yard activities.

Each track will be designated and some switches will be controlled by the YC while others will be manually controlled. All train movements within the Yard will be at slow speed and under the direction of the YC. The Yard Control system will be linked to the load/unload operators and systems where required. Steady communications between the YC and the load/unload operators will implement the plan for how trains move between the Yard and the load/unload facility.

The Yard Control System will require a radio system to communicate with the train operator, the ground crew for operations, equipment inspection, the load/unload operator, any power switches and other needs. This radio system will be of the same design as the line system, but the yard Operations will work on a separate frequency so there are not conflicts in communications.

1.23.3 Level Crossing Systems

These are overlay systems installed at each road crossing at grade with a railway and which can be integrated with the signal system as required. National railway regulators issue rules surrounding what level of road crossing railway warning system is required at each road crossing. This can graduate from a passive crossing warning sign to an integrated set of lights, gates and bells warning system. While there are not a multitude of crossings found on this remote route, nevertheless each road crossing will have an assessment done of the interactions between the number of trains and the number of roads expected at this crossing. This assessment will determine the level of crossing protection which is required. This assessment will be reviewed with the road authority for each road and submitted to the regulator for their review and information.

1.23.4 Train Safety Monitoring Systems

In this area there will be the need to provide both the rail network as well as the trains that operate over it, different safety monitoring systems which will warn of any pending failures so that the appropriate actions can be taken to mitigate before they become a safety issue. There are a number of these systems which can be employed for this purpose and they generally apply to the operations, equipment, rail corridor roadbed and road/rail interface areas. Some of these are outlined below. This is not meant to be an exhaustive list, but indicative for cost purposes at this conceptual level for the type of equipment that should be designed into the railway systems at the outset.

Table 28 Safety Appliances

Safety System	Frequency	Spacing	Type of Inspection
Wayside Inspection Systems (WIS)			
Hot Box Detector(HBD)	Continuous	25 km	Axle Bearing Health
Dragging Equipment Detector	Continuous	25 km	Under car equipment
Track Inspection	Every 2 days	2 days	Visual inspection of Track & Roadway conditions
Wheel Impact Load Detection (WILD)	Continuous	Terminus	Wheel condition
Signal System Continuity	Continuous	NA	Functionality of whole system
Switch Position	Continuous	NA	Confirmation of Switch position & continuity
Rail Break Detection	Continuous	NA	Electronic detection of rail continuity
Falling Rock Detection	Continuous	As required	Detect falling rock on track
Network Management System	Continuous	24/7	Detect health of signals/fiber/radio
Equipment Inspection	Train arrival	Each Terminus	Visual inspection of rail equipment
Various System Inspection and Maintenance	As Regulated	As Required	Test & Examine the system and record results/make corrections
On Board Systems			
Air Brake monitoring Electro Pneumatic Control (ECS)	Continuous	Each car/train	Detect changes in air brake pressure, individual car brake functions, (including air pressure at end of train)
Engine Health	Continuous	Each loco/train	Monitor and report health of engines
Car Axle Health	Continuous	Each car/train	Monitor and report health of car axles
Tank Car Mounted track inspection	Continuous	Two car sets	Monitor condition of track continually for any deterioration or change

Safety Monitoring Systems will consist primarily of Hot box/Dragging Equipment Detectors (HBD), Wheel Impact load Detectors (WILD), track inspection twice a week over the line. Track inspections will be supplemented by track detection tied to train control systems to make sure any rail breaks are detected. This would include use of Track geometry cars and Rail sonic testing cars on a regular basis. Such equipment may be mounted on modified tank cars or locomotives for use in regular revenue service for virtually non-stop testing of rail and roadbed.

The locomotives will also have health monitoring equipment onboard which can be supplemented to detect various car issues such as wheel hunting, hot bearings among others. The load out rail terminal will be the location for increased detections such as scanning of all running elements on the rolling stock and specific car visual tests making certain that these cars and engines do not require additional maintenance beyond the normal prescribed intervals. In this way, with greater car inspections in the terminals and action taken before trains are loaded and sent on line, delays to trains over the road should not be impacted by any equipment failure.

All in all the safety systems that are available can be configured in the right combinations to provide for a high level of confidents that the trains can make their trip times from load to unload sites within the time limit set for this winter and summer. Note that these safety systems support and form part of the maintenance and care of both rolling stock, controls systems and track. Further descriptions of maintenance are found below in their own sections.

1.23.5 Power Supply Systems

The operations of these train control systems and their supporting communications equipment require power to enable their operations. For a new railway in this remote territory there are two manners in which this can be provided. One system would be through local power generating equipment set up at each location where power is required. This system would require the use of generators, a fueling system and the ongoing maintenance of this equipment on site.

The alternative would be to supply a power cable the length of the corridor which is powered by any grid connections it crosses, or generators at regular intervals along the rail corridors. This system would provide power at each location required and need maintenance and fueling as well.

With the need for power supply from generators, there is a need for fuel delivery to these sites. A system of road or rail supply of fuel will need to be set up to service the fuel consumption of these generators. For remote sites this will have to be by supply train (as outlined earlier) or use of hi-rail propane trucks which refill smaller local tanks enroute. Similarly for track maintenance, there will need to be a plan for how to provide the regular as well as emergency maintenance for these generators on an ongoing basis. These generators will be the back bone of the radio and signal control system. Power to these areas will need to be continuous over the full time of train operations.

1.23.5.1 Power and Safety Monitoring Systems

Power Service to both the line and yard sites will be required. All main bungalows, automatic switches, radio tower sites, Safety detection systems, wayside buildings, crew change buildings, fix block locations, yards and siding locations etc. Where available Grid power should be developed and provided to as many locations as possible. With grid power feeds, power will be extended along the rail corridor to service as many sites as possible. Considerations will be given to the need for backup generators to supplement this service. Where power cannot be provided from the grid, generators will need to be set to feed the power needs in the area. This will create the need for supply of fuel and maintenance of these sites. The 2 main terminus locations and their many power needs will need to be served from the grid.

1.23.5.2 Communications Systems

Key to all of these systems is reliable two way communications. A communications system is needed to support each of the Train Control systems in various ways. For the CTC system, communications is used in two ways; one is to transmit data between the RTC/Signals/Switch controls to manage the signal system and authorize the movement of trains over the corridor as well as detect train position and movement. Second, it is the means of voice communications between the train crew, wayside maintenance employees and the RTC. This communication supports train movements and the wayside maintenance employees undertaking their jobs to inspect and maintain the rail corridor and its various systems.

There are a number of communication systems available for this purpose. For the CTC system this is generally provided through an industry proven set of radios and radio towers communicating over the rail corridor. For advanced PTC, communications will require not only the same radios and tower provision that the CTC system will need, but it will also require intermediate towers and continuous data stream connection between the RTCC computers and the locomotive's on board computers. Between these central and onboard computers, the train's authority to occupy any portion of the rail corridor track will be transmitted and confirmed. As such the communications must be continuous and have redundancy. The requirements for this level of communication of data is significant and must meet stringent requirements because it is now carrying the responsibility of maintaining the train authority to exclusively possess a section of the track which no other occupant can possess without proper authority provided. This requires the constant connection between the computers issuing the authority and the train operator.

1.23.5.3 Radio Network

The radio network would be set up to cover the complete length of the rail corridor for data and voice. Voice service would be required for all trains on line along with any authorized wayside personnel who would have need to work on the Right Of Way (ROW), operator on track, or work on track which would disable the track or signal systems for any period of time. Each switch and each end of Block location will be fitted with radio communications or fiber communication to a radio tower. This is the means for the RTC to control the train movements and set the switches according to the plan for train service past that point. Each switch can be requested to be positioned in the normal (strain through) position or the Divergent position. Each position of the switch changes the speed for the train through this site and this information along with the confirmations that the switch has been positioned as requested is sent to the ROCC and the RTC and the ROCC provides that information to the Train onboard computer which displays this information to the operator for them to adjust their operation of the train accordingly.

It is recommended that a type of radio system be installed similar to the following:

- A dedicated TETRA data radio system for ETCS Level 2 communications
- Nearly continuous data radio coverage in open areas and tunnels
- One radio site at each passing loop, Rail Head Yard, Mid-section site

1.23.5.4 Fibre Optic Cable

Fibre optic cable as well as radio coverage will provide the necessary robustness to provide not only high data transmission reliability but contact with all railway personal on moving equipment.

The rail communications system should consider the following features:

- 96 core single mode optical fibre cable that will interconnect all rail sites from Railhead yard to Delta Junction
- A number of dark fibres in the common cable to be allocated for vital signaling communications, other fibre bundles allocated for Loading and Unloading yard users

- OCC based dedicated Network Management System for rail fibre transmission
- Shared equipment rooms, radio towers and off-grid power supply packages with project-wide communications systems and services.

In addition, back up communication such as microwave line of sight links should be considered as well to provide back-up for rail critical services and circuits. This can use both radio towers as well as additional hill top sites depending upon the terrain.

1.23.6 Determining the Appropriate Train Control Systems

As stated earlier, whichever system is chosen, regulatory approval for these systems will need to be reviewed closely with the USA and Canadian regulators and develop what is required for this approval both in the testing and proofing of these systems and the operational use over time.

There are a range of studies that need to be undertaken to design the most suitable train control systems for this application, balancing reliability with the best functionality to provide the safest railway. Some of these are:

- Radio systems evaluations study
  - Evaluate available system for voice and data
  - Evaluate security of radio systems
  - Evaluate level of integrity of systems
  - Evaluate ability of continuous communications of system on this route.
- Prelim Radio Architecture
  - Train to wayside voice
  - Train control between train and ROCC
  - Voice communications along line
  - Voice train to RTC
- Radio system location study
- Regulatory requirements evaluation
  - FRA
  - TC
- Power system requirements
  - Identify Power usage locations and amount
  - Locate power feeds from Grid
  - Locate power service needs supplied by generator
- Prelim Power system Architecture
- Yard Signal system requirements
  - Number of switches controlled and how
  - Radio requirements
  - Yard control system type required
- Prelim Yard System Architecture
- Computer control system requirements
  - Identify operational ROCC and On-board computer needs
  - Other computer needs
- Preliminary Fibre optic system architecture
  - Identify fibre drop requirements
  - Identify fibre equipment needs
- Preliminary safety monitoring systems layout
- Preliminary NMC system requirements
  - Determine fibre, power, signal and radio requirements

- Determine computer and reporting system requirements
- Preliminary Signal system requirements
  - Number of switches and locations
  - Number of Blocks required
  - Interface with computer control system

1.24 Signals and Communication Maintenance (S&C)

The Alberta to Alaska Railway will require a signals and communication (S&C) system for the effective management of train operations. This section describes the maintenance associated with these systems.

An acceptable S&C maintenance strategy should include:

- Breakdown maintenance
- Limited preventative maintenance using a small group of technicians and support staff.

The following is assumed for the S&C system:

- Modern Signal control system
- Minimal bonding will be required
- All mainline turnouts will be power operated
- All communication systems will be modular
- All power systems will be supported by fuel supply as required.

1.24.1 Communications Network Management System

Maintenance and repair of the signal, fiber optic and radio system is fundamental to the operation of the signal system and its need to be fail safe at all times. A Network management system is required to detect system faults and failures and provide a 24/7 response to these matters. These reports of problems may be operational or equipment related, but in all cases the train movement will be controlled to the level of protection the rules require until the failure is understood and corrected. By this means the signal, fiber optic and radio system must provide a level of safety protection by switching to a failsafe mode until the problem is understood and corrected. The 24/7 monitoring and response provides the train system with early warnings and protection against possible danger and an early response to the issue at hand. This will be coordinated through the Operations Control Centre.

Both minor and major S&C maintenance will need to be appropriately planned and implemented in order to minimize the impact on train operations. Minor maintenance should be planned on the basis of train schedules, and conducted at a particular location when the track is free of traffic. Major maintenance requiring an extended work block, or shutdown, should be coordinated with other maintenance activities to minimize overall track outages.

Most of the signaling and field equipment for the S&C system should be of a modular design. Faulty equipment can then be replaced on a change-out basis and sent for repair. Once the railway is in operation an Asset Management System (AMS) should be used to manage equipment and inventory requirements.

1.24.1.1 Signal Inspections

The signals and communication group and the power group are required to follow a required procedure of testing and maintaining of their equipment so that no outage and therefore delays to train service develops. As such they are done on a series of periodic cycles as part of a preventive or planned maintenance approach. The results and data gathered during the track inspections determination the type, location, frequency and urgency of maintenance works to performed on the line.

1.24.1.2 Location of S&C Maintenance Crews

The S&C maintenance crews will be located at the same location as the track maintenance crews. In this way they can support each other's work and consolidate on housing and storage needs.

Locating crews in this manner will enable them to productively manage and respond to the maintenance requirements of the S&C system of the railway from the Loading Yard to the Unloading Yard. Throughout the railway network, much of the S&C maintenance activities will likely occur at siding turnouts and communication towers.

1.24.1.3 S&C Maintenance Crew Size

Each S&C maintenance crew should consist of three (3) individuals to provide preventative maintenance and fault rectification. These teams should be multi-skilled and consist of the following positions:

Foreman: Lead crew through daily activities. Responsible for performing a pre-job briefing, arranging for track protection and ensuring the quality of work.

Maintainer: Assist foreman and deal with any maintenance issues.

Technician: Maintain and service communication infrastructure.

Equipment for each crew:

- 1 signal maintenance truck hi-rail with crane
- 1 Crew Cab hi-rail

All S&C maintenance crews should report to a Signals Supervisor who should be responsible for the entire railway network.

A Communications Supervisor should be responsible for the communications infrastructure and should manage technicians located at the Rail Traffic Control Centre and at each intermediate section of the railway. IT specialists are to maintain the railway computer system and servers.

Both supervisory positions should report to an S&C Manager. The S&C Manager should also manage the power generation systems utilized at the section camps. The following figure shows an organizational chart including supervision and labor:

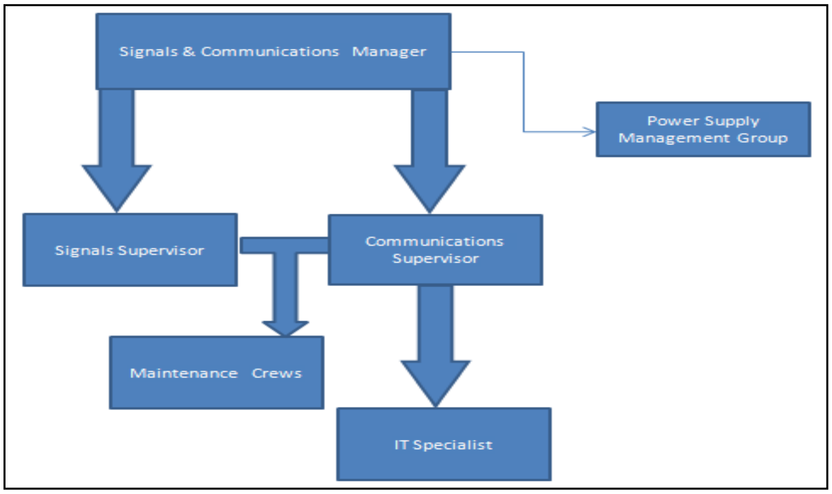


Figure 26 Signal & Communication Maintenance Organizational Chart

Given the small number of personnel envisioned for the S&C maintenance function, work flexibility is expected to be limited. Nonetheless the tasks these crews will be required to undertake can be accomplished if carefully managed. Special attention to the allocation of personnel will be required during absences, illness or vacation.

Other individuals that will be required periodically to support multiple S&C crews include:

Boom Truck Operator: Distribute material and cleanup scrap.

Signal Mechanics: Repair defective equipment. These mechanics will be located at the load/ Unload Yards.

1.25 Track Maintenance

The Alberta to Alaska Railway will be a purpose build railway designed to haul bitumen from the oil sands region near Fort McMurray to the Trans-Alaska Pipeline at Delta Junction for eventual loading to tanker ships at the deep water port of Valdez. Once this railway has been constructed and commissioned into operation, an important focus of managing the railway over time will be the ongoing maintenance of its infrastructure.

The railway length between the Fort McMurray Loading yard and the Delta Junction unloading yards is approximately 2,400 km. Due to the length of the railway and harsh winter climate, in order to facilitate this operation maintenance crew centers and associated facilities will be required along the length of the line. It is presently envisioned that major maintenance facilities will be located at terminus yards of Fort McMurray and Delta Junction, with eight (8) online maintenance facilities established. This level of maintenance locations puts these groups close to the track throughout the railway and enables more direct maintenance and inspection on the whole railway.

The following Infrastructure Maintenance Plan (IMP) outlines the maintenance strategy proposed for the Alberta to Alaska Railway to ensure safe and reliable train service over the duration of its expected life. The IMP presented in this document is based on current North American maintenance standards.

An acceptable strategy based on current practices and standards suggests an IMP should be organized into the following four (4) railway infrastructure maintenance categories:

- Track
- Signals and Communication
- Bridges, Structures and Tunnels
- Emergency Response

To determine a feasible approach for an IMP for the Alberta to Alaska Railway, this report presents important assumptions, exclusions, inclusions and principles. Two (2) alternatives for maintenance facilities are also developed and evaluated on the basis of the requirements of the railway. And where appropriate, estimates for each of the four (4) IMP categories:

- Staffing requirements
- Equipment lists for:
  - Day to day maintenance
  - Capital renewal maintenance
- The location of facilities
- Quantities of materials required
- Required maintenance blocks which will:
  - Minimize impacts on the train service.
  - Utilize shutdowns at the loading and unloading locations

1.25.1 Track Maintenance Strategy

Current North American and international maintenance standards and regulations were investigated to develop a railway maintenance strategy. The resources consulted included:

- Guideline To Best Practices For Heavy Haul Railway Operations, Infrastructure Construction and Maintenance Issues, International Heavy Haul Association, June 2009,
- American Railway Engineering and Maintenance-of-Way Association, 2010

These resources were used to evaluate and address the workload over time for railway infrastructure maintenance.

An illustration of various relationships of workload over time is shown in the following figure:

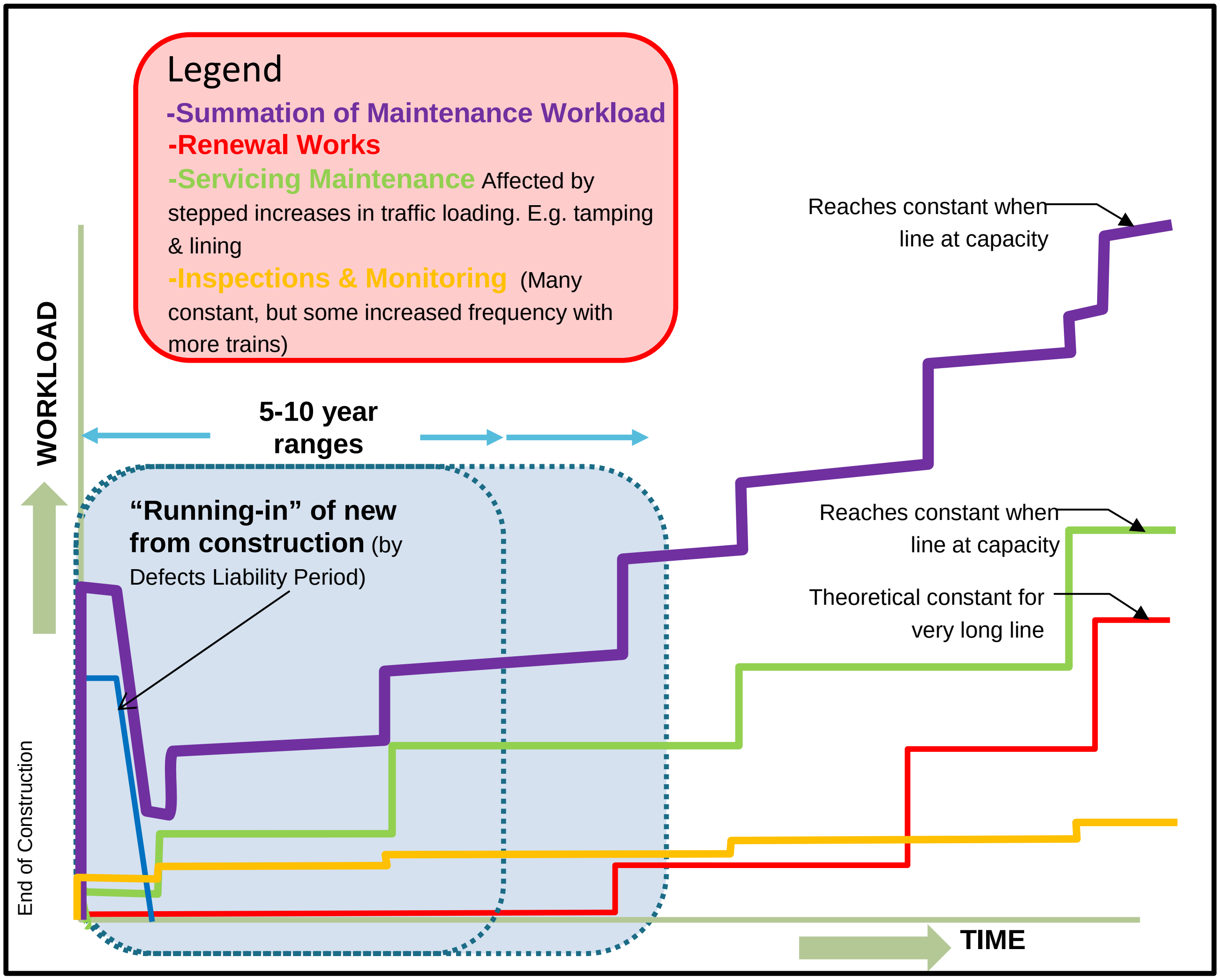


Figure 27 Railway Maintenance/Workload vs. Time

Figure 27 outlines how following the construction of a major new railway there will be a "running in" period. This period will deal with any irregular defects due to sub-par manufacturing and construction that would not be realised during normal QA/QC procedures. With the adjustments of these irregular defects infrastructure maintenance becomes more predictable and regular after 5 to 10 years. Irregular defects become minimal and maintenance requirements increase as annual tonnage increases.

Once the railway tonnage levels off, maintenance reaches a theoretical constant which can be managed with sufficient deficiency testing and preventative maintenance management. One of the challenges will be to manage railway assets which have been put in service at the same time and therefore deteriorate at a fairly equal rate. The proactive planning to widen the window of replacement of these assets, to ensure a reasonable workload each year is covered below in Section 1.26 Capital Renewal Program Maintenance.

It is anticipated that the Alberta to Alaska Railway will follow this infrastructure maintenance workload profile over time. As a consequence an acceptable IMP strategy should include:

- Regular inspection
- Constant monitoring of asset utilization & defect detection reports to amend maintenance procedures
- Preventative maintenance
- Minimal response time to reduce train delays.

1.25.2 Track Maintenance and Operations Centre Coordination

While there is road access to approximately 50% of the proposed route, nevertheless a significant amount of work will be carried out using the railway as the access point to the work site. Therefore providing track and work time to crews in an organized and planned manner is essential if the railway is to deliver the demand tonnage.

Therefore all infrastructure maintenance would be coordinated through the Operations Control Centre at the railhead yard. This would ensures the best overall planning for moving the bitumen as required, providing the time to do the necessary work while resulting in minimal impact to rail services.

1.26 IMP Report Assumptions / Exclusions / Inclusions / Principles

Before the tactical requirements of an IMP can be developed in a manner consistent with the selected infrastructure maintenance strategies, it is first necessary to identify the critical assumptions, exclusions, inclusions and principles that are material to this exercise. These considerations are listed below:

1.26.1 Assumptions

- The route from loading to unloading facilities will be approximately 2,400 km
- The railway's mainline will be constructed on concrete ties
- Rail corridor maintenance headquarters spaced approximately every 290 km with their territory extending on average 185 km.
- There shall be sufficient sidings to efficiently run trains and allow for minimum required work blocks
- Annual tonnage will be 125 Million Gross Tonnes (MGT) for 1.0 mbpd barrels & 175 MGT for 1.5 mbpd barrels
- Maintenance of all aspects of the railway will be done via on-track travel
- Shifts will be 10 hours a day with 20 hour of light available in summer months
- Every passing siding shall have a backtrack with turnouts at either end to be used by maintenance groups and for setting off bad-ordered cars.
- The train control system will utilise track circuits
- 17 trains in a 24 hour period

1.26.2 Exclusions

- Loading and Unloading facilities
- Railway building facility maintenance
- Rolling stock & locomotive maintenance
- Any third party facilities.

1.26.3 Inclusions

- Railway infrastructure between the loading and unloading facilities
- The regular day-to-day and annual capital renewal program maintenance of:
  - Track
  - Signals and communication
  - Power service
  - Bridges, structures and tunnels
  - Emergency response.

1.26.4 Principles

- Safety above all else
- Minimize delays to trains
- Maintain maximum allowable track speeds
- Quality over quantity.

It is important to note the development of an IMP is critically dependent on the items listed above, which is based on the detailed design plan of how the Alberta to Alaska Railway is constructed and operated. As the detailed design is progressed the assumptions and principles will need to be reviewed and updated for compatibility with any design changes.

1.27 Maintenance Facilities & General Crew Requirements

From loading to unloading, the Alberta to Alaska Railway will run a distance of over 2,400 km through terrain that will be difficult to access. Maintenance Crew Centers will be needed to support the various infrastructure maintenance activities that will be required by the railway over time. These crew centers are where maintenance personnel, equipment and much of the materials will need to be stationed. The location of these crew centers will have a significant impact on maintenance productivity and responsiveness.

Locating the maintenance facilities only at the Loading and Unloading Yards would result in each facility being required to maintain about 1,200 km. This distance is far too great for effective maintenance and response. The preferred distribution of maintenance facilities would be to have two (2) principle Maintenance site, located at each terminus and provide for eight (8) facilities on line for supporting 10 maintenance crews. This would enable each crew to be responsible for approximately 185 km of territory. The impact on productivity and responsiveness (e.g., travel time) for varying spacing is shown in the following table:

Table 29 Facility Spacing Options

185 km Facility Spacing		
Work Day Length (Hours)	10.0	20 hours of daylight in summer provide potential for 2 shifts
Average Return Travel Distance (km)	92.5	
Travel Speed (km/h)	40.0	
Train Spacing (Hours)	1.0	
Return Travel Time (Hours)	2.3	
Average Time to Clear Train (Hours)	0.5	Based on 20 km spacing of clearing points for On-Track equipment
Delay per Train Due to Virtual Train Occupation (Hours)	0.3	Includes time cleared ahead of train, actual train occupation, and delay obtaining permission to return to work after a train has left
Total Time Lost to Meet Train (Hours)	0.8	
Trains Met per Day while Traveling	3.6	
Total Travel Time (Hours)	5.1	
Trains Cleared While Working	3.3	
Delay While Working (Hours)	1.1	
Productive Time per Day (Hours)	3.8	Traveling and Train Clearing time are considered non-productive
Productivity	38%	

Where crew territories are greater than 185 km then it is anticipated that significant challenges will be encountered to perform work near the midpoint between maintenance facilities. The preceding table demonstrates that the 185 km spacing only allows for 38% worker productivity and greatly reduces the ability to conduct such work within the allotted work day. As train volumes increase, this number will drop significantly. More facilities will need to be added in areas of high traffic or frequent maintenance. Based on these concerns, several permanent work locations for infrastructure maintenance should be considered, including:

- Principle maintenance facility yard sites located at Fort McMurray and Delta Junction
- Secondary maintenance facilities located at Fort Nelson and Kirkman Creek
- On-line Maintenance crew facilities located at railway sidings (Hotel, Mike, Easy, New York, Williams and Quincy

This configuration would permit crew locations would be distributed over the railway and would result in the 10 maintenance crews distributed across the network with each crew being responsible for approximately 185 km of the rail corridor. These facilities will be fully utilized by all infrastructure maintenance crews year round for regular day-to-day maintenance activities. To minimize facility costs, construction camps can be used for large periodic capital renewal programs. The following figure shows the approximate locations of these facilities and their geographical coverage.

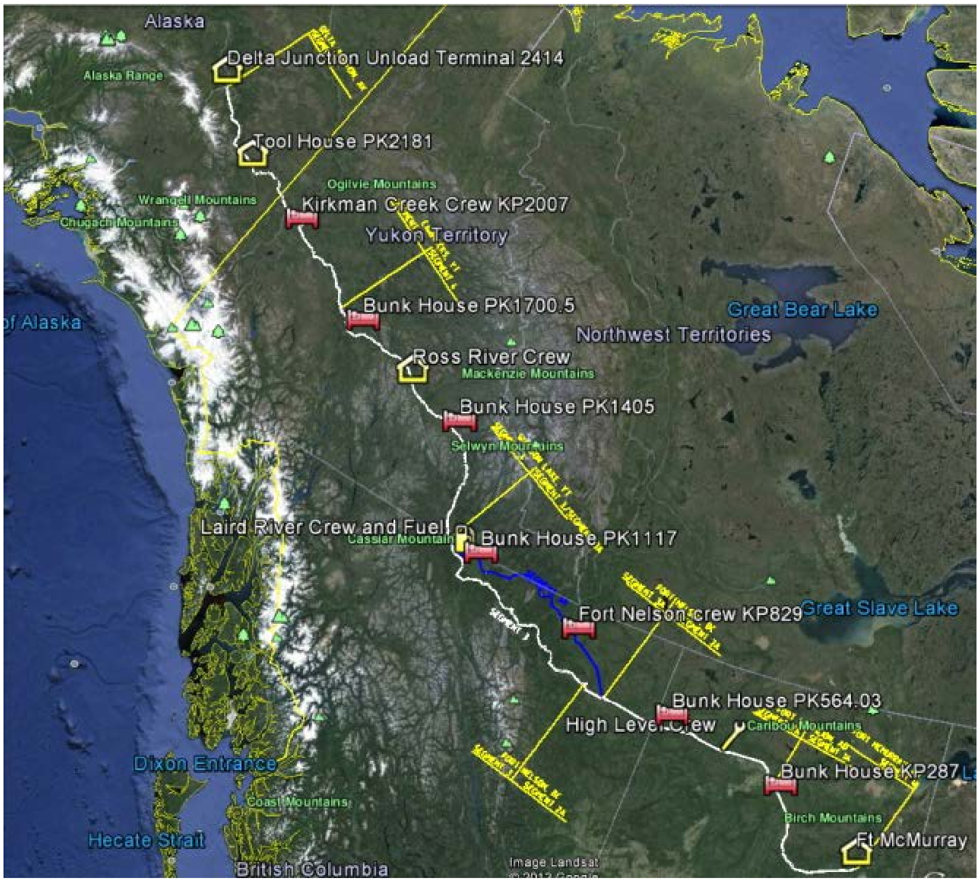


Figure 28 Railway Maintenance Facility Locations

Spacing of the maintenance facilities will result in the following eight locations:

Table 30 Resulting Maintenance Facility Locations

Maintenance Facilities	km
Fort McMurray	0
Hotel Siding Bunk House	287
Mike Siding Bunk House	564
Fort Nelson (2 Crews) (also a train crew home station)	829
Easy Siding Bunk House	1,117
New York Siding Bunk House (2 Crews)	1405
Williams Siding Bunk House (2 Crews)	1,700
Kirkman Creek (also a train crew away station)	2,007
Quincy Siding Bunk House	2,181
Delta Junction	2,400

1.28 Loading and Unloading Yards Maintenance Crews

The Loading Yard is proposed to be at Fort McMurray is where the main maintenance facilities will be located for all maintenance forces. This will consist of offices, the main receiving and shipping stores facility for materials and equipment, as well as work equipment and signals maintenance shop as well as a rail welding shop. The principal maintenance facilities located at Fort McMurray will be responsible for supplying the smaller online maintenance storage sites located at the Maintenance Crew Centers.

It is anticipated that the office at this location will also house the operations management staff for the railway. Consequently the management staff for the maintenance functions can work with the operations staff to plan, coordinate and manage the required maintenance work blocks around the operations of trains.

A storage facility or Stores building will consist of an indoor location for weather effected supplies and small items and an adjacent out door secure facility primarily to store rail, ties and all other non-weather dependant items. This site will be services by rail and road so that materials can be received at this facility then redistributed out over the railway as required.

The equipment and signals shop will maintain and repair all of the track maintenance equipment and be used for the storage of equipment that is not in use as well as provide signals with a light repair shop for their electronic equipment. This whole complex will be serviced by sidings to receive and ship materials by rail along with on track machinery access to the shop area.

This terminus will also provide all rail for the maintenance of the railway. A Rail Welding Shop will be set up to manage the supply of rail for each tears maintenance program. This will be manned all year with a crew of track personnel responsible for this welding plant.

The following personnel will be expected to be dispatched from this location:

Loading Facilities

- Regular day-to-day maintenance
  - One (1) Track crew for yard protection
  - One (1) Track crew for line work

  - One (1) Welding crew for welding shop
  - One (1) Signal & Communications maintenance crew for yard protection
  - One (1) Signal & Communications crew for line work
  - One (1) Bridges & Structures crew

These crews will typically begin and end their shift at the Loading Yard.

The Unloading Yard at Delta Junction will require a smaller version of these facilities to support the online work as well as the yard maintenance requirements.

The following personnel will be expected to be dispatched from this location:

Unloading Facilities

- Regular day-to-day maintenance
  - One (1) Track crew for yard protection
  - One (1) Track crew for line work
  - One (1) Signal & Communications maintenance crew for yard protection
  - One (1) Signal & Communications crew for line work
  - One (1) Bridges & Structures crew

1.29 On Line Maintenance

Facilities for the online Crew Centers are expected to be significantly smaller than those at the Load and Unload yards. However these facilities will be considered multi-use facilities and serve as storage facilities for track and signal material as well as have the capacity to do some minor equipment maintenance. There will be two larger centers at Fort Nelson and Fort William which will act as online distribution centers in support of the material distribution requirements to the various line points.

For each of the line point Crew Centers the following basic personnel will be expected to be dispatched from these locations:

- Regular day-to-day maintenance
  - One (1) Track crew
  - One (1) Signal & Communications maintenance crew

These crews will typically begin and end their shifts at their respective facilities. The track crew may be split into two groups from time to time as required to handle various efforts. The Signals group will support the signals, communication and power every day needs.

However the bridges and structures teams will be located out of the two terminuses and will work cycles where they will go online and stay at various sites along the line to undertake their maintenance and inspection duties. For the three (3) online sites where two (2) sets of crews are located, the number of personnel would be double.

1.30 Inspections

During the first few years after the railway is in operation, major flaws or defects with any of the infrastructure are expected to be unlikely. However, qualified inspectors for track, signals, power, communications, bridges & structures should be retained to follow the required inspection schedules and help develop the plan for maintenance and plant renewal. These people will also be available to provide training to new employees.

1.30.1 Track Inspection

Track Maintenance begins with the need and regulatory requirement to visually inspect the track on a frequent basis. From each of the maintenance locations, inspectors will travel over the track on the frequency defined by the regulator, usually every second day, and record the condition of the track structure. This is the primary safety feature and data gathering of Track maintenance. It is from this effort and the addition of other technological testing such as rail flaw detection or ride quality detection and others which set in motion the determination of what maintenance is required and where and with what urgency.

In addition to the physical characteristics of the railway, the management of track maintenance will also be a function of:

- What work each crew will perform
- How often this work will need to be done
- The location of high maintenance areas.

Identifying the type, frequency and intensity of the work that will need to be done will ensure personnel requirements are properly defined. In general, track maintenance will consist of regular day-to-day maintenance activities and the rehabilitation of infrastructure through periodic capital renewal programs. Crossings, turnouts, curves and areas of heavy breaking will require the most attention. It is also important to understand the effects of the climate in which the railway will operate. The Alberta to Alaska Railway will span a large section of northern Canada and Alaska. The railway will be subjected to four seasons with large temperature swings and in particular extreme cold. The winter season extends from November to April where average temperature will be between -10 °C to -30 °C with extreme cold as low as -60 °C. This is contrasted by the summer season from May to August where 0 °C to 30 °C can be regularly encountered.

Visual track inspections are the most frequent and represent the principal inspection works. From each of the maintenance locations, inspectors will travel over the track, typically every second day but dependent on the class of track and tonnage being carried, and record the condition of the track infrastructure. This is the primary safety feature and data gathering of track maintenance. Special track inspections are required following a flood, fire or severe storm prior to the passage of any trains to ensure that no major damage has occurred to the rail infrastructure and to ensure the safe passage of trains.

Visual inspections are accompanied by more detailed inspections including an annual walking track inspection for concrete tie tracks with a curvature of 4 degrees or greater. Supplemental track inspections are necessary in order to identify defects not easily identified or impossible to identify by a track inspector. These come in the form of an electronic track inspection using a heavy geometry car as well as an ultrasonic rail flaw inspection which are both performed twice annually according to FRA regulations. It is assumed that the electronic and ultrasonic inspections will be performed by an external firm and no staffing requirements have been forecasted.

In addition, the signals and communication group or the power group are required to follow a required procedure of testing and maintaining of their equipment so that no outage and therefore delays to train service develops. Similarly the bridge & structures group will need to follow regular inspections and identify the maintenance work required for the various structures and culverts. These are covered further below in separate sections.

1.30.2 Automated Rail Inspection

One approach the railway may wish to employ for constant monitoring of track geometry and rail inspection is through the application of instrumentation attached to one of the tank cars. This not only permits a complete record of track every 100 hours, it does not consume track capacity with additional trains. This data can be stored and compared after each trip to provide a complete record to not only detect any signs of deterioration but indicate wear trends as well. Such instrumentation is invaluable in providing data for track maintenance.

1.31 Warm Weather Maintenance

The following is a list of activities each track crew will be responsible to perform over their territory. These activities will not necessarily occur each day, however they will be performed on a regular basis and as determined by the track supervisor:

- Rail Lubrication, grinding and maintenance of turnouts and components
- Ultrasonic and laser testing of rail for defects and wear
- Removal of temporary speed restrictions due to track defects
- Housekeeping of maintenance facilities and material stockpiles
- Field flash butt welding
- Plant flash butt welding
- Ditch cleaning
- Vegetation control
- Crossing maintenance
- Rail grinding
- Spot de-stressing
- Spot tie renewal
- Spot surfacing
- Bog hole repairs
- Material distribution
- Short rail installation
- Track inspection
- Rail support items such as Pads, clips and insulator replacement
- Emergency response.

A summary of general track maintenance activities are shown in the figure that follows:

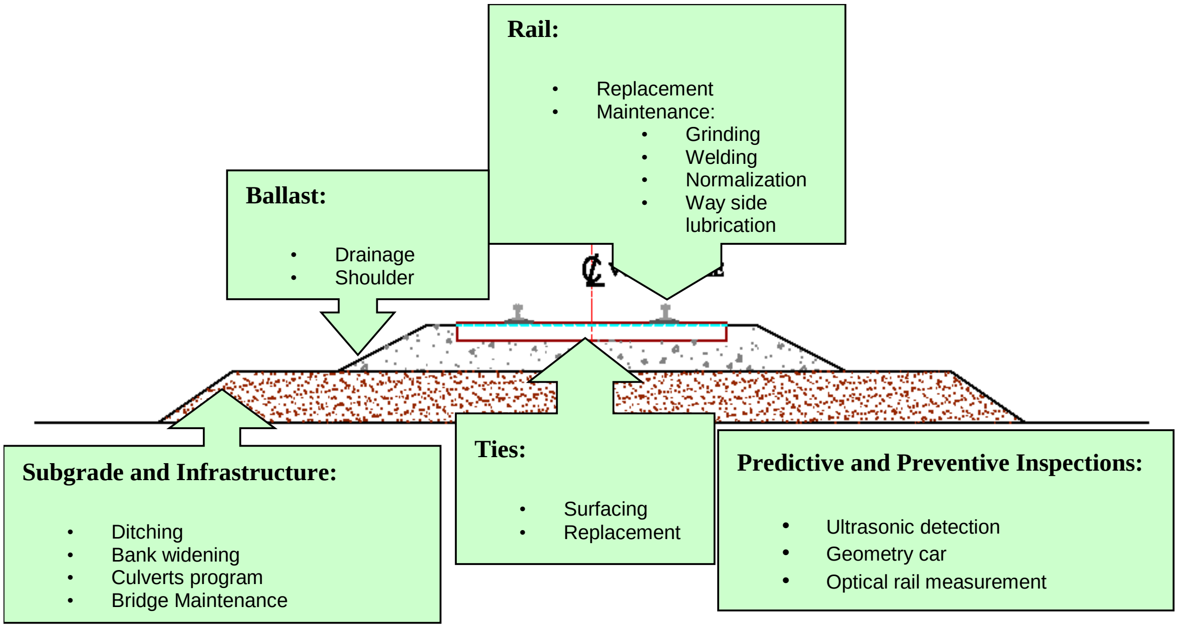


Figure 29 Track Maintenance Activities

1.32 Cold Weather Maintenance

Some of the warm weather maintenance activities will continue to be performed throughout the cold weather maintenance program. Cold weather maintenance includes the standard cold weather works as well as the works associated with the transitional temperatures and the effects of the freeze-thaw cycle. During the cold weather months, the track infrastructure will be frozen and many of the tasks required under warm weather operations will no longer be necessary. The reduction in standard maintenance works will not result in a reduction in maintenance time and costs as it will be replaced by cold weather specific tasks as well as by the additional time required to perform standard tasks in cold weather. The maintenance crews will transition to Cold weather maintenance works in order to ensure continual operations.

Cold weather maintenance activities will not necessarily occur each day, however they will be performed on a regular basis and as determined by the track supervisor.

- Snow clearing online and at switches
- De-icing at switches
- Rail break Repairs/Replacement
- Snow and land slides
- Track shimming
- Flooding inspection and protection

1.32.1 Snow Clearing

The majority of the maintenance works during the cold months will be directed towards snow clearing. Snow accumulates as direct precipitation but will also accumulate as snow drifts and drawn in by train movement. While seasonal totals are not large, snow and ice can disrupt normal train operations.

Based on the proposed number of train movements and average speed, general snow clearing along the right of way for drifts between siding locations should not be required. However snow clearing will need to be performed at many levels and at many locations by a large workforce. Manual snow clearing is performed using brooms, shovels, salt and portable heaters for precise work near turnouts, structures, tunnels or confined locations.

Mechanised equipment consisting of on track brooms, plows, snow blowers and dump trucks will clear and remove snow from general areas. Track snow clearing will be performed with a track mounted snow plow typically in the form of a modified ballast regulator. In addition this will be supported by the use of a Snow spreader, used to push back the drifts and make room for the next snowfall or allow for train crews to work alongside a train that has been stopped for inspection of a railcar from a WIS or onboard alarm.

Cold air blowers will be installed along the line where turnouts are positioned. This equipment must be inspected, maintained and refuelled to ensure reliable usage when needed. For major snow accumulation based on hard to plow areas such as deep cuts, a snow plow or rotary cleaner will be kept at hand. A large track plow or rotary blower will be dispatched when large accumulations of snow exceed the ability of smaller equipment.

1.32.2 Rail Breaks

Due to the extreme cold that the line will operate through and the very high variance in seasonal temperatures there rail breaks may occur. When the rail is subjected to temperatures of -20 °C or less, the steel transitions from a ductile to brittle state increasing the possibility of a break occurring. The ability to provide the tools, equipment and manpower to handle these in winter is an important element in the IMP.

1.33 Track Maintenance Crew Sizes

Each maintenance crew should consist of ten (10) individuals plus one (1) inspector with the following responsibilities:

Inspector: Travel over the territory and inspect the whole right of way. Make notes of items to be repaired, grade these items and advise the foreman and supervisor of what is found for repair.

Foreman: Lead crew through daily activities. Responsible for performing the pre-job briefing, arranging for track protection and ensuring the quality of work.

Assistant Foreman: Assist foreman. In the absence of the foreman perform the foreman’s duties.

Permanent Machine Operator (PMO) (2): Operate equipment necessary to complete work. Be trained to perform minor mechanical maintenance on machinery and equipment. When not operating equipment, perform duties of a labourer.

Welder (2): Perform any welding and/or grinding required. When not welding, perform duties of a labourer.

Labourer (4): Perform track work.

A crew consisting of ten (10) individuals has the ability to perform small to mid-size maintenance tasks. And when there is a need to attend to two (2) job sites the crew can be split. For example, when a frog needs to be ground, the welder can work with the assistant foreman and/or a labourer to complete that task while the foreman and the rest of the crew are attending to another activity or set of activities. This flexibility is especially advantageous when the number of tasks becomes larger. It is also an advantage when the maintenance crew has to support larger operations such as ballast cleaning. For instance, part of the remaining crew can help to dump ballast leaving the balance free to continue their normal tasks. Having this size of crew also mitigates the risk due to absences, illness or vacation.

Equipment for each crew:

- 1 Inspection truck hi-rail
- 1 Track maintenance truck hi-rail with crane and power pack
- 2 Crew Cabs hi-rail
- 1 Speed Swing hi-rail

Other individuals that will be required to support multiple maintenance crews include:

> Boom Truck Operator: Work with the maintenance crew to aid in material distribution and scrap cleanup. This operator will support multiple maintenance crews.
>
> Mechanics: Repair any defective light and heavy equipment. Seven (7) mechanics stationed between the Unloading and the Loading yards should be sufficient.

Major operations such as rail relay, tie replacement, ballast cleaning, turnout renewal, and rail grinding & surfacing should have their own dedicated crews once the railway is being operated at or near full capacity. This will ensure a better final product and increased production since the operators will be specialized in performing a particular task.

1.34 Capital Renewal Program Maintenance

Capital renewal programs are developed as a result of the gathering of reports from track inspectors, collection and analysis of track detection reports from various rail bound detection equipment that will travel over the railway on a frequent basis and provide reports of the condition of the track bed and the rails and ties etc. From the analysis of all of this information and specific inspections of the line, a maintenance plan is developed to renew rail, ties and ballast as required, lift and line the track to improve the ride and wear of the track, where rail should be ground to extend its life, and which turnouts and frogs will need replacing or welding to maintain their extended use. These programs will require a significant investment in equipment, material and personnel. These programs are crucial to balancing short to medium term maintenance requirements with long term railway performance. If insufficient effort is made to maintain the track network to a suitable standard through various capital renewal programs, then slow orders will accumulate over time. The result will be longer train cycle times and a diminished railway capacity.

To maintain railway performance the following infrastructure renewal programs will need to be planned and implemented annually in a manner to address the replenishment needs of the railway infrastructure:

- Rail relay & grinding
- Tie replacement
- Ballast cleaning or shoulder renewal
- Turnout or frog renewal
- Track surfacing.

Based on past experience preliminary schedules for each of these programs can be estimated. However these schedules can only be finalized once the Alberta to Alaska Railway is fully operational and its particular requirements have been evaluated.

In comparison to the daily maintenance activities, these Major Program Maintenance (MPM) items will require larger, specialized teams consisting of experienced foremen, assistants and many more machine operators. Typically these crews will be responsible for more than one of the capital renewal programs. It will be the responsibility of the staff managing these programs to plan and undertake as much of these MPM activities during the 36 non-operating days at the 1.5 million barrel per day operation.

Due to the entire railway going into service at the same time, engineering will have to analyse the various data they gather on track conditions and prepare carefully for material repair or renewal. In the early years this will be crucial as eventually all of these parts will need repair and replacement but it will be imperative to have this done in a progressive way so that not all has to be done at the same time. This program will have to be spread out over time and evenly done.

1.35 Railway Structures Maintenance

For the purposes of bridge, structure and tunnel maintenance it is assumed that the Alberta to Alaska Railway will require one (1) or two (2) crews to inspect and do small repairs during the running in and infancy of the railway. As the railway ages, the Structures group will grow to four (4) or five (5) gangs spread over the network as required. This can only be determined once the alignment is finalized and bridge and culvert quantities and locations are established.

All bridges are assumed to be of steel and concrete construction without wooden components. Culverts are constructed of corrugated steel pipe (CSP) or concrete. Bridge crews will be trained to perform maintenance tasks with standard plant and equipment. Bridge maintenance policies and procedures will be developed and in place.

1.35.1 Inspections

Bridge and culvert inspections will be performed on an annual basis, to comply with regulatory requirements, and most importantly, to provide input to a planned maintenance system. More frequent inspections will be dictated by an advance meteorological and flood prediction warning system, and following threshold earthquake warnings (>4.8 Richter scale).

The objective of these ad hoc inspections will be to check for scour and erosion damage, together with potential seismic damage. Such extreme event warnings will trigger track inspections as well.

Programmed inspections of all rail carrying structures (bridges and culverts) are vital to maintain the infrastructure in good operating condition. Detailed records of all inspections complete with photographs and recommendations should be retained and funding should be allocated accordingly for any recommended repairs. It is highly recommended that inspection access be provided in the design of the structures to eliminate the need to use a Bridge Inspection Vehicle (BIV).

Additional detailed inspections should be performed as conditions arise and warrant further inspections such as derailments and after significant flood events.

1.35.1.1 Bridge Maintenance and Inspection

All bridges should be visually inspected on an annual basis with no more than 18 months between successive inspections. The railway is responsible for maintaining an inventory of required materials for all bridges located on its right of way and at minimum ensure the following information is recorded and available:

- Locations (i.e. subdivision and mileage)
- Bridge type
- Total length
- Individual span length
- Maximum height, bottom of rail to water level

- Year built
- Deck type
- Obstacle being crossed (i.e. water body, roadway, etc.)
- Geo-referenced coordinates
- Bridge rating
- Line/load capacity
- Date of line/load capacity evaluation
- The name of the party responsible for the inspection and maintenance of the bridge.

A visual inspection consists of a qualified inspector visually examining all components of the structure for any obvious defects. Particular attention should be given to the bearing areas as well as end and bearing stiffeners and the overall condition of the steel and concrete. Bridge and pier seats, top and bottom flanges and all horizontal members should be kept free of dirt and debris in order to slow the progression of section loss and deterioration.

Access to the bridge locations will generally be by means of a hi-rail truck with proper flagging protection provided by the railway.

1.35.1.2 Detailed Inspections

Since all bridges will be constructed with new materials, it is recommended that detailed inspections be performed once every ten (10) years, and/or frequency readjusted when defects are observed that warrant additional inspections. A detailed inspection consists of detailed measurements of section loss and corrosion for all steel components and any scaling or delamination on concrete surfaces. Other notable features such as scour under piers and abutments, sleeper conditions, should also be recorded during a detailed inspection.

In order to properly inspect the bridge structures for a detailed inspection, a rail mounted bridge inspection vehicle (BIV) would normally be utilised to access all components of the structure. This rail mounted vehicle would be required to obtain necessary track time in order to carry out the inspections which would occupy the track for an extended period of time. A typical detailed inspection of a 75’ Deck Plate Girder (DPG) span would take approximately 2 to 4 hours depending on the condition of the steel.

To prevent occupancy of the track, it is recommended that all bridges be equipped with inspection ladders, and walkways to facilitate the inspections from within the bridge structure. For an inspector to inspect the bridge from within the girders and without the need of a BIV, a DPG span can be equipped with a steel grating walkway that extends from one abutment to the other where all spans are DPG’s. Where mixed spans of concrete and steel DPG’s are used, hatch access thru the walkway grading and inspection access wrung on piers and abutments will need to be considered. In particular, an inspector will need to access all the bearings on both sides of the girders on all abutments and piers, bottom flanges, particularly over the bearings as well as intermediate, bearing and end stiffeners and horizontal and vertical bracing throughout the structure. Boom mounted cameras can also be used to do these inspections and remove the risk to the inspector where walkways are not provided.

1.35.1.3 Reporting

The qualified bridge inspector should provide the results of the inspection to a senior bridge engineer for review and approval. Each bridge should have its own inspection report outlining the current condition of all components as well as maintenance recommendations for current and future years.

A five (5) year priority maintenance program should also be developed from the visual and detailed inspection reports. The priority maintenance program should list the recommended repairs and their estimated cost. Management can then use this information to prioritize maintenance activities and allocate funds.

1.35.2 Culvert Maintenance

Culverts are used under railway tracks to allow upstream water to flow downstream. They are also used to control water drainage along the track right of way. The number of culverts on the Alberta to Alaska Railway has only been estimated at this point. They will be constructed of either steel or concrete and shall be installed at a minimum of 1.7 meters below the base of the rail and should extend to the greater of the following distances: 600 mm beyond toe of slope or 900 mm beyond ditches.

1.35.2.1 Inspections

Culverts shall be inspected on a regular basis. The frequency recommended is for large culverts (nominal diameter of 3.0 meters) to be done on an annual basis and smaller size culverts (nominal diameter less than 3.0 meters) to be done every 3 years. Communication with local track supervisor should be done to find out if any abnormalities were observed at any of the culvert locations. Special or additional inspections may be required although some of the culverts were not scheduled to be inspected. As mentioned previously, a hi-rail truck should be provided to access the culvert locations. A culvert inventory record shall be produced and contain the following information:

- Location (i.e., Subdivision and mileage)
- Culvert type
- Total length
- Depth of fill, bottom of rail to invert
- Inlet and outlet conditions including:
  - Elevation
  - Cleanliness
  - Headwall
  - Wingwall
  - Gabion
- Tunnel conditions including:
  - Roof
  - Side walls
  - Joints
  - Length
  - Cleanliness

1.35.2.2 Reporting

The inventory record should include a rating for each of the culvert items listed above. A qualified inspector should be responsible for looking into each and every culvert to assess its overall condition and to determine if any repairs are required. It is not anticipated that any repairs to the culverts will be required for an extended period of time. However, each culvert should be inspected on an annual basis to confirm there are no issues.

1.35.3 Structures Maintenance Crew Size and Equipment

1.35.3.1 Structures Crew

The structures maintenance crew will be spaced across the entire alignment in order to deal with issues and inspection requirements similar to the track and S&C groups.

- Foreperson
- Assistant Foreperson
- Welders (2)

- Steelworkers (2)
- Carpenters (3)
- Labors/bridge persons (3)

1.35.3.2 Structures Equipment

- Crew cab (3)
- Boom Truck (1)
- Speedswing (may share with track maintenance crews) (1)
- Dumper or equivalent (1)
- 50 Tonne hi-rail crane (1)
- Mobile trailer or containers for tools and equipment and mobile workshop (4)

1.36 Railway Staffing

1.36.1 Indicative Organisation

The railway organisation will appear to resemble a lot of freight railways, with one major difference; it is a very streamlined group since the focus is much narrower with the servicing of essentially one product. Therefore instead of taking a typical railway organisation and scaling it in order to develop the size and costs of the manpower required, a more appropriate approach was to build it from ground up. This required far greater effort to produce but provides a verification of the operating plan to ensure there are no significant omissions.

The numbers of employees reflected herein relate to a service level of 1.0 mbpd barrels per day. Excluded in this organisation is work which does not require full time employment from the railway. This can range from contract repair of road service trucks, to legal work in the US.

1.36.2 Focus on Safety

In the organization there needs to be a major focus on training and safety. Major North American railways have a focus, but in this case the organisation envisages a special Superintendent of health and safety who has an open door to the president. His organisation not only includes trainers, but quality control and independent inspectors who would conduct independent audits.

1.36.3 Two Countries, Two Companies

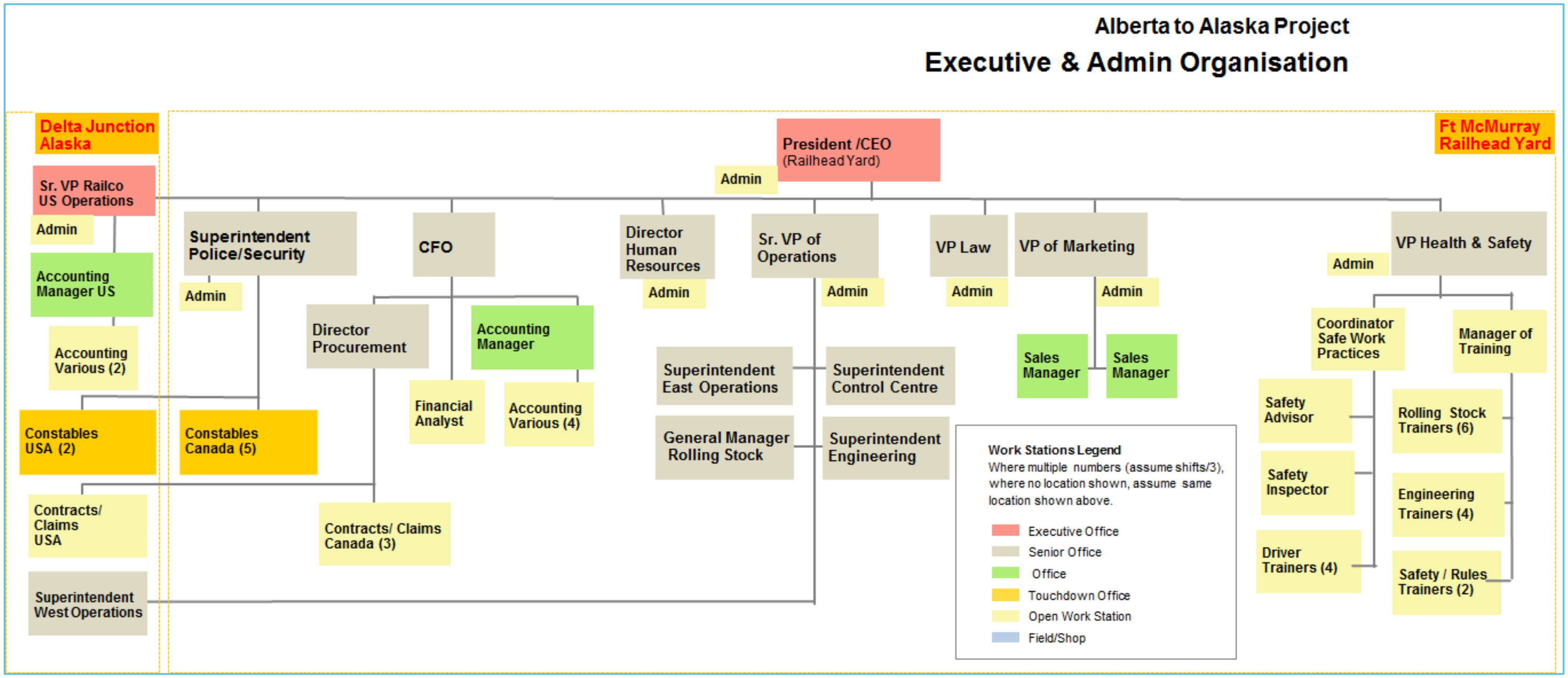
Notwithstanding ownership, there is the legal requirement to have a US company established for US rail operations. This company employ those working within Alaska. Nevertheless note that amount of staff located at Delta Junction unload yard is significant. In addition, there will be additional work in dealing with cross border work and tax issues.

Table 31 Indicative Distribution of Staffing

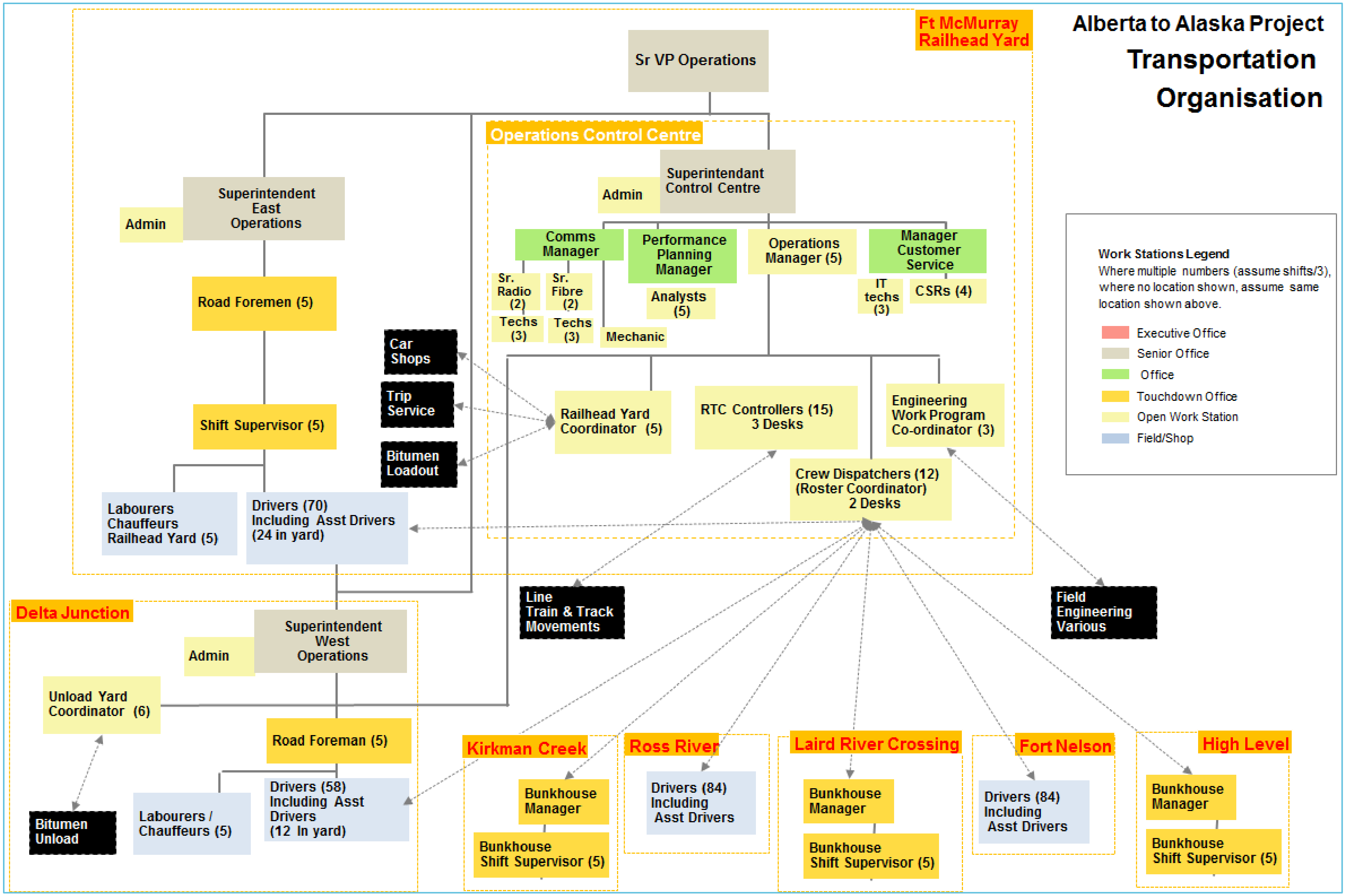
Location			Exec & Admin	H&S	Transportation[1]	Rolling Stock[2]	Engineering	Security	Total
Alberta	873	Ft McMurray	21	22	160	498	129	7	837
		Hotel					15		15
		High Level			6				6
		Mike					15		15
BC	152	Fort Nelson			84		30		114
		Easy					15		15
		Laird River			6	17			23
Yukon	165	New York					30		30
		Ross River			84				84
		William					30		30
		Kirkman Creek			6		15		21
Alaska	340	Quincy					15		15
		Delta Junction	8		74	179	62	2	325
Total	1530		30	22	420	694	356	9	1530
Percentage of Employee Workforce			2%	1%	28%	45%	23%	1%	100%

1. **Includes OCC** **2. Includes Bitumen and Supply Train Rolling Stock**

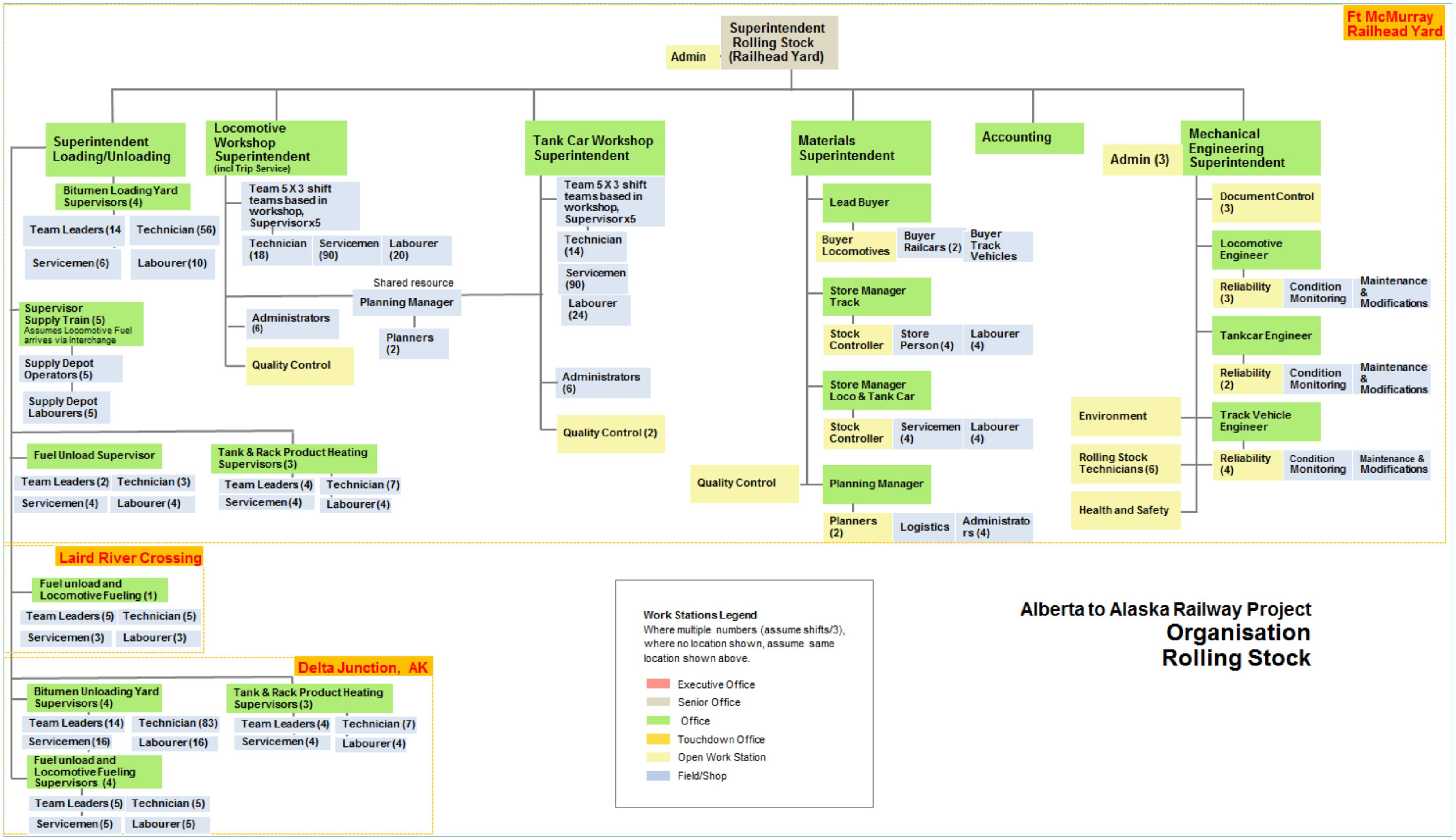
1.36.4 Executive/Administrative



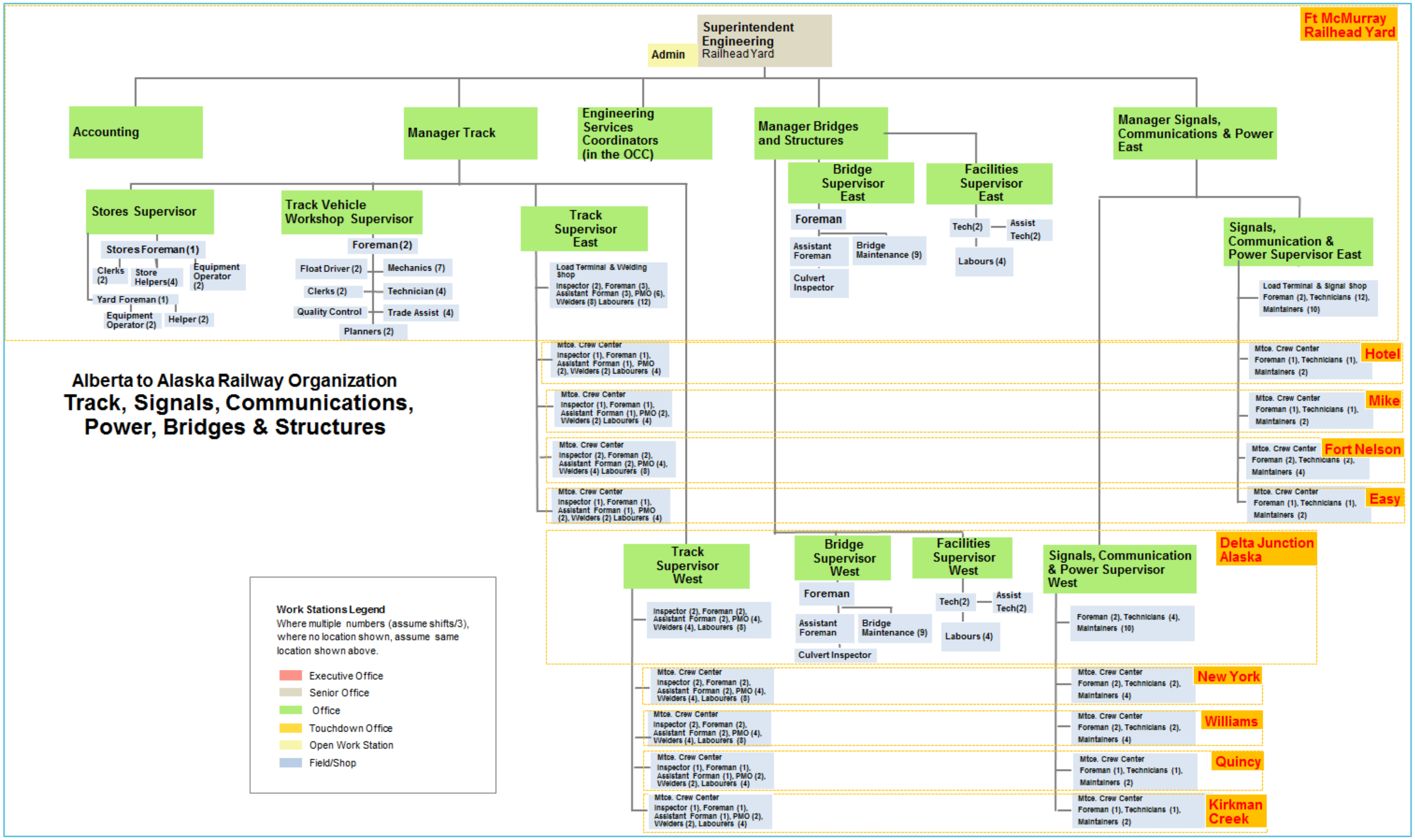
1.36.5 Transportation



1.36.6 Rolling Stock



1.36.7 Engineering Infrastructure



1.36.8 Challenges/Opportunities

There will be two basic challenges to putting the staffing together for this railway, one finding sufficient experienced staff to ramp up the organisation within a three year period and two attracting and retaining employees at remote locations.

In terms of the ramp up of employees there will be a significant need to recruit temporary experienced railway personnel whose experience can be used to train and mentor the first generation of new employees for this railway. There will be a significant need for recruitment and training during this ramp up period. Working in favour of meeting this need is the fact there is a long construction timeframe plus a 3 year ramp up should afford some relief.

With respect to attracting and retaining employees in remote areas, obviously most of the railway runs through isolated areas. While this does attract some people who enjoy these types of locations, the vast majority of people will not find it attractive in terms of living and working and as such there is an expectation that there would be a high turnover in the first years of operation. High wages will help recruit in the short term but are not a long term solution, since they attract temporary workers looking to make good money and leave. Both of these factors put pressure on start-up costs. Travel, training and accommodation expenses will be higher until the railway gains it permanent employment base.

On the other side is the recognition that this railway can provide the local population with the opportunity for substantial employment within their own communities.

2.0 Transport Board of Canada and Surface Transportation Board Applications

2.1 Introduction

Canada and the United States have a long and shared history of freight railroad transportation within and between the two North American countries. The railroads have enabled the economic development of large territories, as well as enabled freight to pass through border crossings which cover long distances. The technical and operational foundations for railroads in both countries are intertwined, facilitating the seamless movements of freight. Over time, the commercial, technical and operational permitting of railroads has received additional complimentary reviews whose foundations include environmental and ecological aspects as a response to the greater insights for the role and impact of rail transportation. The regulatory agencies, the Transport Board of Canada (TBC) and Surface Transportation Board (STB) for the United States, have merged these regulatory perspectives in their decision making.

2.2 Canada Transport Act Certificates of Fitness

Sections 90 to 94 of the Canada Transportation Act (CTA) require a person proposing to construct or operate a freight or passenger railway under federal jurisdiction to apply to the TBC for a certificate of fitness. The TBC issues such certificates if it is satisfied that there will be adequate third party liability insurance coverage for the proposed construction and operation.

This section is designed to identify steps in obtaining and maintaining such a certificate and should be used in conjunction with sections 90 to 94 of the Act. Further, the action must align with the *Railway Third Party Liability Insurance Coverage Regulations* (Regulations). In the event of a conflict of interpretation and action, the CTA and the Regulations will prevail, including the compendium of decisions and rulemaking.

The section applies only to federally-regulated railways, which are those meeting one of the following criteria:

- operates across provincial/territorial or international boundaries;
- is owned, controlled, operated or leased by a federal railway;
- has been declared by Parliament to be for the general advantage of Canada; or
- is an integral part of an existing federal undertaking.

2.2.1 Application

An application for a certificate of fitness must include a completed certificate of insurance form, and must indicate the termini and route of each operation. In addition, a railway company may apply to the TBC to vary an existing certificate of fitness, so that it reflects an additional route, a change in the termini or route, or a change in railway construction or operations.

The TBC strives to deal with all of its cases within 120 days. However, the TBC may take more than 120 days to issue a decision due to the complexity or the particular circumstances of an application or a case.

2.2.1.1 Certificate of Insurance

Sections 1 to 6 of the certificate of insurance form require the company name, the name of the insurance broker or agent, the type of insurance, details of each insurance contract and a confirmation that the operating risks listed in the subsequent section 7 of the form are known to the insurer. The authorized representative of the insurance company must endorse these sections.

Sections 7 and 8 of the certificate of insurance form require information related to the risks associated with the proposed construction or operation of the railway. It also asks the applicant to confirm that the applicant has fully disclosed these risks to the insurance company. The applicant must endorse these sections. The TBC will accept only the original back-to-back certificate of insurance form provided in the regulations.

2.2.1.2 Self-Insurance

The TBC will assess the applicant's ability to hold a specific amount of self-insurance, either deductible or self-insured retention. If the applicant files complete annual financial reports with the Minister of Transport or the TBC, there is no further requirement. Otherwise, the applicant may have to give the TBC audited financial statements for the three most recent complete fiscal years or provide other financial information that demonstrates the applicant is financially capable of carrying the proposed amount of self-insurance.

2.2.1.3 Insurance Company

If, for any reason, the TBC believes that the insurance company may not have the financial ability to pay its contractual level of insurance coverage, the applicant may have to provide the TBC with the last three years of the insurance company's audited financial statements and/or the insurance company's solvency rating, as determined by recognized rating agencies.

2.2.1.4 Temporary Railway Construction or Operation

The applicant must have third party liability insurance coverage for any proposed temporary construction or operation of a railway as a result of exceptional or unforeseen circumstances. The conditions remain applicable for holders of existing certificates.

2.2.2 Notification of Changes

The Applicant must notify the TBC in writing, without delay, whenever the applicant may renew, cancel or alter their liability insurance coverage, or whenever a change in construction or operation may mean that the liability insurance coverage is no longer adequate.

The applicant must also notify the TBC in writing of any potential erosion that may cause the applicant's liability insurance coverage to be no longer adequate, or when there is any change in deductible or self-insured retention that would affect the level of insurance.

The applicant must ensure that the insurance contract includes a provision that requires the insurer or its authorized representative to give the TBC at least 30 days' prior written notification of renewal, cancellation, expiration or material alteration of the insurance coverage.

2.2.3 Compliance

Pursuant to subsection 94(2) of the Act, the TBC may suspend or cancel a certificate of fitness if it determines that the applicant's insurance coverage is no longer adequate. The applicant may have to send supplemental information to the TBC to assure it that the insurance is still adequate.

Also, section 174 of the Act provides, in part, that any person or company who contravenes a provision of the Act, or a regulation or order made under the Act, is guilty of an offence punishable on summary conviction and subject to fines as set out in the Act.

2.2.4 Confidentiality

All documents filed with the TBC become part of the public record and may be made available for public viewing. However, in accordance with the TBC's General Rules, a claim for confidentiality can be made.

2.2.5 Railway Safety Management System Regulations

All railways holding a certificate of fitness are subject to the Railway Safety Act and all the requirements (such as regulations, rules, standards, etc.) pursuant to that Act.

The Railway Safety Management System Regulations require all federally-regulated railways to have a safety management system. New railway companies must send specific information on their system to the Minister of Transport sixty (60) days before beginning their operation.

Information on the Railway Safety Act may be found at the Transport Canada Web site at www.tc.gc.ca.

2.2.6 Decisions and Appeals

Each TBC decision is subject to the following conditions:

- it is binding upon the parties and remains in effect until it is amended or rescinded;
- it may be reviewed by the TBC, if there has been a change in the facts or circumstances;
- it may be appealed to the Federal Court of Appeal on a question of law or jurisdiction, within one month after the date of the order or decision; and
- it may be appealed to the Governor in Council at any time.

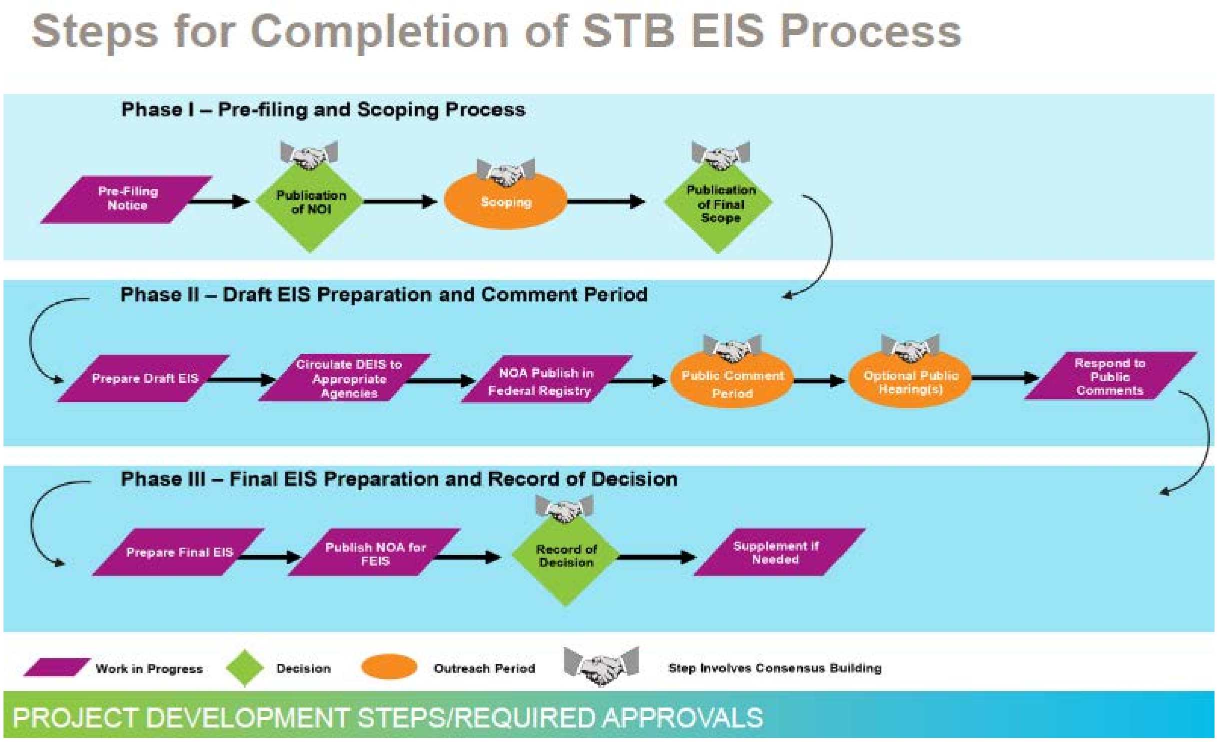
2.3 STB Application, Review and Decision Process

In the United States, the STB has sole jurisdiction to permit railroad facilities and operations for new and extended railroads. The procedures are identified under two sections of the US Code, 49 U.S.C. 10901 or 49 U.S.C. 10502. The STB process begins with the application filed by the Applicant. There may have been earlier informal meetings with the STB to identify an overall schedule and anticipated scope of work aligned with the project scope. Once the Applicant has completed their own design work and assessment of the environmental impacts they would be in a position to submit the application to the STB.

The STB will examine the defined Project Purpose and Need as an initial point of evaluation for the proposed project. The G7G team may be in a position to define their project, in part, on the project's ability to improve the economy of the US and Canada in an environmentally balanced manner. The attributes of the Project may include:

- Near and intermediate need for petroleum fuels in North America fulfilled by the Project
- Project's contribution to national economies, with inclusion of ecological attributes and footprint effects
- The Project's enhancement of the economic participation and choice for less advantaged peoples in a global economy
- The Project's contribution to an improved alignment of Petroleum Supply, Processing and Use
- The Project is advantageous for a broad constituency of stakeholders and adjacent peoples

Once the Applicant has assembled the necessary information, the formal application begins a sequence of STB events as outlined in the figure below. Phase 1 refers to the early discussions with the STB.



The STB will review the application and then retain the services of a preferred environmental firm, as well as select specialists if needed, to conduct their environmental review. The STB will maintain a close connection between the Project's anticipated purpose and need and the potential environmental effects and impacts, as well as potential mitigation measures if needed. The STB also tracks the written record to verify if appropriate and substantive information has been assembled and submitted.

The Alberta to Alaska Railway application would be aided by a clear identification of the design purpose and context for the project by demonstrating the project's impact on the following:

- Proposed action is aligned with the Alberta to Alaska Railway Mission and Purpose
- The anticipated Project's ability to restore and sustains TAPS benefits while preserving the existing TAPS mitigation measures and the environmental balance achieved under the current infrastructure investment and monitoring decisions
- The proposed Project's alignment with the TAPS Purpose and Need

The Applicant will need to describe the Project and its incorporation of a project design context shaped by railroad technology and operations traversing State of Alaska and First Nations, arctic and mountainous regions, as well as potential marine ecological settings. All feasible and viable alternatives will have been considered, including:

- No Action Alternative
- Modal alternatives considered
- Connectors and Common Segments

The information assembled will need to meet the substantive requirements of peer federal and state agencies, even those without specific jurisdiction, in order to sustain the balance of the STB final resolution, findings and alternative selection. The record will include the information and intermediate decisions leading to the Preferred Alternative. The following Table is a representative Table of Contents for a project that may capture the relevant information in an environmental document.

Candidate Table of Contents

1.0 Purpose and Need
2.0 Proposed Action and Alternatives
3.0 Geology and Soils
4.0 Water Resources Introduction
4.2 Surface Water
4.3 Groundwater
4.4 Floodplains
4.5 Wetlands
5.1 Biology Introduction
5.2 Vegetation
5.3 Wildlife
5.4 Fisheries
5.5 T E
6.0 Cultural Resources
7.0 Subsistence
8.0 Climate and Air Quality
9.0 Noise and Vibration
10.0 Energy Resources
11.0 Grade Crossing Safety & Delay
12.0 Navigation
13.1 Land Use
13.2 Parks and Recreation
13.3 Visual
13.4 Hazardous Materials
14.0 Socioeconomics
15.0 Environmental Justice
16.0 Cumulative Impacts
17.0 Short term versus Long term Impacts
18.0 Commitment of Resources
19.0 Mitigation
19.1 Mitigation Measures
19.2 Monitoring and Reporting
20.0 References
21.0 List of Preparers
22.0 Final EIS Circulation
23.0 Comments, Summaries & Responses
24.0 FEIS Index
Appendices