MOTT MACDONALD

Second Narrows Bridge Capacity Analysis

Summary Report

December 17, 2019

Confidential

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Executive summary

The Second Narrows Rail Bridge (SNB) is a vertical lift bridge connecting Vancouver and North Vancouver, which is raised for marine traffic transiting the Burrard Inlet, taking away service windows for North Shore Trade Area trains. Over the next 10 to 15 years, it is expected that both marine and rail traffic will significantly increase.

To better understand how the utilization of the bridge has changed over previous years and how it is likely to change in the future, the Vancouver Fraser Port Authority (VFPA) have commissioned two separate studies to undertake the analysis. Ausenco has been engaged to estimate the SNB utilization by marine traffic, while Mott MacDonald has been engaged to analyze the availability, capacity and utilization of the SNB for rail traffic.

The SNB is located at the east end of the Burrard Inlet with a number of rail-served marine terminals to the north and CN's Thornton Tunnel immediately to the south. The rail analysis for the SNB study only considers the 6.3 km SNB signal block section from Willingdon Junction to the North Shore bridge signals which includes the Thornton Tunnel.

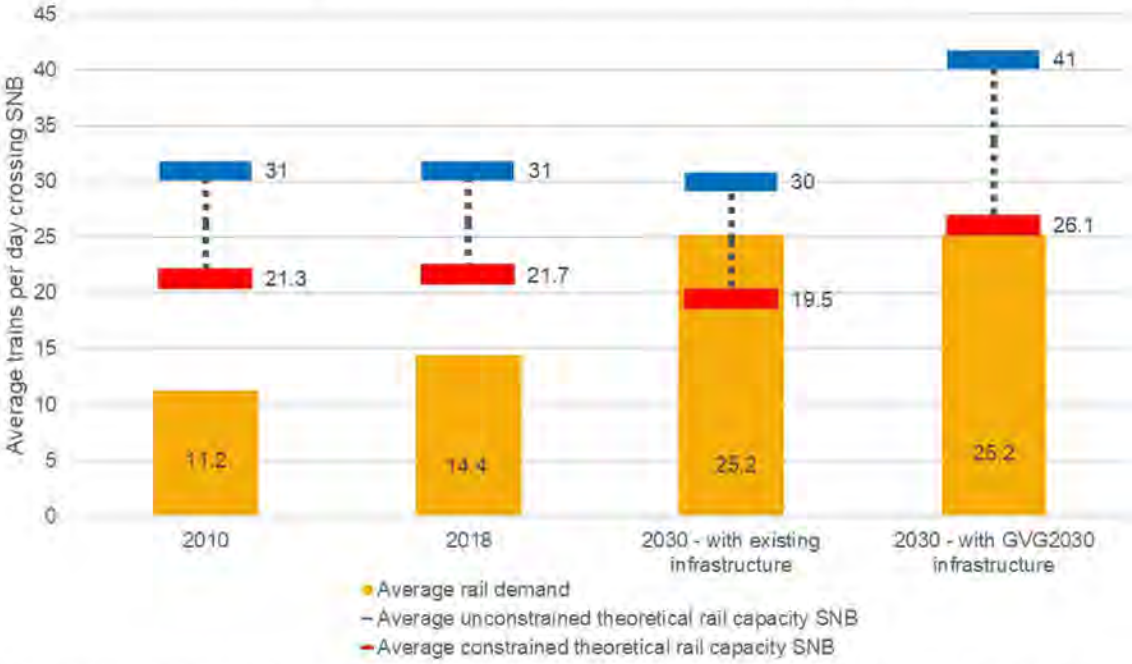
Figure S.1: Second Narrows Bridge Study Area, rail segment in red

Source: Google Earth

Using the data from the Ausenco marine analysis and assumptions made for relevant rail traffic parameters across the SNB, the theoretical capacity for rail traffic and utilization of this capacity was assessed. The average SNB capacity and utilization was estimated for three horizon years: 2010, 2018 and 2030. In addition, the impact of the Greater Vancouver Gateway 2030 (GVG2030) infrastructure projects was assessed. This included the Thornton Tunnel ventilation system upgrade and grade separation of Douglas Road in Burnaby, BC.

Figure S.2 shows the average rail demand and the theoretical rail capacity on the SNB for the three horizon years with existing infrastructure and the GVG2030 infrastructure scenario.

Figure S.2: Annual average rail demand and SNB theoretical rail capacity.



The unconstrained theoretical rail capacity assumes no SNB openings (i.e. no rail outages), while the constrained theoretical rail capacity includes bridge openings due to marine traffic. The figure shows that despite an increase in rail demand between 2010 and 2018, on average there is still sufficient theoretical capacity for rail traffic. Between 2018 and 2030, it is estimated that rail demand increases significantly while the average constrained theoretical rail capacity is reduced due to marine traffic growth. This leads to an average utilization of the available rail capacity of approximately 130%, indicating a capacity constraint for rail traffic on the Second Narrows Bridge (without inclusion of the GVG2030 infrastructure projects).

By implementing the GVG2030 infrastructure projects, it is estimated that the average theoretical rail capacity will increase by more than 30% (as shown in Figure S.2). This theoretical analysis demonstrates the average rail capacity slightly exceeds the demand for 2030. However, average monthly data shows that rail capacity utilization still exceeds 100% for several months and the high utilization would not allow for much flexibility in rail operations. Due to restrictions in terminal handling of trains and infrastructure use outside of the study area, it is expected that even with the GVG2030 infrastructure in place additional measures will be required to accommodate the increase in marine and rail traffic across the Second Narrows Bridge.

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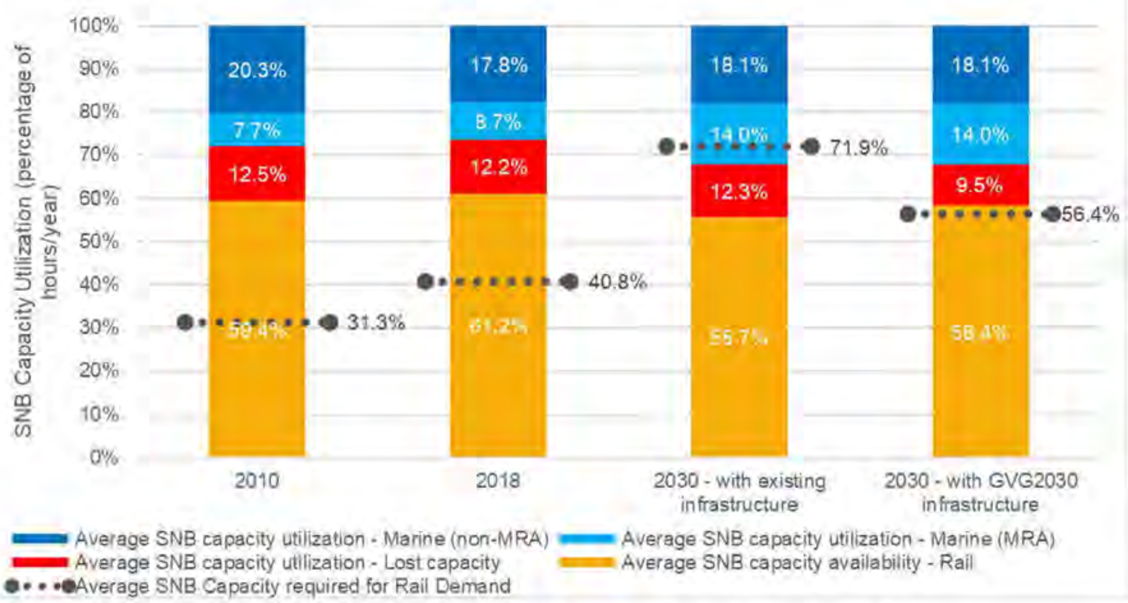
The data in Figure S.3 represents the utilization of the Second Narrows Bridge with respect to time. Between 2010 and 2018 the marine utilization of the SNB decreased slightly which translates to a slight increase in theoretical rail capacity. Between 2018 and 2030, it is estimated that the SNB utilization by marine traffic increases significantly due to a growth of vessels bound by the Movement Restricted Area (MRA) rules, resulting in a significant reduction in theoretical rail capacity. The GVG2030 infrastructure projects increase theoretical rail capacity by reducing train travel times, thus, less time is required to move the same number of trains across the bridge, without impacting marine traffic. Finally, for each horizon year a significant part of the SNB capacity is lost because available time windows for rail traffic are too short for a train to fully cross the section. If marine and rail traffic are better coordinated, there are opportunities to reduce this capacity loss.

Figure S.3: Annual average SNB capacity utilization.



Based on the conclusions from this analysis, the recommended next steps are:

1. Conduct a sensitivity analysis of marine traffic inputs and the assumptions for the rail corridor to verify the conclusions of this analysis;
2. Implement the GVG2030 infrastructure projects to increase rail capacity on the Second Narrows Bridge;
3. Undertake further investigation to identify additional opportunities to reduce train travel time across the SNB and/or improve the efficiency of rail operations across the Burrard Inlet;
4. Investigate opportunities to improve operational integration and collaboration between marine traffic and rail traffic to reduce lost capacity. For example, implementing fixed bridge opening windows for pleasure craft to increase predictability and efficiency of the SNB marine utilization; and,
5. Liaise with rail operators to identify the level of spare capacity required for variability in rail demand and flexibility in rail operations. Based on this, a target rail capacity can be determined to assess whether the measures identified in points 2 and 3 above are sufficient.

1 Introduction

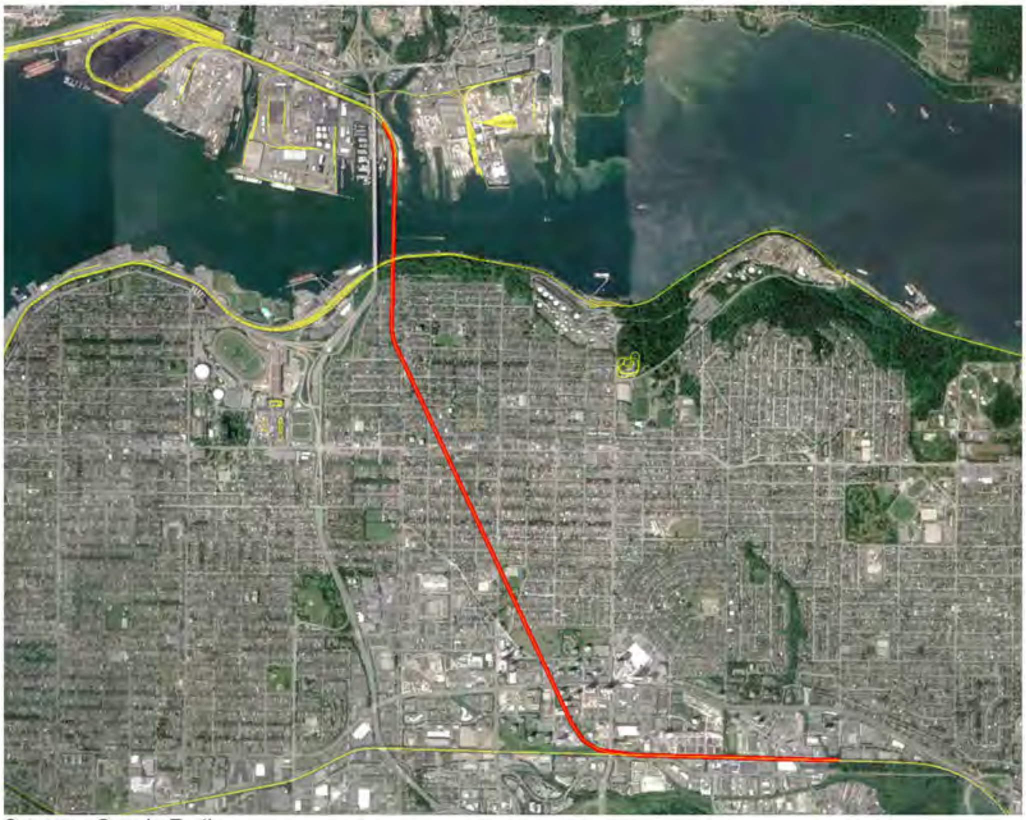
Owned and operated by Canadian National Railway (CN), the Second Narrows Rail Bridge (SNB) is a vertical-lift railway bridge that crosses the Burrard Inlet. It provides the only viable rail link between the North Shore and the rest of the Lower Mainland's rail network. The Vancouver Fraser Port Authority (VFPA) has recently committed to infrastructure investments to improve this rail corridor. However, the raising of the lift bridge for marine traffic takes away service windows for North Shore Trade Area (NSTA) trains. With the anticipated increase in rail traffic to the North Shore and ships calling at terminals east of the bridge, rail-vessel conflicts are becoming more common. As such, the availability, capacity and utilization of the bridge for both modes of transportation requires careful consideration.

In 2016, VFPA commissioned Ausenco to carry out a simulation of the marine movements using their existing model of the bridge and marine operations. This was done ostensibly to investigate the effects of the proposed Trans Mountain Expansion (TMX) Project on bridge usage.

In 2019, VFPA commissioned Ausenco to update the model to assess the expected availability rates and average availability windows of the bridge based on updated marine traffic forecasts. Using these outcomes, the VFPA has commissioned Mott MacDonald to evaluate the rail constraints to bridge use and how marine traffic is affecting the rail capacity of the bridge. In addition, VFPA wants to better understand the impact of the growth in marine traffic on the improved rail corridor with the inclusion of the GVG2030 infrastructure projects to determine an appropriate cost recovery structure.

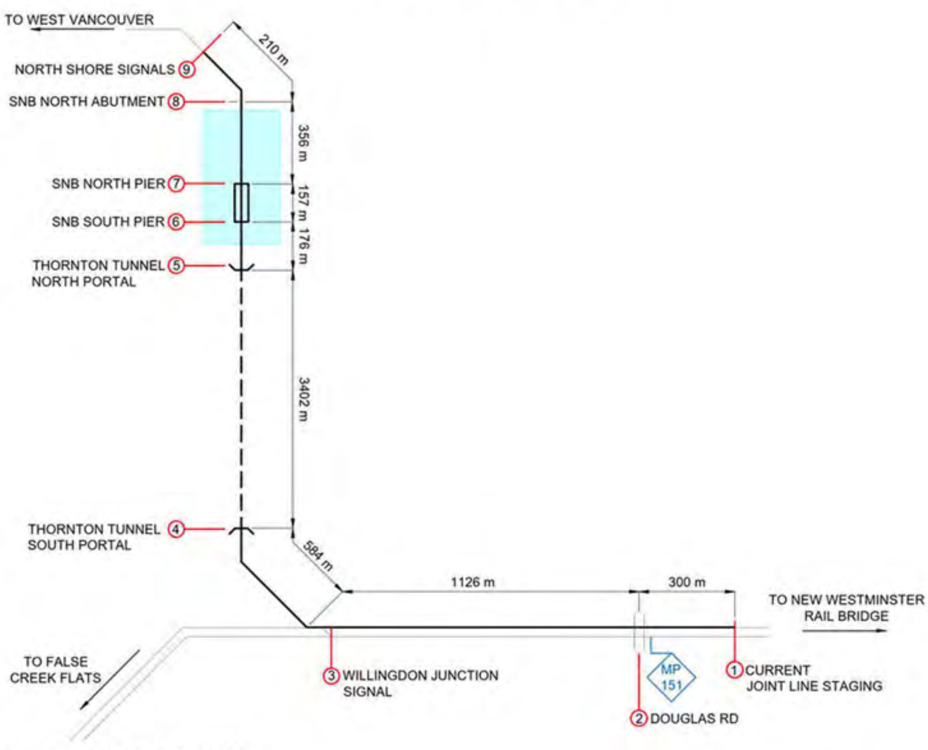
Figure 1.1 and Figure 1.2 (overleaf) show the study area considered for the Second Narrows Bridge. This study area spans from the train staging area east of Douglas Road crossing at the south side of the study area to the bridge signals (30AD to 30ED) on the northern side of the Second Narrows Bridge. This segment has a length of approximately 6.3 km. Between Douglas Road and the Second Narrows Bridge is the 3.4 km-long Thornton Tunnel. During the interval between trains servicing the Northshore, exhaust fumes from the locomotives must be purged from the tunnel to reduce the level of air pollution. This delay between trains utilizing the tunnel impacts the overall capacity of the rail corridor.

Figure 1.1: Second Narrows Bridge Study Area, rail segment in red



Source: Google Earth

Figure 1.2: Second Narrows Bridge study area, schematic view



Source: Mott MacDonald

2 Methodology and Assumptions

A number of key principles and assumptions were used in the methodology for analyzing the bridge capacity. In addition, Ausenco provided key inputs to the analysis relating to marine traffic as described below.

2.1 Definitions

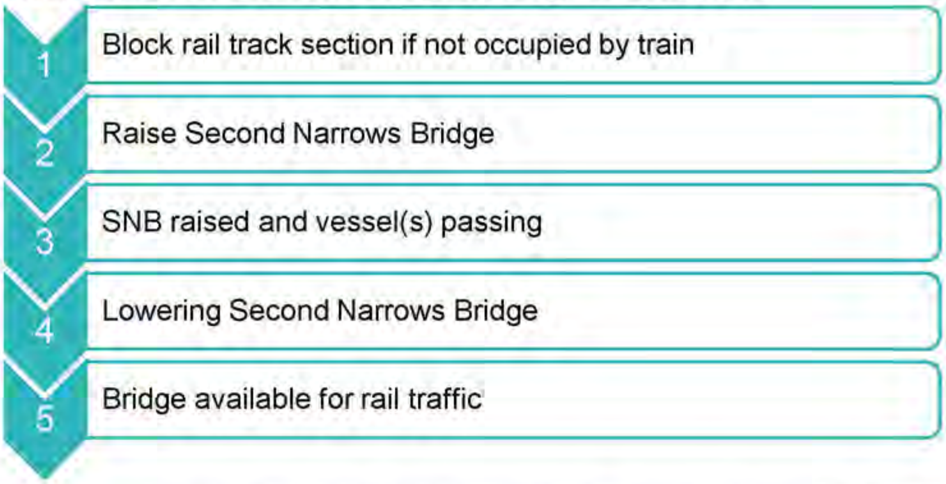
This study uses the following definitions:

- **Rail demand**: average trains per day crossing the Second Narrows Bridge based on the cross-berth annual throughput in metric tonnes and average train length specific to each terminal.
- **SNB capacity utilization (marine)**: percentage of time the Second Narrows Bridge is utilized by marine traffic and not available for rail (i.e. bridge raising, vessel passing and bridge lowering), averaged over monthly and annual periods.
- **Unconstrained SNB rail capacity**: average trains per day that can **theoretically** cross the Second Narrows Bridge without any bridge opening restrictions.
- **Constrained SNB rail capacity**: trains per day that can **theoretically** cross the Second Narrows Bridge taking into account the SNB capacity utilization by marine traffic, averaged over monthly and annual periods.
- **SNB capacity available for rail traffic**: the constrained SNB theoretical rail capacity expressed in percentage of time, taking into account the average travel times across the SNB section, averaged over monthly and annual periods.
- **SNB capacity lost**: percentage of time the Second Narrows Bridge is not utilized by marine traffic, resulting in time windows which are too short for rail traffic to cross the full track section, averaged over monthly and annual periods. This equals the total time minus the SNB capacity utilization by marine traffic and the SNB capacity available for rail traffic.
- **Constrained SNB rail capacity utilization**: average rail demand divided by the average constrained SNB **theoretical** rail capacity by rail, indicating percentage of SNB **theoretical** rail capacity utilization. If this utilization is more than 100%, rail demand exceeds the capacity.

2.2 Methodology

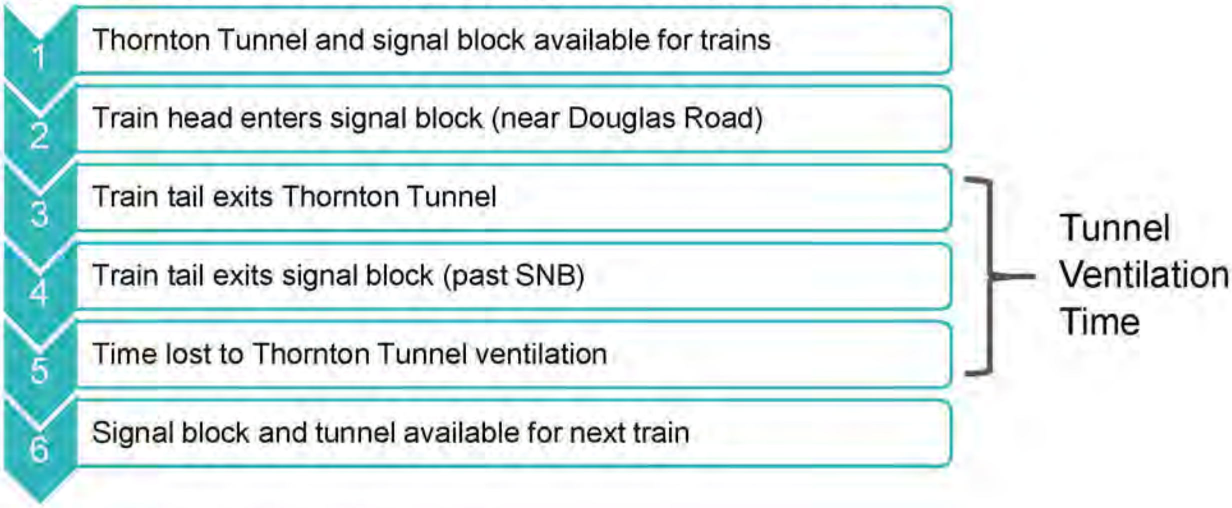
The methodology of this analysis is based on using available data to provide an overview of Second Narrows Bridge theoretical capacity for rail traffic. This analysis is founded on Mott MacDonald's interpretation of the SNB transit process for marine and rail traffic. Figure 2.1 shows the process for marine traffic crossing the Burrard Inlet and including the raising of the Second Narrows Bridge. The required time windows are described and determined in the Ausenco report and are assumed to be rigid. The Ausenco study outputs that are used as inputs for this analysis are described in the next section.

Figure 2.1: Second Narrows Bridge crossing – marine traffic



From a rail perspective, the process of crossing the Second Narrows Bridge to the North Shore Trade Area is shown in Figure 2.2. A key element in the rail traffic crossing is the time required to purge the Thornton Tunnel of exhaust fumes before the next train can enter the tunnel and signal block section. This is defined as the Tunnel Ventilation Time and has a significant impact on the time between trains travelling through this section. This also results in a slight difference in the travel time between northbound and southbound trains.

Figure 2.2: Second Narrows Bridge crossing – rail traffic (northbound)



This analysis considers three horizon years:

1. 2010: Baseline scenario prior to the delivery of projects funded by the Asia Pacific Gateway Initiative (APGCI).
2. 2018: Current status scenario after the implementation of the APGCI.
3. 2030: Future demand scenario taking into account both marine traffic and rail demand growth along the Burrard Inlet leading to additional utilization of the Second Narrows Bridge.

In addition to the above three horizon years, this study has considered the Greater Vancouver Gateway 2030 (GVG2030) infrastructure upgrade projects that are part of the National Trade

Corridor Fund to assess the impact on the theoretical rail capacity over the Second Narrows Bridge. Under consideration are:

- Upgrade to the tunnel ventilation system of the Thornton Tunnel; and
- Implementation of a grade separation at Douglas Road / Holdom Avenue.

The assumptions for these infrastructure upgrades are discussed in Section 2.4.5.

Outputs for each of these horizon years have been broken down into annual and monthly averages. The monthly average provides insight in possible capacity constraints due to seasonal variations in traffic volumes, with marine traffic peaking in summer (July – August) and rail traffic peaking in fall (October). It is important to note that due to the use of averages over a full month and year, the analysis does not consider daily variations in marine traffic or rail demand. This means that even though there may not be capacity constraints on a monthly basis, this does not necessarily mean that there are no capacity constraints on a daily basis. Similarly, if on a monthly average there is a capacity constraint, this does not necessarily imply that there is a capacity constraint every single day.

2.3 Ausenco simulation data

Outputs from Ausenco's analysis were used as inputs for the marine utilization of the Second Narrows Bridge for the 2010, 2018 and 2030 horizon years. Ausenco's inputs, assumptions and simulation results are described in their report, *104203-01-RPT-0001 CN Bridge Utilization Study* (refer to Appendix A). Ausenco distinguishes two vessel categories through the Second Narrows Movement Restricted Area (MRA) of the Burrard Inlet (located at the Second Narrows Rail Bridge):

- Vessels bound by MRA rules (MRA vessels, e.g. tankers and bulkers); and,
- Vessels not bound by strict movement procedures (non-MRA vessels, e.g. pleasure craft and patrol boats).

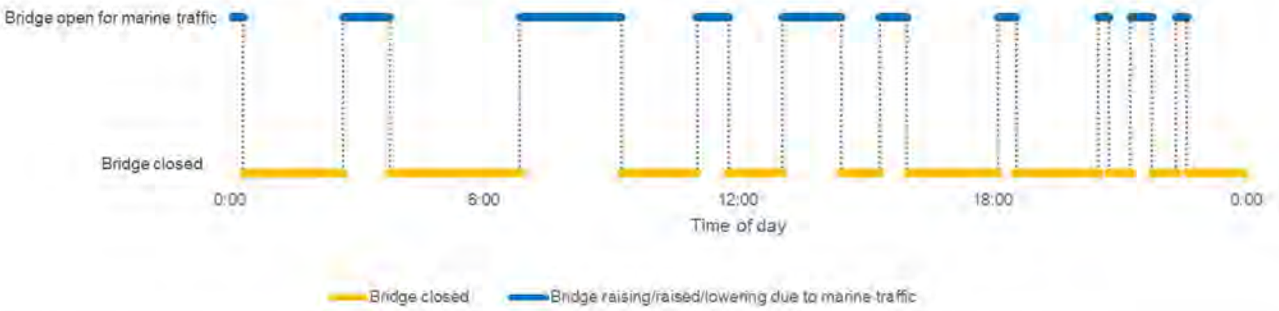
These vessel categories have different impacts on the SNB availability. Figure 2.3 shows average durations for MRA and non-MRA vessels to pass the SNB. Ausenco indicated that these durations include the raising of the bridge, the vessel passing and fully lowering of the bridge for rail operation to recommence.

Figure 2.3: Durations of SNB utilization for vessel categories

Source: Ausenco

Ausenco provided separate time series for the three horizon years with timestamps indicating the time the SNB starts raising and the time the SNB has returned to a fully lowered position (see overleaf Figure 2.4 for an example of a typical day of SNB openings).

Figure 2.4: Time series of Second Narrows Rail Bridge openings for typical day in 2030.



The period between these timestamps is considered as time the SNB is utilized by marine traffic and not available for rail traffic. Each of Ausenco's time series included a 19-year simulation to capture the tidal cycle. This full period has been analyzed and averages per year and month have been included in the results of this study. Ausenco assumed the bridge remained open for marine traffic if the period between openings was shorter than 30 minutes.

2.4 Assumptions

The Second Narrows Bridge capacity analysis is based on several assumptions as defined below:

2.4.1 Rail demand

- For 2010 and 2018 historical VFPA cross-berth data was used to determine the annual throughput;
  - 2018: the monthly cross-berth data was used to determine monthly throughput;
  - 2010: no categorization of cross-berth data by month was available. This analysis assumes the same monthly distribution trend as for 2018;
- For 2030 the annual and monthly cross-berth throughput was determined based on the North Shore Trade Area model developed by Mott MacDonald (GVG2030 simulation);
- The average number of cars per train and the average car load was estimated for each commodity and terminal destination to determine average number of trains per day per horizon year; and,
- The average number of cars and locomotives per train, the average locomotive length and the average car length was estimated for each commodity and terminal destination for each horizon year to determine average train length per horizon year.

2.4.2 Infrastructure

- The study area considers the 6.3 km section from Douglas Road junction to the North Shore Second Narrows Bridge signals, as illustrated on Figure 1.2;
- The study area is considered a single signal block section that can only be occupied by one train at the same time;
- Both ends of the study area are considered a 'black box' and assume that trains can continuously enter and leave the signal block section on both ends of the study area. This means that restrictions due to terminal handling of trains and other rail infrastructure are not considered;

- Once a train enters the signal block section, the time window to cross the full section needs to be sufficient to traverse the full length. That is the time window from when the head end of the train enters the section to when the tail of the train leaves the section; and,
- The Thornton Tunnel requires to purge smoke from the tunnel before the next train can enter the tunnel. This Tunnel Ventilation Time is assumed to be a 20 minutes tail-to-tip headway.

2.4.3 Travel times

- An average speed of 10 mph was assumed for the full study area segment based on speed limitations across the section and a stationary train at the start;
- Average train lengths per horizon year were estimated (see rail demand) to determine the tip-to-tail clearance time of the signal block section;
- Travel times for the first train within a closed bridge window assumes that the Thornton Tunnel has been purged and the train can travel through based on the average speed;
- Travel times for each subsequent train within the same window assumes that the Thornton Tunnel needs to be purged before the next train is allowed to enter the signal block. This is assumed to be the Tunnel Ventilation Time minus the travel time from the tunnel exit to the end of the signal block; and,
- Travel times are determined for the north-south and south-north travel direction. The average of both travel times is assumed as the travel time to determine capacity.

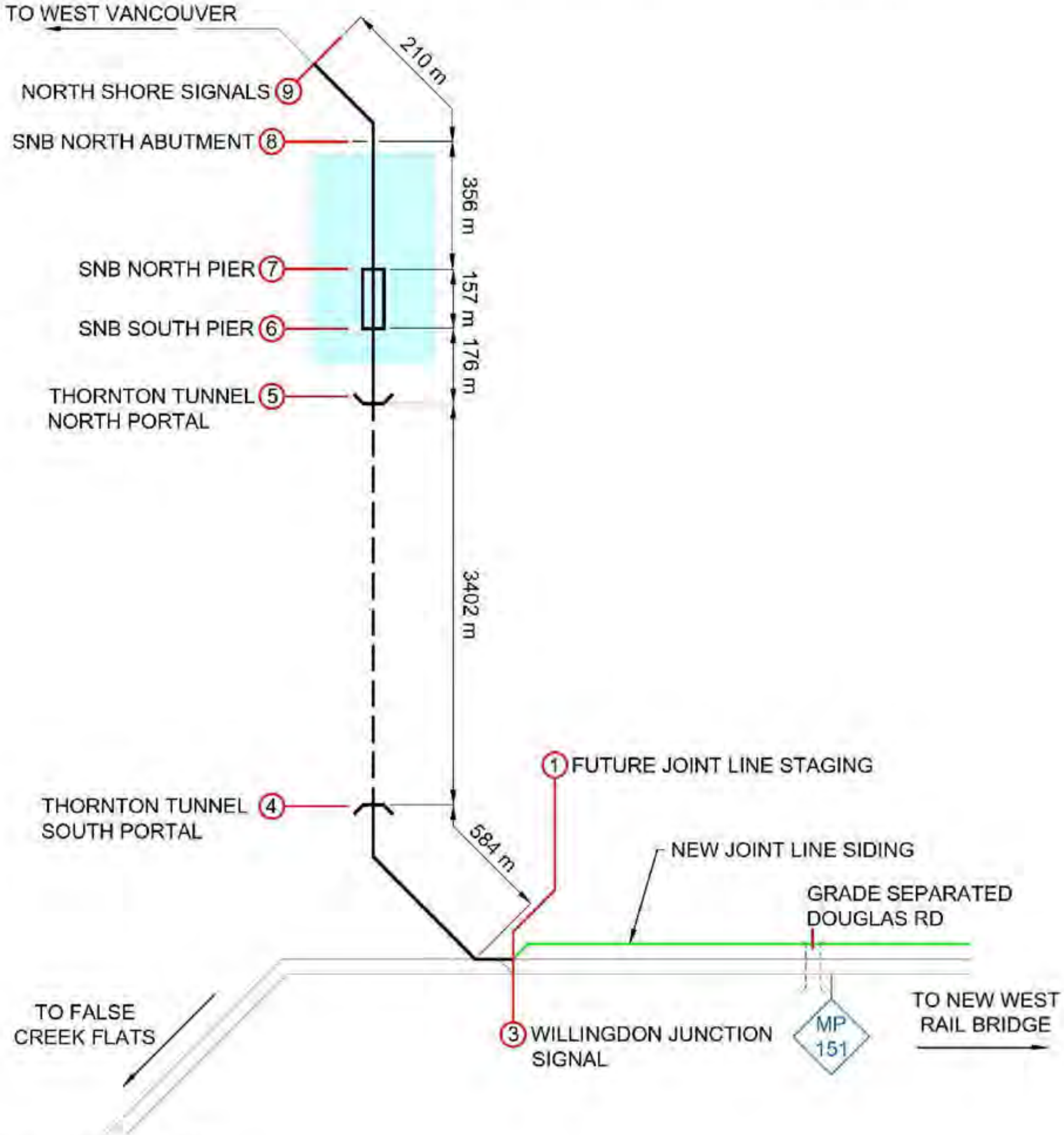
2.4.4 Theoretical rail capacity

- The unconstrained theoretical rail capacity is determined based on a 24-hour period assuming no marine traffic, therefore the SNB is available for rail traffic for the full period. The Thornton Tunnel is assumed to be clear at the start of the 24-hour period;
- Constrained theoretical rail capacity is determined based on the average travel times for the first and subsequent trains and the time series for SNB openings provided by Ausenco. For each time window it was determined how many trains can cross the full SNB section, assuming that the marine traffic is fixed and rail traffic needs to conform to this; and,
- The difference between the time required for the trains crossing the full SNB section and the opening of the bridge for marine traffic is assumed to be lost SNB capacity.

2.4.5 GVG2030 infrastructure upgrades

- Upgrades to the Thornton Tunnel ventilation system reduce the tunnel ventilation time from 20 minutes to 10 minutes tail-to-tip headway; and,
- Douglas Road Grade Separation enables the starting location on the south side of the section to move northwards, thus allowing trains to stage closer to the Thornton Tunnel. For the purpose of this analysis, this effectively moves the signal from Douglas Road to Willingdon Junction, reducing the section length from 6.3 km to 4.9 km. See Figure 2.5 (overleaf) for the updated schematic view of the section with the siding included.

Figure 2.5: Second Narrows Bridge study area, schematic view with GVG2030 infrastructure upgrades



Source: Mott MacDonald

3 Results

The analysis was completed over the 3 identified horizon years for both annual and monthly averages. Using these results, the benefits created by the GVG2030 infrastructure projects on the SNB rail capacity have also been quantified.

3.1 Occupation Time of Segment

For 2010 and 2018, the average train lengths were determined using a combination of the historical data provided by VFPA and Mott MacDonald's prior experience working with the different North Shore terminal operations. Meanwhile, the future 2030 scenario incorporated both new terminal operation (i.e. G3), changes in handled commodities (e.g. Fibreco) and optimization of the existing grain fleet. These assumed changes to the 2030 scenario increased the overall average length of the trains transiting the signal block section.

An average tip-to-tail travel time between signals is determined using the following formula for each horizon year:

$$Travel\ time, t = \frac{signal\ block\ length + train\ length}{rail\ travel\ speed} + ventilation\ time$$

Table 3.1 summarizes the key inputs and assumptions to determine bridge capacity for the three horizon years. The basis of the estimated train lengths for each horizon year are further detailed within Appendix B.

Table 3.1: Overview of key analysis inputs

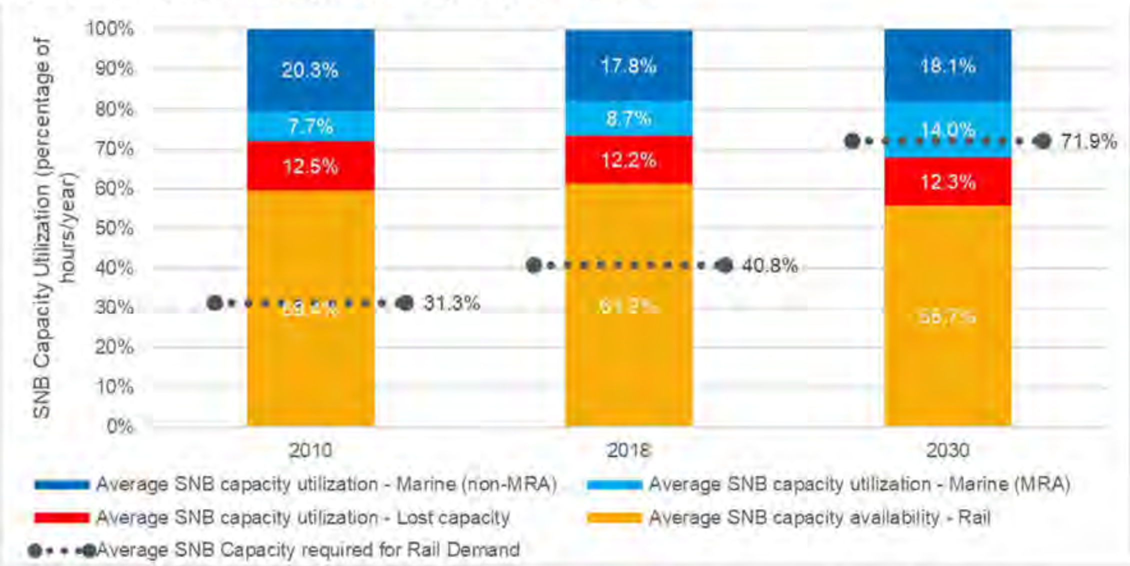
Input	unit	2010	2018	2030	2030 GVG2030
Average train length	m (ft)	2,098 (6,883)	2,185 (7,170)	2,417 (7,929)	2,417 (7,929)
Tunnel ventilation time (tail-to-tip)	minutes	20	20	20	10
Average rail travel speed	mph (m/s)	10 (4.47)	10 (4.47)	10 (4.47)	10 (4.47)
Signal block length	m	6,311	6,311	6,311	4,885
Average travel time, first train within window	mm:ss	31:21	31:41	32:32	27:13
Average travel time, subsequent trains within window	mm:ss	45:56	46:15	47:07	34:27

The first train travelling through the tunnel during the analysis day assumes that no tunnel ventilation is required. Every subsequent train travelling through the tunnel thereafter will be required to wait for the purging of exhaust fumes from the tunnel, resulting in a longer travel time. Further details are provided in Section 2.4.3.

3.2 Annual Second Narrows Bridge capacity

Figure 3.1 shows the annual average utilization of the Second Narrows Bridge capacity, expressed in the percentage of hours the bridge is utilized per year. The top bars (blue) represents the average SNB capacity utilization by non-MRA and MRA marine traffic, indicating that in 2010 on average 28.0% of the SNB capacity is estimated to be utilized by marine traffic (20.3% non-MRA and 7.7% MRA). The middle bar (red) shows the average annual capacity of the SNB that is lost. For 2010, it estimated that 12.5% of the time the SNB is neither utilized by marine traffic nor available for rail traffic because time windows are too short for a full train to cross the SNB section ("lost" capacity). The remainder of the average annual SNB capacity is shown in the bottom bar (orange). This is the average annual SNB capacity that is available for rail traffic. In 2010, this is estimated to be 59.4% of the time (the equivalent of 217 days).

Figure 3.1: Annual average SNB capacity utilization.



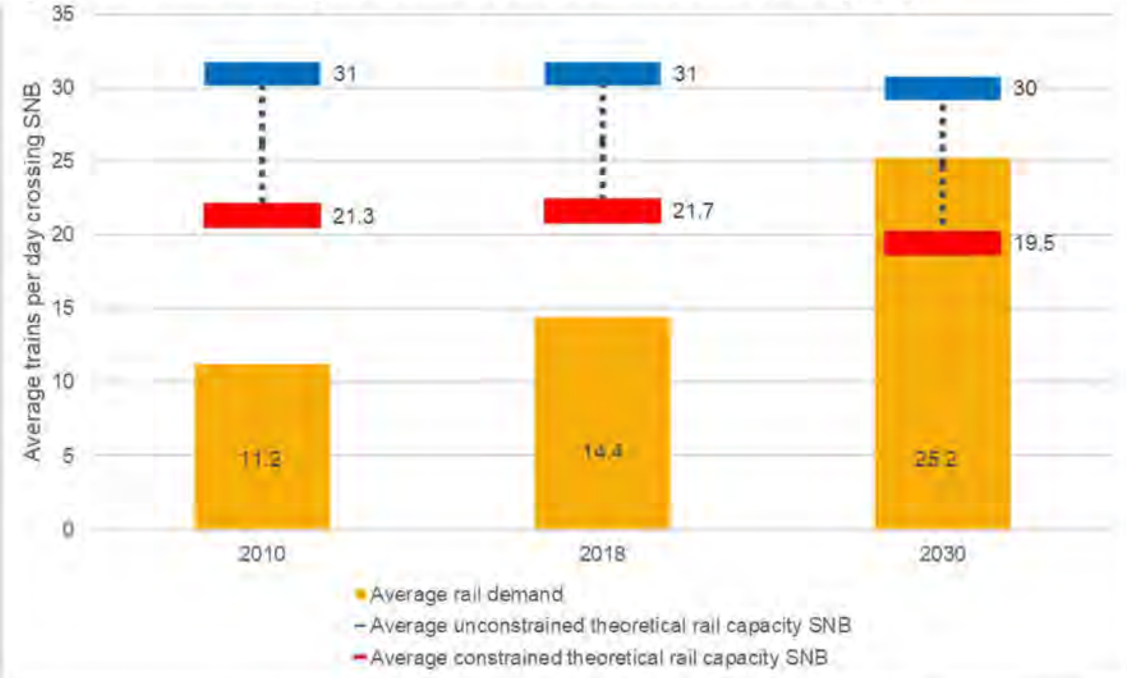
The dotted line (grey) shows the average SNB capacity that is required based on the rail demand in that year. The SNB capacity is calculated from the number of trains per year and the average travel time across the SNB. In 2010, this average SNB capacity that is required for rail traffic is estimated at 31.3% (the equivalent of 114 days). Since the SNB capacity for rail traffic is below the SNB capacity that is available for rail traffic, it is estimated that on average the constrained rail capacity on the SNB is utilized for 53% in 2010. However, because this analysis uses averages, this does indicate whether for the 2010 marine and rail traffic volumes there were no conflicts between marine and rail movements. It is very likely that there have been circumstances where a train had to wait for marine traffic to pass and the SNB to close before it could proceed through the signal block section.

The figure also shows the comparison between the 2010, 2018 and 2030 horizon years. Between 2010 and 2018 the average utilization of the SNB by marine traffic shows a slight decrease. Due to reduced marine traffic, the lost capacity of the SNB also decreased slightly. As a result, the available SNB capacity for rail increased in 2018. However, the rail demand also increased (both in terms of average train length and total cross-berth throughput), resulting in an increased SNB capacity required for this rail demand. Despite this increase, the constrained rail capacity of the SNB is utilized for 67% on average, indicating no capacity constraints over the one-year average.

For 2030, marine traffic is expected to increase, utilizing approximately 32.1% (18.1% non-MRA and 14.0% MRA) of the SNB capacity, whereas the lost capacity of the SNB remains similar. This results in a decrease in the SNB capacity available for rail traffic. However, rail demand is also estimated to increase by 2030, resulting in a constraint between the available SNB capacity for rail and the SNB capacity required for rail. It is estimated that the average theoretical rail capacity utilization is 129%, indicating a constraint for rail traffic over the Second Narrows Bridge if no GVG2030 infrastructure projects are implemented.

Figure 3.2 shows the annual rail demand and rail capacity over the Second Narrows Bridge. The orange bars show the rail demand expressed in trains per day crossing the Second Narrows Bridge. In 2010, this rail demand is estimated to be 11.2 trains per day. The top bar (blue) shows the unconstrained theoretical rail capacity over the Second Narrows Bridge, assuming the bridge is not utilized by marine traffic. The bottom bar (red) shows the constrained rail capacity. This considers the Second Narrows Bridge capacity utilization by marine traffic and the lost SNB capacity due to time windows that are too short. The difference between these two indicates the reduction of theoretical rail capacity due to SNB openings.

Figure 3.2: Annual average rail demand and SNB theoretical rail capacity.



The figure shows that there is an increase in rail demand over time. Between 2018 and 2030, it is estimated that there will be a strong growth in number of trains over the SNB. Since these trains are also anticipated to increase in length, this will result in a slight decrease in the unconstrained rail capacity over the SNB from 31 trains per day to 30 trains per day. The figure also shows that over time, the constrained rail capacity over the SNB is similar in 2010 and 2018 (in line with marine traffic volumes), but is estimated to decrease by 2030 as a result of increased marine traffic volumes. The figure demonstrates a capacity constraint in 2030, given the constrained SNB rail capacity is 19.5 trains per day while rail demand is 25.2 trains per day. This indicates that nearly 6 trains per day are not able to cross the SNB due to a lack of available capacity for rail traffic.

Table 3.2: Overview of key annual average outputs.

Output	unit	2010	2018	2030
Average rail demand	Trains/day	11.2	14.4	25.2
Average unconstrained theoretical rail capacity	Trains/day	31	31	30
Average constrained theoretical rail capacity	Trains/day	21.3	21.7	19.5
Average utilization of theoretical rail capacity	Percentage	52.6%	66.6%	129.3%
Average SNB capacity utilization by marine	Percentage of hours/year	28.0%	26.6%	32.1%
Average SNB lost capacity	Percentage of hours/year	12.5%	12.2%	12.3%
Average SNB capacity available for rail traffic	Percentage of hours/year	59.4%	61.2%	55.7%
Average SNB capacity required for rail traffic	Percentage of hours/year	31.3%	40.8%	71.9%

Figure 3.3 shows a 'typical day' for the opening and closing of the Second Narrows Bridge for the 2030 marine traffic volumes. The blue line (top) shows when the bridge is unavailable to rail traffic due to marine traffic. This analysis is based on the windows between these bridge openings and determines how many trains can cross the Second Narrows Bridge within that timeframe. The orange line (bottom) shows when this window can be effectively used by train traffic, assuming the required travel times. The red line (middle) shows the lost capacity and represents the time at the end of each window that is not utilized by rail traffic because the window is too short for a train to pass. In this particular example, there are 19 trains that can traverse the Second Narrows Bridge within the available time windows.

Figure 3.3: Second Narrows Bridge opening and closing on typical day in 2030 with existing infrastructure (number of trains crossing SNB shown per window).

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3.3 Monthly Second Narrows Bridge capacity

3.3.1 2010

Figure 3.4 and Figure 3.5 show the estimated bridge utilization, rail demand andrail capacity for each month in 2010. Despite the increase in marine traffic through the summer months, this increase in utilization does not create a capacity constraint for rail traffic.

Figure 3.4: Averaged monthly SNB utilization – 2010.

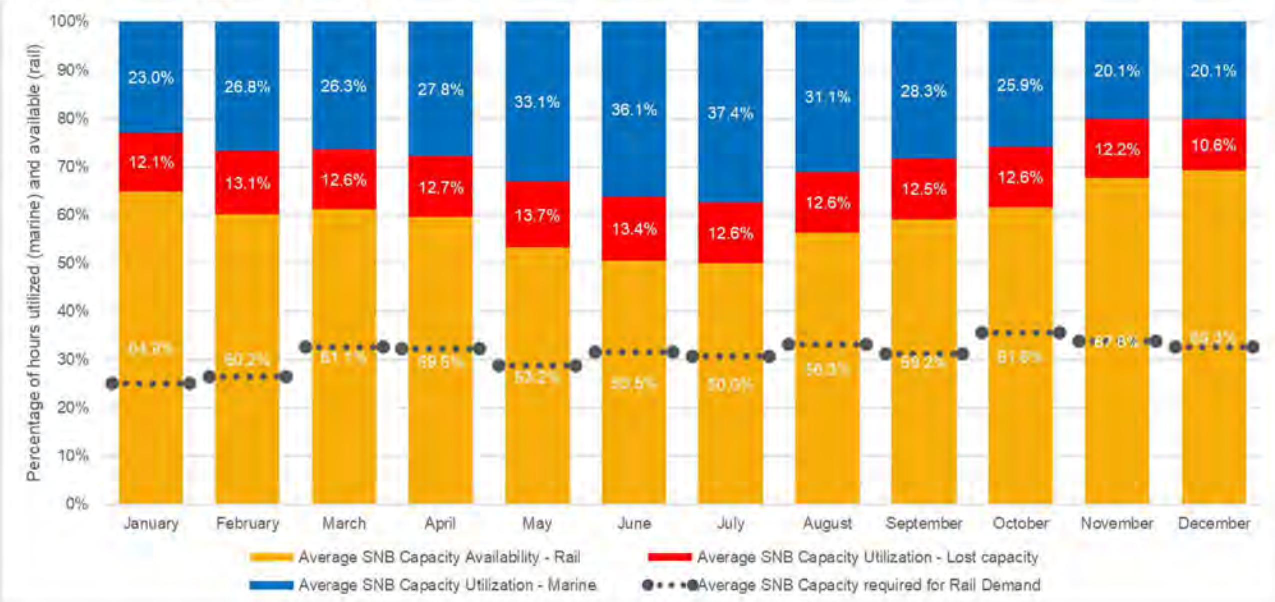
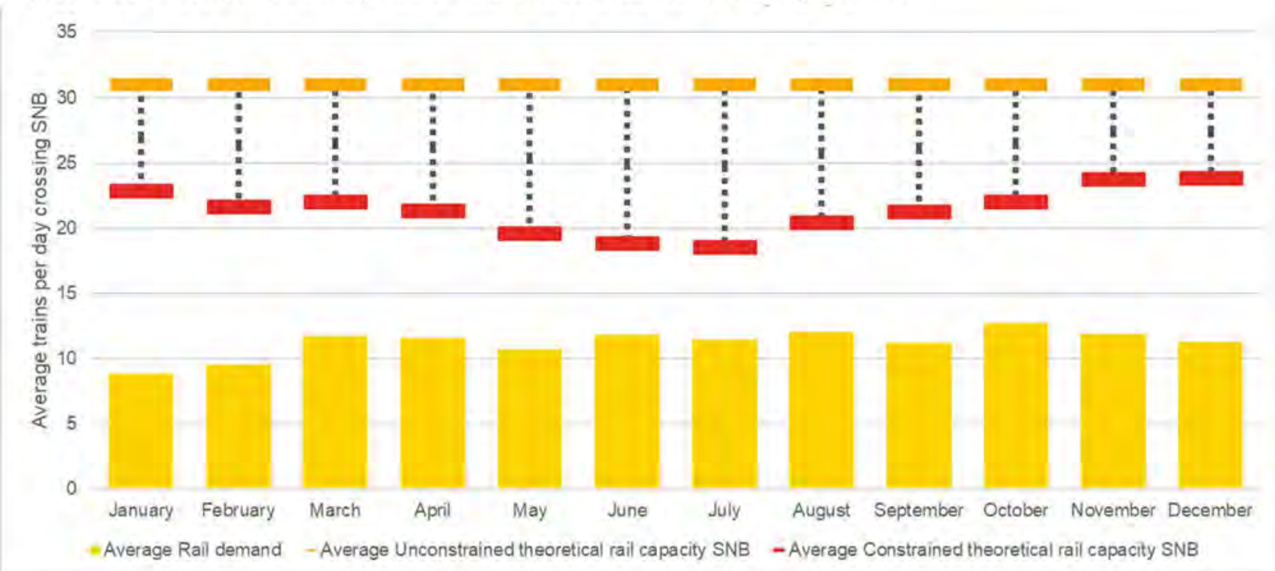


Figure 3.5: Averaged monthly rail demand and SNB rail capacity – 2010.



3.3.2 2018

Figure 3.6 and Figure 3.7 (overleaf) show the estimated bridge utilization, rail demand and rail capacity for each month in 2018. Similar to the 2010 outcomes, this shows fluctuations in marine traffic and rail traffic throughout the year, but despite the increase in rail demand from 2010, the monthly averages do not show a capacity constraint.

Figure 3.6: Averaged monthlySNB utilization – 2018.

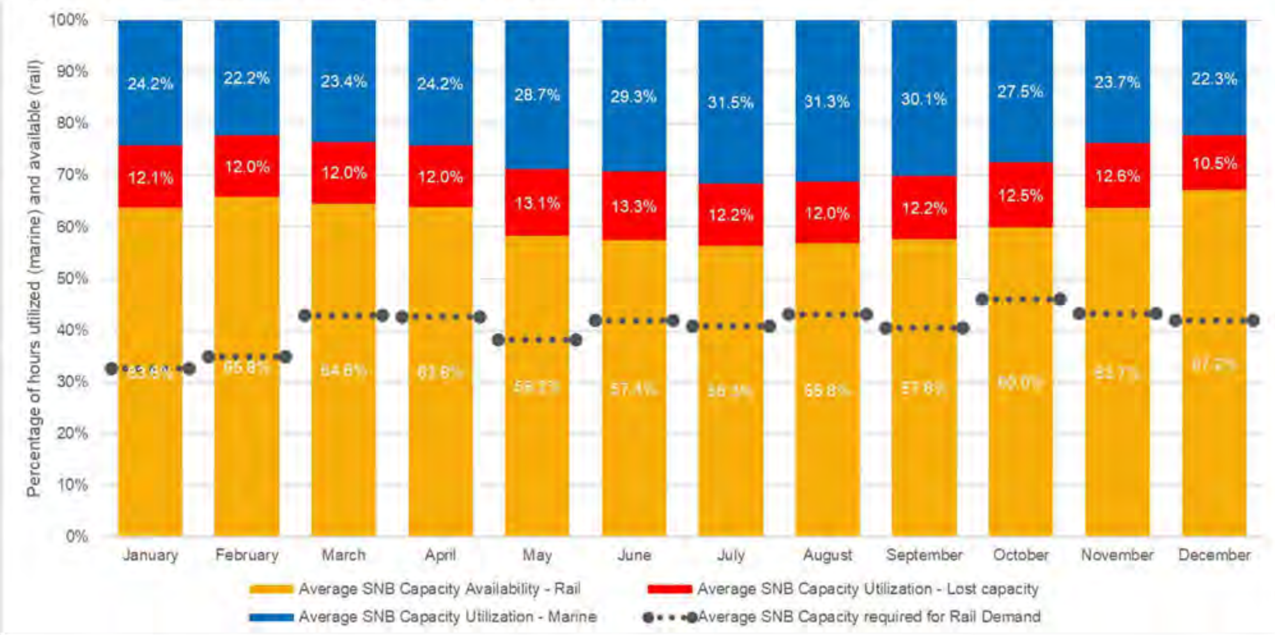
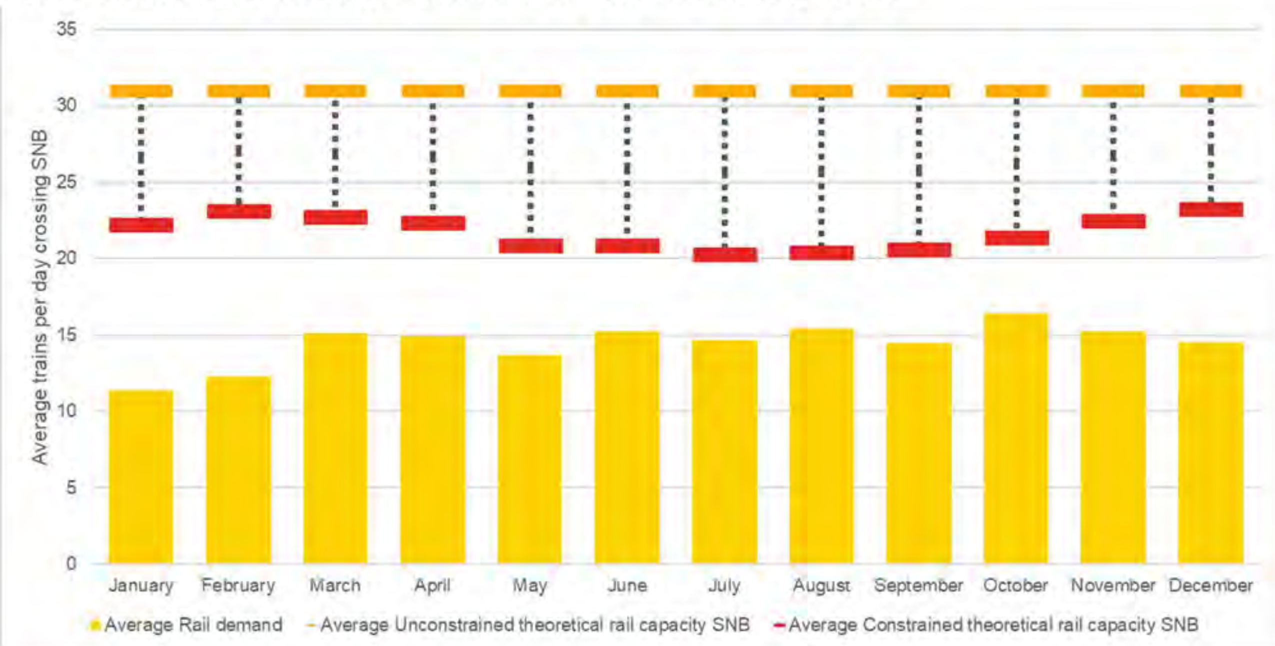


Figure 3.7: Averaged monthlyrail demand and SNB rail capacity – 2018.



3.3.3 2030 (Excluding GVG infrastructure projects)

Figure 3.8 and Figure 3.9 (overleaf) show the estimated bridge utilization, rail demand and rail capacity for each month in 2030. This shows that the rail demand exceeds the constrained rail capacity on the SNB for each month and not just during the peak months of marine or rail traffic.

Figure 3.8: Averaged monthly SNB utilization – 2030.

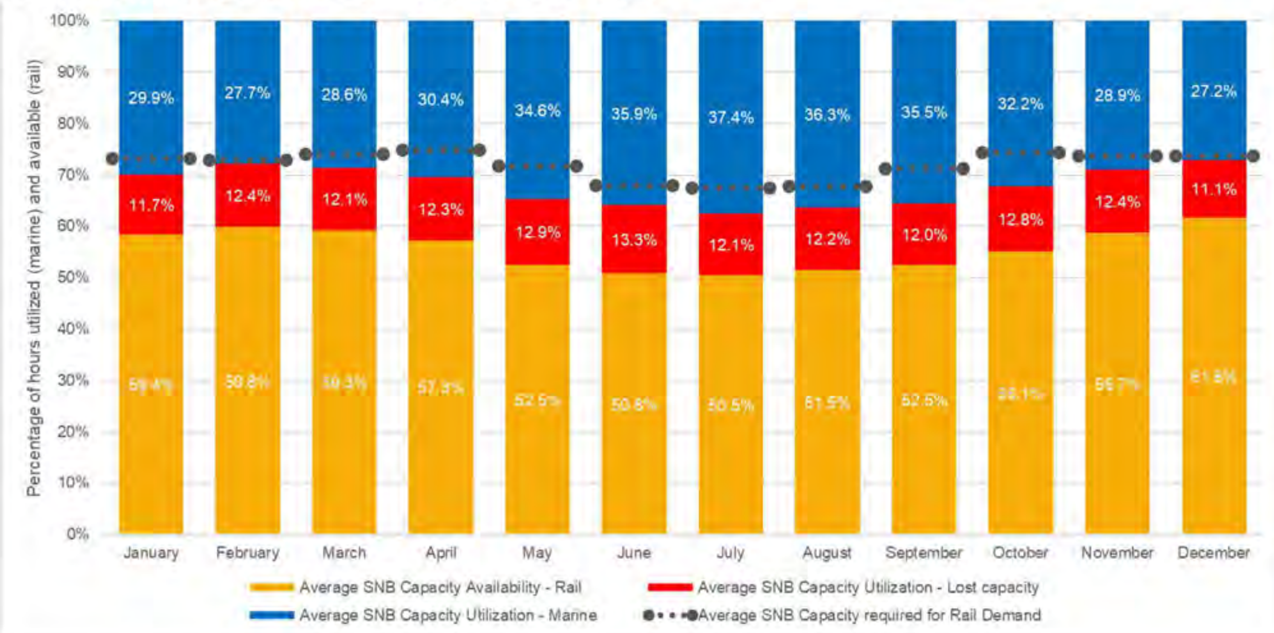
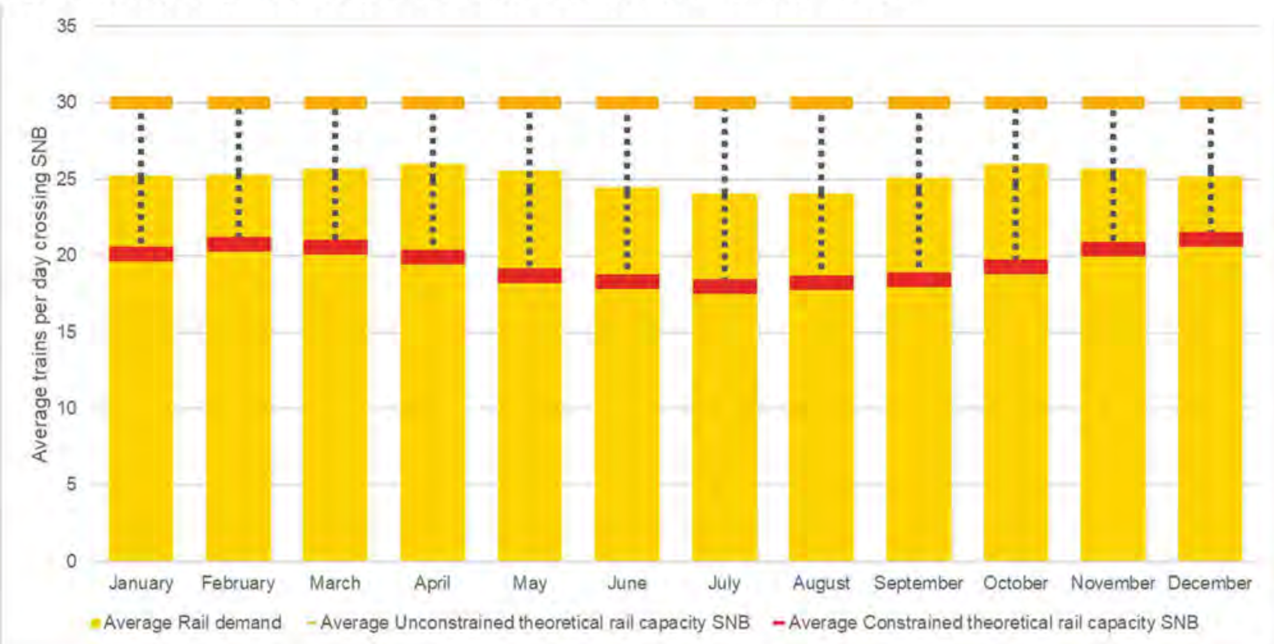


Figure 3.9: Averaged monthly rail demand and SNB rail capacity – 2030.



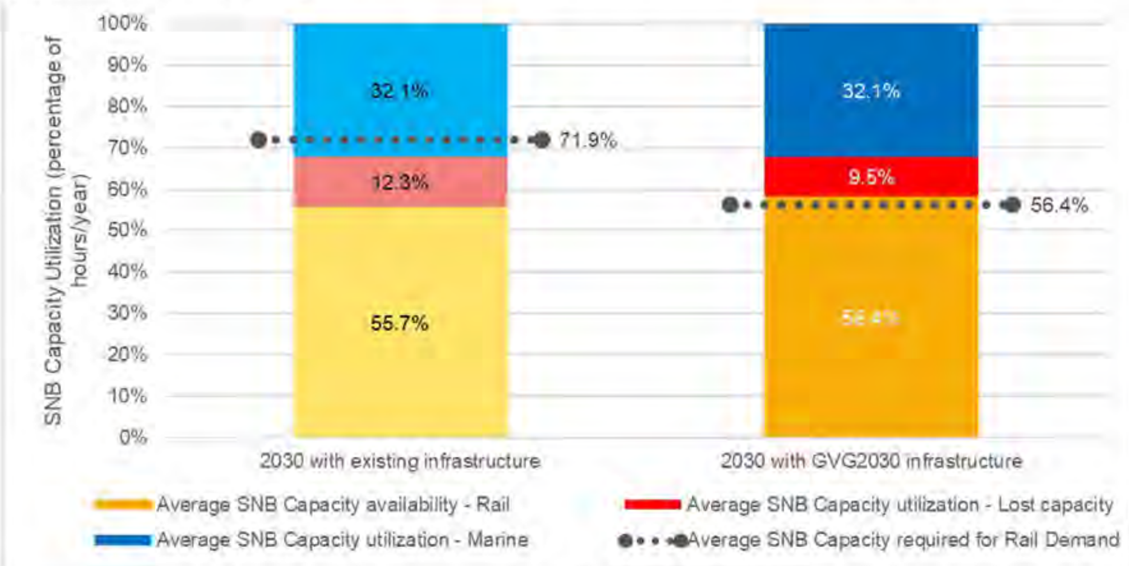
3.4 Impact of GVG2030 infrastructure on Second Narrows Bridge capacity

With the combined increase in rail and marine traffic in 2030, bridge availability for rail is insufficient to meet the growing demand without finding opportunities to better utilize that availability. Through previous Gateway simulation work, a number of infrastructure projects were identified to increase rail capacity and therefore, maximize utilization of existing rail infrastructure including the Second Narrows Bridge. The key projects assumed to positively impact the rail capacity on the SNB include the Thornton Tunnel ventilation upgrade and the Joint Line Douglas siding.

3.4.1 Annual Second Narrows Bridge capacity

Error! Reference source not found. shows a comparison between the annual SNB utilization in 2030 with and without the identified GVG2030 infrastructure projects.. These projects effectively reduce the average travel time between the north shore and the rest of the Lower Mainland's rail network. The utilization by marine traffic does not change and assumed to be fixed for this analysis.

Figure 3.10: Annual average SNB utilization – 2030 existing infrastructure versus GVG2030 infrastructure.



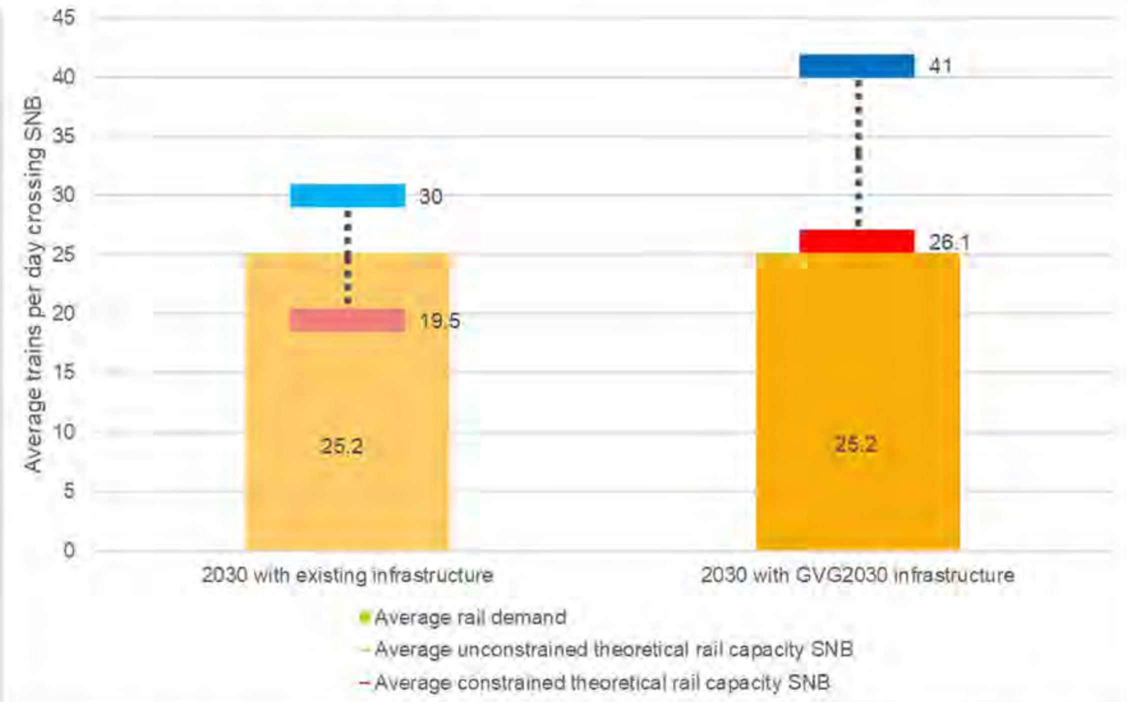
With a reduction in the train travel time and therefore a more efficient use of the time windows between bridge openings, it was estimated that the lost capacity would reduce from 12.3% to 9.5%. As a result, the SNB capacity available for rail increases to 58.4%.

In itself, this is not a significant increase and not sufficient to meet the 2030 rail demand. However, with the reduced travel times, the rail traffic makes more efficient use of the available SNB capacity. As a result, the SNB capacity required for rail demand reduces from 71.9% with existing infrastructure to 56.4% with GVG2030 infrastructure.

It is estimated that the rail utilization of the SNB is reduced from 129% with existing infrastructure to 97% with GVG2030 infrastructure. This would suggest that the increase in marine traffic combined with the identified GVG2030 infrastructure, results in a SNB average annual capacity sufficient for the increase in rail traffic. However, this does not account for monthly or daily variations in marine traffic and rail demand and the available 'spare' capacity is very small requiring on time arrival of trains at the SNB when windows permit train movements

Figure 3.11 (overleaf) presents the same results using train movements rather than average bridge utilization percentages. The figure shows the annual average rail demand and rail capacity for the 2030 horizon year with and without the GVG2030 infrastructure. The reduced average travel times for trains results in an increase in unconstrained rail capacity on the Second Narrows Bridge from 30 trains per day to 41 trains per day. More importantly, the constrained rail capacity increases from less than 20 trains per day to more than 26 trains per day.

Figure 3.11: Average annual rail demand and SNB rail capacity – 2030 existing infrastructure versus GVG2030 infrastructure.



For convenience, a comparison of key metrics from the two 2030 scenarios presented on the charts above are summarized on Table 3.3.

Table 3.3: Overview of key annual average outputs for 2030 scenarios

Output	unit	Existing Infrastructure	GVG2030 Infrastructure
Average rail demand	Trains/day	25.2	25.2
Average unconstrained theoretical rail capacity	Trains/day	30	41
Average constrained theoretical rail capacity	Trains/day	19.5	26.1
Average utilization of theoretical rail capacity	Percentage	129.3%	96.5%
Average SNB capacity utilization by marine	Percentage of hours/year	32.1%	32.1%
Average SNB lost capacity	Percentage of hours/year	12.3%	9.5%
Average SNB capacity available for rail traffic	Percentage of hours/year	55.7%	58.4%
Average SNB capacity required for rail traffic	Percentage of hours/year	71.9%	56.4%

3.4.2 Monthly Second Narrows Bridge capacity

Figure 3.12 (overleaf) shows the monthly SNB utilization for 2030 with and without the GVG2030 infrastructure. Like the annual average results, the marine traffic utilization does not change, while the lost capacity is reduced which provides additional available SNB capacity for rail traffic. The figure also shows that the required SNB rail capacity exceeds the available rail capacity for several months (the average monthly utilization of rail capacity varies between 90% and 103%). The 5 months where demand exceeds capacity are highlighted in the figure.

Figure 3.12: Monthly average SNB utilization – 2030 existing infrastructure vs. GVG2030 infrastructure

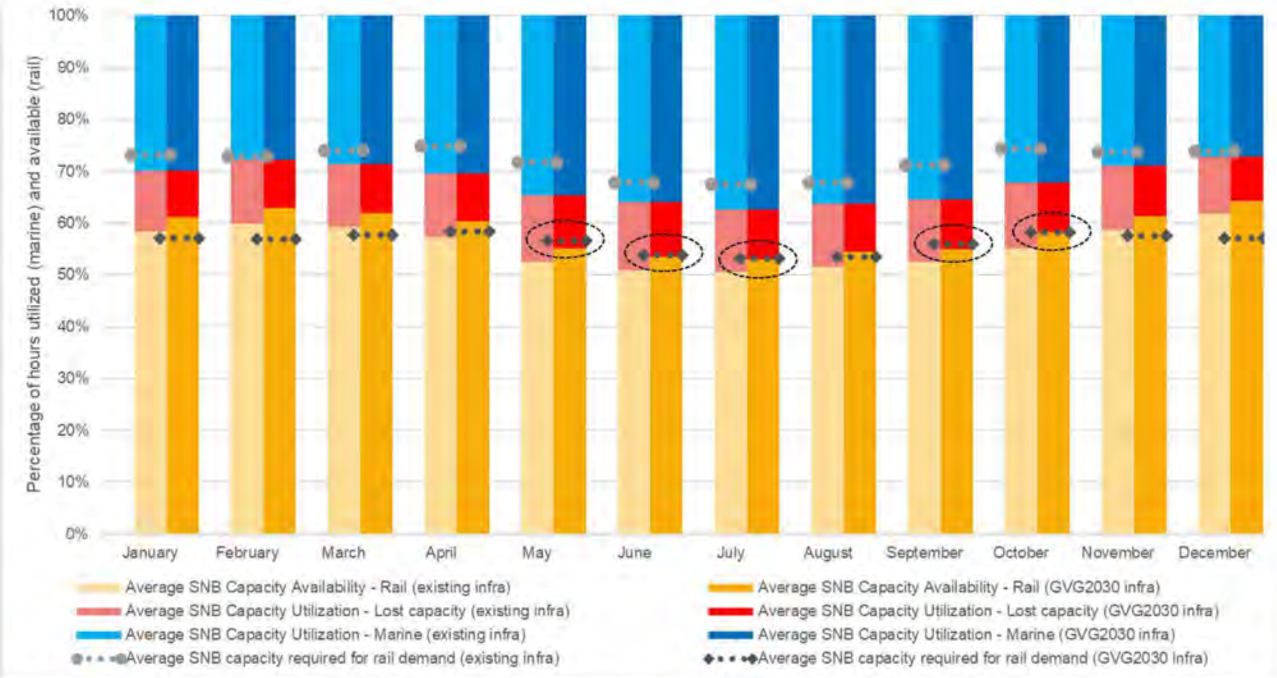
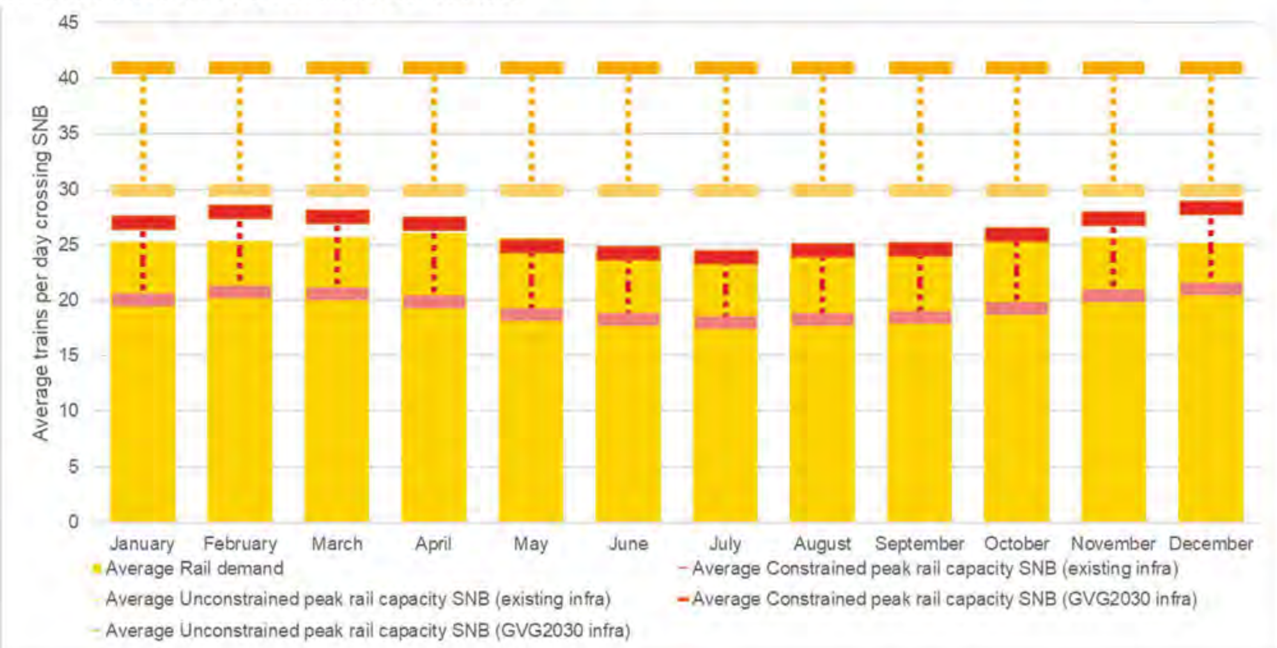


Figure 3.13 presents the same results using train movements rather than average utilization percentages. The average constrained rail capacity increases significantly due to the infrastructure upgrades.

Figure 3.13: Monthly average rail demand and SNB theoretical rail capacity – 2030 existing infrastructure vs. GVG2030 infrastructure.



3.4.3 Second Narrows Bridge typical day operations

Figure 3.14 shows a 'typical day' for the opening and closing of the Second Narrows Bridge for the 2030 marine traffic volumes. The top figure shows the bridge usage by rail traffic with the existing infrastructure, while the bottom figure assumes the GVG2030 infrastructure has been implemented, reducing train travel times.. Within the same available time windows, 19 trains can traverse the Second Narrows Bridge with the existing infrastructure compared to 25 trains with the GVG2030 infrastructure.

Figure 3.14: Second Narrows Bridge opening and closing on typical day in 2030 with existing infrastructure (top) and GVG2030 infrastructure (bottom) (number of trains crossing SNB shown per window).

4 Summary and Recommendations

4.1 Summary

Based on this analysis of the Second Narrows Bridge capacity, several conclusions can be drawn:

1. No sensitivity analysis to the marine traffic inputs or the rail traffic assumptions was conducted. However, it is to be expected that changes to some of the assumptions will significantly impact the results of this analysis.
2. This SNB capacity analysis only considers average theoretical capacity utilization over annual and monthly periods. Within these averages, there will be variations on a weekly, daily and hourly basis. On a more granular level, bridge utilization will vary and capacity constraints are more likely. It needs to be considered that in order to maintain flexibility in rail operations, there will need to be theoretical spare capacity for rail traffic on the Second Narrows Bridge.
3. The Ausenco inputs show a slight decrease in marine traffic between 2010 and 2018 and a significant increase in the marine utilization of the Second Narrows Bridge between 2018 and 2030. This is the result of increased MRA traffic through the corridor (increasing SNB utilization from 7.7% to 14.0% between 2010 and 2030).
4. Approximately 12% of the Second Narrows Bridge capacity is lost when the bridge is in the lowered position and not utilized by marine traffic, but simultaneously cannot be utilized by rail traffic because the available time window is too short.
5. Between 2010 and 2018 it is estimated that there is a small decrease in utilization of the Second Narrows Bridge by marine traffic, resulting in a minor increase in the constrained theoretical rail capacity. In the same period, rail demand is estimated to increase therefore increasing the utilization of the constrained rail capacity. However, this analysis shows sufficient spare capacity for rail traffic on the Second Narrows Bridge to allow for flexibility in rail operations.
6. Between 2018 and 2030 with existing infrastructure, it is estimated that both the marine traffic utilization and rail demand over the Second Narrows Bridge increase significantly. This results in an expected rail utilization that exceeds the available rail capacity by almost 30%.
7. The GVG2030 infrastructure projects have a significant positive impact on the rail capacity of the SNB. These projects allow train traffic to more efficiently use the available time windows between marine traffic utilization of the Second Narrows Bridge. The average annual constrained rail capacity slightly exceeds the rail demand. However, the monthly averages suggest that in some months the rail utilization slightly exceeds the rail capacity. Therefore, with the implementation of GVG2030 infrastructure projects, it is expected that additional measures will be required to accommodate the increase in marine and rail traffic and to provide some flexibility in rail operations and timetabling.
8. The analysis does not assume any latent rail demand impacts resulting from improved GVG2030 infrastructure which could potentially increase the constrained rail capacity across the SNB. In addition, the Ausenco inputs assume that the Second Narrows Bridge remains open if the available time window for rail traffic was shorter than 30 minutes. In the scenario including GVG2030 infrastructure, it is estimated that the travel time for the first train is shorter than 30 minutes. As a result, there may be some additional usable SNB windows for rail traffic that have not been included in this analysis.

4.2 Recommendations

Based on the summary of results above, the following recommendations have been formulated:

1. A sensitivity analysis of both the marine traffic inputs and the assumptions for the rail corridor is recommended to improve the understanding these inputs have on the overall results. The sensitivity analysis should consider assumptions such as the number of vessels, rail average speed etc.
2. The GVG2030 infrastructure improvements have a significant positive impact on the rail capacity across the Second Narrows Bridge. Although the analysis assumed 2030 as the horizon year, it is expected that the capacity constraints will materialize sooner and therefore the infrastructure upgrades are recommended to be implemented before 2030.
3. The identified GVG2030 infrastructure improvements by themselves are likely insufficient to fully resolve the capacity constraint. It is therefore recommended to investigate additional opportunities to reduce travel time across the section and/or improve the efficiency of marine and rail operations across the Burrard Inlet.
4. The results show a significant capacity loss due to short time windows between marine openings that are not usable for rail traffic. It is recommended that improved operational integration and collaboration between marine traffic and rail traffic is investigated to see if the amount of lost capacity could be reduced. In particular, considering the more predictable deep-sea vessels, opportunities may exist to increase usable bridge capacity for rail traffic without significant infrastructure investments.
5. Further discussion with CN is recommended to identify the level of spare capacity for rail traffic required for flexibility and variability in rail demand and operations. Ultimately, a target minimum rail capacity across the SNB needs to be defined to evaluate whether the proposed measures sufficiently resolve the capacity constraint.

Appendices

A. Inputs & Assumptions Report

104203-01-RPT-0001 - CN Bridge Utilization Study, Inputs & Assumptions – 27 Sep 2019

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104203-01-RPT-0001
Revision A

Vancouver Fraser Port Authority Second Narrows Marine Traffic

CN Bridge Utilization Study

Inputs and Assumptions

September 27, 2019

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Revision Status

Revision	Date	Description	Author		Approver	
A	Sep 27, 2019	Inputs and Assumptions	Stephen Wong	Simulation Consultant	Jason Smolensky	Project Manager

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Table of Contents

1 Introduction

1.1 Background

The Burrard Inlet is a body of water located in Vancouver, Canada well-protected from the open ocean. A large variety of marine traffic, including, passenger vessels, deep sea vessels, and recreational vessels traverse to and from the inlet on a regular basis. The inlet also contains two passenger vehicle bridges and the CN Bridge that connect Greater Vancouver's central and northern regions. Figure 1-1 shows a map of the Burrard Inlet.

Figure 1-1 – Map of Burrard Inlet

Vessel movements through the Second Narrows Movement Restricted Area (MRA) of the Burrard Inlet are complex due to variable metocean conditions and traffic rules that are applicable to different vessel types. The CN Bridge, situated within the MRA, is required to rise for nearly all vessels that require passage through the MRA due to its low profile. Any time that the bridge is raised for vessel transits it becomes unavailable for rail traffic. Vessel traffic is expected to increase with the projected expansion plans for terminals within the Burrard Inlet, and opportunities for rail movements are expected to decrease as a result.

Vancouver Fraser Port Authority (VFPA), who manages all marine and rail operations in the Burrard Inlet, is interested in understanding the impact of future vessel traffic through the Second Narrows on the CN Bridge rail capacity.

In 2016, Ausenco carried out a simulation study for VFPA[1] using Ausenco's existing model of the Trans Mountain Expansion Project (TMEP), which included all forecasted vessel traffic resulting from the TMEP as well as from other terminal expansions east of the MRA. The simulation model was updated with new information provided by VFPA to create a representation of the vessel traffic levels after all known terminal expansions would be completed. The model accurately captured all the rules and interactions in the MRA and was used to evaluate the utilization of the CN Bridge.

VFPA approached Ausenco to update this study as well as to carry out additional analyses to support a larger study they are carrying out to assess rail constraints to the North Shore and implications for North Shore terminal growth.

[1] Ausenco, 101462-010-RPT-0001, *Port of Vancouver Second Narrows Marine Traffic CN Bridge Utilization Study*, Draft Memorandum, Revision B, March 1, 2017

1.2 Study Scope

VFPA is interested in understanding the CN Bridge availability windows constrained by marine traffic for three horizon years:

- Pre Asia Pacific Gateway Corridor Initiative (APGCI) (2010).
- Post-APGCI (2018).
- Future Expansion Year representing all known terminal expansions (2030).

VFPA will use the outputs of this study to inform potential marine/rail optimization schedules as well as inputs to a third-party rail modelling exercise.

2 Inputs and Assumptions

This section describes the inputs and assumptions used in the assessment of the CN Bridge utilization. Only the changes to the existing TMEP model are included in this document. Complete details for the existing TMEP model and MRA operational assumptions can be found in the "TMEP Marine Transportation Assessment" report referenced in Section 2.1.

2.1 Sources of Data

The inputs to the model used for this study were based the following sources:

- TMEP Marine Transportation Assessment, "TMEP Marine Transportation Assessment rev3.docx", prepared by Ausenco, dated June 25, 2015.
- Second Narrows Bridge Operations Report, *"2018 Vessels Only 2019-07-18.xlsx"*, provided by VFPA.
- Selected Trade Area Terminals Vessel Calls, *"PoV - 2010 & 2018 - Selected Trade Area Terminals - Vessel Calls.xlsx"*, provided by VFPA.
- Delcan Report, *"2011-07_Second_Narrows_Rail_Bridge_-_Clearance_Detection_System_Feasibility_Study_-_Final_Report_-_Delcan.pdf"*, provided by VFPA, dated July, 2011.
- Port Information Guide, *"2019-05-01-PORT-INFORMATION-GUIDE-FINAL-1.pdf"*, provided by VFPA at https://www.portvancouver.com/marine-operations/port-information-guide/, dated May 1, 2019.
- Harbour Operations Manual, *"harbour-operations-manual_practices-and-procedures-for-the-vancouver-fraser-port-authority.pdf"*, provided by VFPA, dated June 10, 2010.
- 2030 Forecast by Mott MacDonald, *"397107-MMD-00-P0-DA-RW-0002 - Gateway Terminal Throughput Breakdown RevA - Uncontrolled draft.pdf"*, provided by VFPA.
- Wind and Visibility Data, Environment Canada, National Climate Data and Information Archive, 1953 - 2018 Historical Visibility and Wind Records at Vancouver International Airport, *"www.climate.weatheroffice.gc.ca"*, September 2019.

2.2 CN Bridge

The Second Narrows Bridge Operations Report, hereafter referred to as the Operations Report, contained data for CN Bridge raising and vessel passing events for 2018. The Operations Report did not contain any bridge lowering events. As a result, the interactions between marine activities and the CN Bridge were based on analysis of 2014 data from the 2016 study for two main categories of vessels:

- **MRA vessels:** tankers, bulkers, barges and other vessels that are bound by the MRA rules.
- **Non-MRA vessels:** recreational vessels, barges, patrol boats, government vessels, and other vessels that require passage through the MRA but are not bounded by strict movement procedures.

Note that Non-MRA vessels have the lowest priority to transit within the MRA. These vessels were not explicitly modelled in the TMEP study, as they did not directly impact the TMEP study. They have been included in the model for this study to accurately evaluate the utilization of the CN Bridge

The modelled time from "Bridge Raised" to "Vessel Passed" was taken to be 35 minutes for MRA vessels and 10 minutes for non-MRA vessels.

The modelled time from "Vessel Passed" to "Bridge Lowered" was taken to be 10 minutes for MRA vessels and 5 minutes for non-MRA vessels.

Figure 2-1 Durations for "Bridge Raised" to "Vessel Passed" and "Vessel Passed" to "Bridge Lowered"

2.3 Modelled Vessel Traffic

For the three horizon years, modelled vessel traffic levels were calculated for MRA vessels and non-MRA vessels.

2.3.1 2010 Vessel Traffic

Table 2-1 shows the calculated number of vessel passings of the CN Bridge in 2010. The number of Deep Sea vessel passings were counted from the Selected Trade Area Terminal Calls. The number of Pleasure Craft vessel passings and the total number of vessel passings were counted from the Delcan Report. All remaining vessel passings were assumed to fall in the Commercial/Tug category.

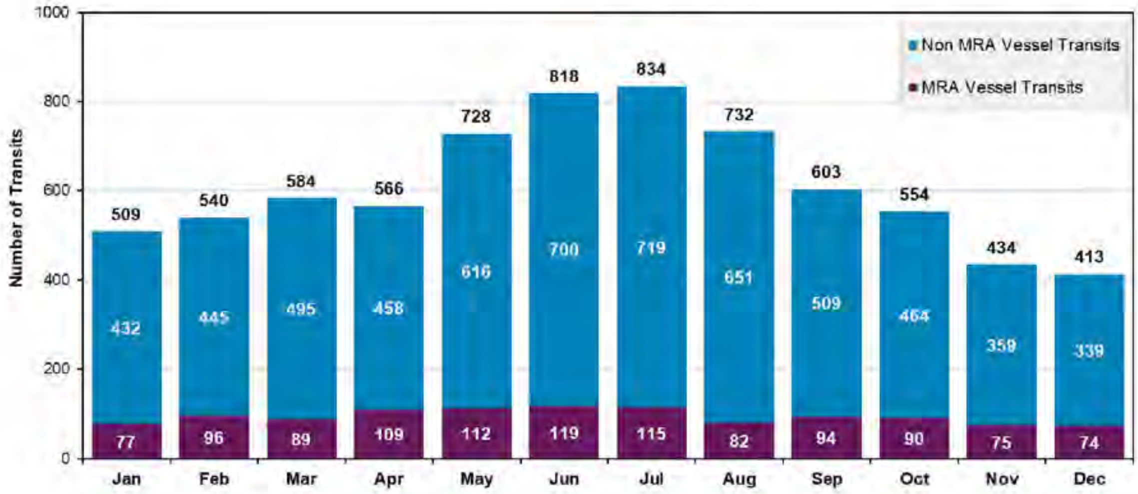
Table 2-1 Number of Vessel Passings in 2010

Vessel Type	Number of Passings
Deep Sea	594
Pleasure Craft	1361
Commercial/Tug	5360
Total	**7315**

Deep Sea vessels were considered as MRA vessels and Pleasure Craft were considered as non-MRA vessels. As in the 2016 study, 10% of Commercial/Tug were assumed to be MRA vessels, and the remaining 90% of Commercial/Tug were assumed to be non-MRA vessels.

Figure 2-2 shows the calculated number of MRA and non-MRA vessel passings in 2010 by month.

Figure 2-2 Number of MRA and non-MRA Vessel Passings in 2010 by Month



The MRA vessels in the model were assigned to terminals east of the Second Narrows Bridge, based on data from the Selected Trade Area Terminals Vessel Calls.

The non-MRA vessels in the model for a given day were generated by randomly choosing a day from the same month and day of the week in 2018, and using the traffic arrival pattern for that day. To account for differences in traffic volume between 2010 and 2018, the number of vessels for that day was scaled by monthly traffic volume and if required, vessels were randomly added or removed from the arrival pattern for that day.

2.3.2 2018 Vessel Traffic

Table 2-2 shows the number of vessel passings of the CN Bridge in 2018, as counted from the Operations Report.

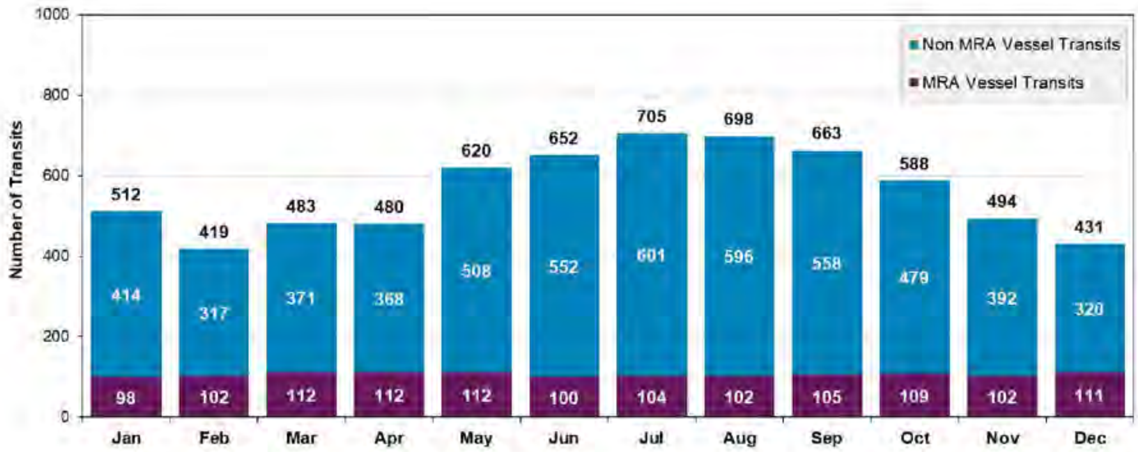
Table 2-2 Number of Vessel Passings in 2018

Vessel Type	Number of Passings
Deep Sea	803
Pleasure Craft	1282
Commercial/Tug	4660
Total	**6745**

As in the 2016 study, 10% of Commercial/Tug were assumed to be MRA vessels, and the remaining 90% of Commercial/Tug were assumed to be non-MRA vessels.

Figure 2-3 shows the calculated number of MRA and non-MRA vessel passings in 2018 by month.

Figure 2-3 Number of MRA and non-MRA Vessel Passings in 2018 by Month



The MRA vessels in the model were assigned to terminals east of the Second Narrows Bridge, based on data from the Selected Trade Area Terminals Vessel Calls.

The non-MRA vessels in the model for a given day were generated by randomly choosing a day from the same month and day of the week in 2018, and using the traffic arrival pattern for that day.

It is noteworthy that total vessel counts for a number of months turned out to be higher in 2010 compared with 2018.

2.3.3 2030 Vessel Traffic

Table 2-3 shows the estimated number of vessel passings of the CN Bridge in 2030.

Table 2-3 Number of Vessel Passings in 2030

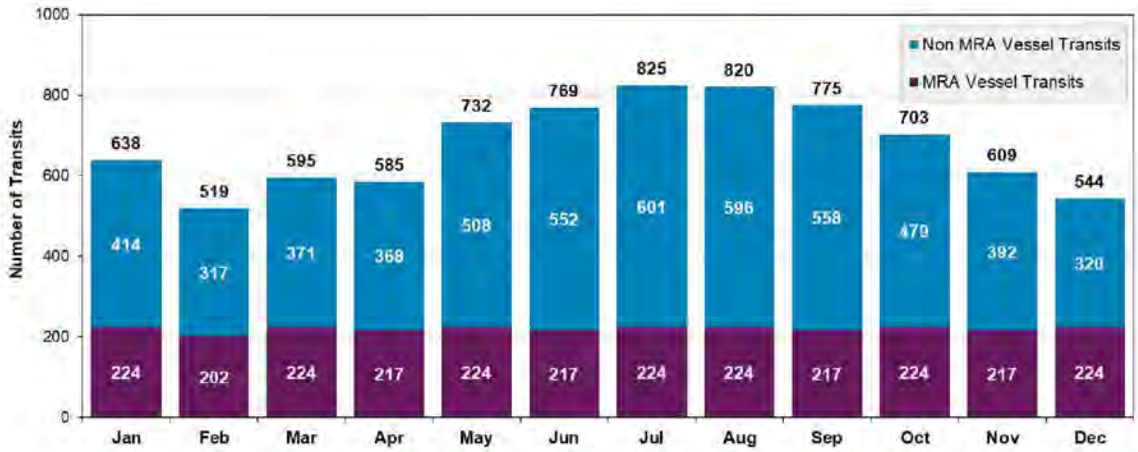
Vessel Type	Number of Passings
Deep Sea	1998
Pleasure Craft	1282
Commercial/Tug	4834
Total	**8114**

The number of MRA vessels at each terminal east of the Second Narrows Bridge (except for the Westridge Terminal) were scaled up from the 2018 counts by the factor at which the berth throughput for the terminal was forecasted to increase in the 2030 Forecast by Mott MacDonald. The number of vessels at the Westridge Terminal, for which Mott MacDonald did not have a 2030 Forecast, was taken from the TMEP study.

The number of non-MRA vessels in 2030 was assumed to be the same as in 2018.

Figure 2-4 shows the estimated number of MRA and non-MRA vessel passings in 2030 by month.

Figure 2-4 Number of MRA and non-MRA Vessel Passings in 2030 by Month



2.4 Tidal Current Restrictions

The tidal current limits in the Second Narrows Traffic Control Zone for this study were updated to be consistent with the latest limits from the 2019 Port Information Guide. Table 2-4 shows a comparison of the tidal current limits for modelled vessels based on information from the 2010 Harbour Operations Manual and 2019 Port Information Guide.

Table 2-4 Comparison of Tidal Current Limits

Vessel Type	Direction	2010 Harbour Operations Manual Current Threshold (knots)		2019 Port Information Guide Current Threshold (knots)	
		Following	Opposing	Following	Opposing
Aframax	Empty	1	1	0.5	1
	Loaded	0.5	0.5	0.5	1
Panamax	Empty	2	2	0.5	1
	Loaded	0.5	0.5	0.5	1
MRA Barge	Empty	-	-	-	-
	Loaded	2	2	2	2
Large Bulker	Empty	-	-	0.5	2
	Loaded	2	2	0.5	2
Dangerous Goods Vessel	Empty	-	-	0.5	2
	Loaded	2	2	0.5	2

The current limits from the 2010 Harbour Operations Manual were used for simulating the year 2010.

The current limits from the 2019 Port Information Guide were used for simulating the years 2018 and 2030.

2.5 Wind and Visibility Restrictions

Wind and visibility data were updated from the previous study to include data up until December 2018. As in the previous study, data for wind and visibility was obtained for the Vancouver International Airport from the National Climate Data and Information Archive from Environment Canada. The historical period from January 1953 to December 2018 was available, but only the most recent period from 2000 to 2018 was used. The Vancouver International Airport, while some distance away from the CN Bridge, was the closest station for which a comprehensive data set could be obtained.

Using the data, the following rules were imposed to vessels in the model:

- All vessels were restricted from transiting by westerly winds exceeding 25 knots.
- MRA vessels were restricted from transiting when visibility was less than 1.5 nmi.
- Non-MRA vessels were restricted from transiting when visibility was less than 0.5 nmi.

3 Simulation Results

4 Conclusions

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