APPENDIX B1

RISK ASSESSMENT SUMMARY REPORT BURNABY TERMINAL

FOR THE TRANS MOUNTAIN PIPELINE ULC TRANS MOUNTAIN EXPANSION PROJECT NEB CONDITION 22

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[redacted]

Prepared for:

TRANSMOUNTAIN

Trans Mountain Pipeline ULC

Kinder Morgan Canada Inc.
Suite 2700, 300 – 5th Avenue S.W.
Calgary, Alberta T2P 5J2
Ph: 403-514-6400

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1.0 INTRODUCTION

In compliance with Condition 22 of Order XO-T260-010-2016, Trans Mountain has completed an updated risk assessment for Burnaby Terminal. The risk assessment forms part of the document entitled "Burnaby Terminal Expansion Risk Assessment Report", prepared by Genesis Oil & Gas Consultants Ltd (the "Genesis Report"), which is included in Appendix B2. The Genesis Report demonstrates that for risks that cannot be eliminated, the risks at Burnaby Terminal have been reduced to As Low As Reasonably Practicable (ALARP) while complying with the Major Industrial Accidents Council of Canada (MIACC) criteria for risk acceptability.

2.0 THE GENESIS REPORT

Given the similarities in methodology required for the approaches to fire risk assessment (the primary subject of Condition 22) and the risk-based approaches used to demonstrate the adequacy of tank containment, impoundment and retention areas (the subject of Condition 24), the Genesis Report includes the technical information supporting both Conditions. The Genesis Report is organized in such a way that the inputs, assumptions, and results related to each Condition are separately identified. In the following discussion, the elements of the Genesis Report that are relevant to Condition 22 for Burnaby Terminal are specifically identified, where applicable.

3.0 DESIGN VARIANCES

Trans Mountain has been issued a Certificate of Public Convenience and Necessity (CPCN) OC-64 as related to the Trans Mountain Expansion Project and amendments to two existing CPCNs as related to existing facilities and pipeline segments: OC-2 and OC049. In addition, the Board issues five orders as related to temporary workspace, pump stations, terminal development and the deactivation of an existing pump station. Of relevance to this condition is Order XO-T260-010-2016, which authorizes the construction of tanks and related infrastructure at Burnaby Terminal.[1] Figure 5-3 in the Genesis Report shows the revised configuration of Burnaby Terminal.

More specifically, with respect to the tanks and the secondary containment areas, the following are the principle elements of the design which are materially different from the design that was reflected in the original TMEP Application and Technical Update No. 2 and approved in Order XO-T260-010-2016:

Tank Sizes (nominal or shell volumes):

[1] Order XO-T260-010-2016 also authorized construction of tanks and related infrastructure at the Edmonton Terminal West Tank Area and Sumas Terminal.

- Tank 74 and Tank 76: Each reduced from 53,300 m^3 (335,000 bbls) to 45,300 m^3 (285,000 bbls) by reducing the diameter from 60.95 m (200 ft.) to 56.40 m (185 ft.).
- Tank 78: Reduced from 53,300 m^3 (335,000 bbls) to 26,200 m^3 (165,000 bbls) by reducing the diameter from 60.95 m (200 ft.) to 42.70 m (140 ft.).
- Tank 80 and Tank 89: Each reduced from 45,300 m^3 (285,000 bbls) to 40,500 m^3 (255,000 bbls) by reducing the diameter from 56.40 m (185 ft.) to 53.40 m (175 ft.).

Tank Spacing (between the tanks identified):

- Tank 74 and Tank 76: Increased from 0.5 diameters to 0.58 diameters.
- Tank 76 and Tank 78: Increased from 0.5 diameters to 0.80 diameters (of Tank 76).
- Tank 80 and Tank 86: Increased from 0.5 diameters (of Tank 80) to 0.81 diameters (of Tank 80).
- Tank 85 and Tank 89: Increased from 0.5 diameters (of Tank 89) to 1.12 diameters (of Tank 89).
- Tank 91 and Tank 93: Increased from 0.5 diameters to 0.77 diameters.
- Tank 93 and Tank 95: Increased fro 0.5 diameters to 0.93 diameters.
- Tank 95 and Tank 97: Decreased from 0.9 diameters to 0.77 diameters.
- Tank 96 and Tank 98: Increased from 0.5 diameters to 0.62 diameters.

  Note 1: As discussed in Trans Mountain's response to City of Burnaby IR No. 1.08.03a (Filing ID A3Y2E6), CSA Z662, Clause 4.15.1.2, requires that the location and spacing of storage tanks be in accordance with National Fire Protection Association (NFPA) Code 30, Flammable and Combustible Liquids Code. NFPA 30, Clause 22.4.2.1, requires that floating roof storage tanks have a spacing of ¼ times the sum of adjacent tank diameters, where open diking is provided (as is the case at Burnaby Terminal). This is consistent with the spacing of 0.25 times the sum of adjacent tank diameters required by the British Columbia Fire Code (BCFC), Division B, Part 4, Clause 4.3.2.2.

  Note 2: ¼ (0.25) times the sum of adjacent tank diameters is equivalent to 0.5 times the diameter of one of the tanks, for adjacent tanks of equal diameter.

Secondary Containment:

- Tank 74, Tank 76 and Tank 78: one three-tank shared secondary containment area reconfigured to one two-tank shared secondary containment area (Tank 74 and Tank 76) and one single-tank secondary containment area (Tank 78).
- Tank 71, Tank 85 and Tank 89: one three-tank shared secondary containment area reconfigured to one two-tank shared secondary containment area (Tank 85 and Tank 89) and one single-tank secondary containment area (Tank 71).
- Tank 91, Tank 93, Tank 95, and Tank 97: one three-tank shared containment area (Tank 91, tank 93, and Tank 95) and one single-tank shared containment area (Tank 97) reconfigured to two two-tank shared secondary containment areas (Tank 91 and Tank 93 / Tank 95 and Tank 97).
- Partial Remote Impoundment Area deleted.

A full description of the secondary containment scheme at Burnaby Terminal is included in Section 6.6 of the Genesis Report.

4.0 RISK REDUCTION BY DESIGN

Although the approved design (represented in the Application, Technical Update No. 2) was in accordance with the applicable governing regulation, codes, and standards, Trans Mountain focused on several core risk-reduction principles in the evolution of the design and incorporated them to the extent reasonably practicable:

- reduce tank sizes, while maintaining operational service levels;
- increase tank spacing;
- eliminate three-tank shared containment areas;
- reduce the secondary containment surface areas; and

- Overflow connectivity between adjacent secondary containment areas.

Trans Mountain was able to follow these principles, as demonstrated by the following:

- five tanks were reduced in diameter, with the resulting aggregate volume being reduced by 50,880 m^3 (320,000 bbls) or approximately 8%;
- the spacing between seven pairs of adjacent tanks was increased by an average of 61%;
- three three-tank shared secondary containment areas were eliminated;
- with the elimination of the three-tank shared secondary containment areas, the associated surface areas were reduced by approximately 50%; and
- overflow connectivity between adjacent secondary containment areas was provided.

5.0 FIRE EVENT RISKS (INDIVIDUAL RISK AND RISK ACCEPTABILITY CRITERIA)

Genesis describes in their report, individual risk as "the probability of an individual experiencing a fatal injury" per year. Individual risk values at various locations surrounding a facility were calculated by Genesis and summarized in their report as contours of equal risk and then overlaid on a map of land use types to be able to compare to the MIACC acceptability criteria. The MIACC acceptable land use criteria, which appear in Section 9.2 of the Genesis Report, are summarized in **Table 1**, below.

Table 1: MIACC Risk Acceptability Criteria (Annual Individual Risk)

Annual Individual Risk Range	Allowable Land Use
Greater than 1×10^{-4}	None
1×10^{-4} to 1×10^{-5}	Manufacturing, warehouses, open spaces (parkland, golf courses, etc.)
1×10^{-5} to 1×10^{-6}	Commercial, offices, low-density residential
Less than 1×10^{-6}	All other uses, including institutions, high-density residential, etc.

If the calculated individual risk values represented by the risk contours correspond with the acceptable level of risk identified for the overlaid land use types, then the facility is considered to have an acceptable risk profile.

6.0 FIRE EVENT RISK ACCEPTABILITY FOR BURNABY TERMINAL

Section 13.0 of the Genesis Report includes multiple figures which show the individual risk contours associated with various events at Burnaby Terminal. Figure 13-11 shows the combined individual risk contours associated with all events. This also appears in Section 14.0, Figure 14-1 and Section 3.0, Figure 3-1. Trans Mountain has produced an illustrative map of Burnaby Terminal and the surrounding area, included in Appendix B3, which enhances the view of the physical relationship between the individual risk contours and the land uses. This illustrative map demonstrates the expanded Burnaby Terminal meets the MIACC criteria of acceptability. In particular, the areas enveloped by the 1×10^{-6} individual risk contour include low-density residential housing (two small areas directly south of the Terminal), agricultural, parkland, and industrial land uses. In addition, the 1×10^{-5} contours do no extend beyond the Terminal property.

According to Genesis's individual risk contour map, the entirety of the currently developed Simon Fraser University (SFU) campus lies outside of the 1×10^{-7} individual risk contour (in blue), as does Forest Grove Elementary School, which demonstrates these land uses are acceptable. The planned future SFU

development areas, south of the currently developed campus (bordering University Drive), lie outside the 1 x 10^{-6} contour (in green), demonstrating these future land uses are also acceptable.

7.0 SPILL EVENT (OVERFLOW) RISK

Genesis was also able to analyze various spill events, fire events causing spills, and the assessment of overflow risk from secondary containment areas, to determine the adequacy of secondary containment.

For Burnaby Terminal, this part of the risk assessment is further addressed in the filing for Condition 24.

8.0 SPECIFIC RISK ASSESSMENT REQUIREMENTS

There are a number of individual requirements that make up Condition 22. The following discusses how each of the requirements is addressed in the Genesis Report for Burnaby Terminal. All references are to sections or figures in the Genesis Report.

a) The effect of any revised spill burn rates

The formulae and approach to burning rates are included in Section 7.3 (Fire) of the Genesis Report.

b) The potential consequences of a boil-over

A boil-over is not a primary event but a type of escalation (domino or knock-on) event. The formulae and approaches for calculating boil-over parameters are included in Section 7.3 (Boil-Over) of the Genesis Report. The thermal radiation contours resulting from boil-overs, for Burnaby Terminal, are included in Section 11.5 (Figure 11-9). The fall-out affected area is identified in Section 11.5 (Figure 11-10). The individual risk contours are included in Section 13.0 (Figure 13-7).

Boil-over was previously discussed at length in Trans Mountain's response to NEB IR No. 6.23 (Filing ID A4R6I4). The following points were identified in the response and these points are reinforced in Section 7.3 (Boil-Over) and Section 8.4:

- The new tanks will be designed with features to prevent the accumulation of water, which is necessary to cause a boil-over event.
- The new tanks will be fitted with fixed automated full-surface fire-suppression systems and back-up mobile systems.
- Boil-over events (in the cases where fires cannot be extinguished) take many hours to develop, allowing emergency management plans (i.e. evacuation) to be initiated.

As identified in Section 7.2, the probability of boil-over, given a full surface tank fire, is taken to be 1.0 per the available literature. This has been done for the statistical analysis required of the NEB condition, and assumes the fixed, automated and back-up full surface fire suppression systems included in the design (which will be installed, tested and maintained in order to suppress a full-surface tank fire) are ineffective or inoperable when required.

As shown in Section 7.3 (Boil-Over), Table 7-4, Genesis has calculated the minimum time to boil-over for the smallest (36.6 m) tanks at Burnaby Terminal (Tanks 71, 72 and 73), with low levels of stored liquid (25% full), is approximately five hours. For larger tanks (i.e. Tanks 80, 89, 96 and 98), with low levels of stored liquid (25% full), the boil-over time is approximately seven hours. The times are much longer for tanks with higher levels of stored liquid, nearly 24 hours for larger tanks at 75% full.

These are significant time periods that would provide opportunity to implement tactical response plan to supress and extinguish a fire well before a boil-over event were to occur. This period also affords opportunity for tiered emergency management plans, if it became necessary. This is reinforced by considering the risk equations presented in Section 9.1.2. of Genesis report. In these equations the term $P(I/E_i)$ represents the probability of individual (I) being present at the time that the escalation event (in this case a boil-over) occurs. Implementation of emergency management measures (proximity control and evacuation) will reduce the value of $P(I/E_i)$ to zero and thus the individual risk at any location within the fall-out effected area to zero.

c) *The potential consequences of flash fires and vapor cloud explosions.*

The formulae and approaches for calculating flash fire and vapor cloud explosion parameters are included in Section 7.3 (Flash Fire) and Section 7.3 (Explosion [Blast]) of the Genesis Report. The thermal radiation contours resulting from flash fires, for Burnaby Terminal, are included in Section 11.3 (Figure 11-7). The thermal radiation contours resulting from vapour cloud explosions, for Burnaby Terminal, are included in Section 11.4 (Figure 11-8). The individual risk contours for flash fires and vapour cloud explosions are included in Section 13.0 (Figure 13-5) and Section 13.0 (Figure 13-6), respectively.

d) *The cumulative risk based on the total number of tanks in the terminal considering all potential events (pool fire, boil-over, flash fire, vapor cloud explosion).*

The cumulative individual risk contours for all events, for Burnaby Terminal, are included in Section 13.0 (Figure 13-10) of the Genesis Report. The events considered include all of the tanks in the Terminal and include tank fires, boil-overs, pool fires, flash fires, and explosions, triggered by various causes. The consequences considered include the effects of heat and smoke.

e) *The domino (knock-on) effect caused by the release of the contents of one tank on the other tanks within the terminal's common impoundment area(s) or on other tanks in adjacent impoundment areas.*

The approaches to the assessment of domino (knock-on) effects are included in Section 8.0 of the Genesis Report. The individual risk contours for all events with domino effects included are included in Section 13.0 (Figure 13-11). These are the governing contours for the determination of fire risk acceptability.

f) *Risk mitigation measures, including ignition source control methods.*

The methods for risk assessment established by Genesis, following accepted practices, do not include risk mitigation measures. As they have been derived from statistical analyses of event data, the event frequencies included in Section 7.1 (Table 7-1) and Section 7.2 (Tables 7-2 and 7-3) and the ignition probabilities included in Section 7.3.4 (Figure 7-10) inherently consider preventative controls that are features of typical industrial facilities. For risk assessment purposes fire-suppression is assumed not to have an immediate enough effect to prevent the initial impacts of heat and smoke. However, even with the use of standardized frequencies and probabilities and without Trans Mountain's enhanced risk mitigation measures being quantitatively taken into consideration, the risk assessment shows that the combined individual risk from all events that could occur within Burnaby Terminal is acceptable based on the MIACC criteria.

Mitigation measures such as fire-suppression and emergency management are important elements of overall risk-management, to prevent the potential for fire escalation and bring fire situations under control, thereby limiting continuing impacts. Fire-fighting systems and emergency management will be addressed in detail in the compliance filings for Conditions 118, 119, 120, 123, 124, 125, 127(a), 136 and 153.

9.0 MINIMIZATION OF RISKS (TO AS LOW AS REASONABLY PRACTICABLE)

As discussed in the preceding sections, the fire risks arising from Burnaby Terminal, without additional mitigation measures being specifically included, are extremely low and are acceptable in accordance with the MIACC criteria. In Design Variances and Risk Reduction by Design, above, Trans Mountain has identified the enhancements made to the design, all intended to reduce the risk associated with both fire and spill events. Trans Mountain has not identified any additional changes that can be made to the design without materially affecting the operational viability of the post-expansion Trans Mountain system. The number of tanks, size combinations, and aggregate capacity are required to fulfill the throughput requirements and service levels (including commodity segregation). Trans Mountain has optimized the physical arrangement of the tanks in the most logical, efficient, and practical way, for development and the constraints of the property. In the response NEB IR No. 3.093b (Filing ID A4H1V2) Trans Mountain has described preventative and mitigative controls designed to reduce the risk of fires and spills. A number of the controls exceed those required by regulation. As such, risks associated with the Burnaby Terminal have been reduced to As Low As Reasonably Practicable (ALARP).