PORT METRO vancouver

Summary Report - Terminal 2 (T2) Trade-Off Process and Outputs

Container Capacity Improvement Program

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Executive Summary

Overview

This summary report documents concept design and planning alternatives assessed against sustainability considerations to provide balance between financial, economic and social considerations during the Project Definition phase of the Roberts Bank Terminal 2 Project. This work was undertaken in order to develop and confirm a reference concept for Port Metro Vancouver (PMV) to bring forward for consultation with the public and stakeholders, and environmental assessment by regulators.

The objective of this summary is to provide a record of the alternatives considered, differentiating factors and alternatives carried forward into subsequent phases of study.

Trade-Off Study

The Trade-Off Study of T2 Orientation and Offset required the integration of multiple technical inputs from separately documented engineering, economic, environmental and consultation reports and from a number of Subject Matter Experts and work stream leads.

Six viable alternative positions for Terminal 2 were identified at Roberts Bank. Two options for terminal orientation were considered, both to the north-west of the existing Deltaport and Westshore pods. The W1 orientation was located parallel to the -10 m depth contour off Roberts Bank, and the W2 orientation perpendicular to the -10 m depth contour. For each orientation, three offset options at a distance of 0 m, 275 m or 500 m from this contour were considered, providing a total of six options.

Each alternative was assessed by the technical experts against differentiators. The main drivers amongst the economic differentiators were construction cost and schedule, influenced primarily by volumes of dredge and fill and the cost of soil improvement required to meet seismic requirements, and potential habitat offsetting costs. Environmental considerations were comprised of potential requirements for habitat offsetting, from the direct and indirect effects of terminal footprint and dredge basins. Taken separately, both economic and environmental considerations favoured the W1 orientation with an offset between 0 m and 275 m. Community and First Nations considerations did not emerge as major differentiators, with these being in alignment with environmental considerations. .

The W1 orientation was identified as preferred, and through further refinement of differentiators, an approach was identified for determining a preferred offset between 0 m - 275 m from the 10 m contour. Further assessment of the impact of dredge, fill and soil improvement on the reclamation schedules did not produce an obvious favourite between W1 (0) and W1 (275) from the dredging and land reclamation costs, constructability and schedule. The cost of habitat offsetting prevailed: W1 (0) causes the least habitat loss and therefore carries lowest habitat offsetting cost.

The W1 orientation with 0 m offset was thus confirmed as the preferred alternative for the proposed Roberts Bank Terminal 2 Project.

Related Trade-Off Considerations

Related Trade-Off considerations were predominantly single-discipline exercises where considerations were dominated by a particular discipline (Transportation or Terminal Planning, for example) supported by inputs from other work streams.

The process was followed for the following Related Trade-Offs, with outcomes noted below:

- T2 Berth Structures – Preferred alternative was caisson structures.
- Causeway Expansion concepts – Causeway widening preferred.
- Tug Basin – Expand existing basin.
- Short-Sea Shipping – Make allowance for barge berths in T2 layout.
- Terminal Planning (Footprint, Automation) - Use fully automated concept as it requires a footprint large enough to accommodate other alternatives.

Conclusion

The concept and engineering trade-offs documented in this summary demonstrate how sustainability considerations were applied to the identification of preferred alternatives in the project definition phase of the Terminal 2 Project.

The summary demonstrates how sustainability considerations were balanced between six alternatives for orientation and offset of the terminal itself.

The related trade-offs also used sustainability considerations to identify preferred alternatives.

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1. INTRODUCTION

Concept Engineering and planning, Environmental Assessment planning and public and First Nations consultation processes inevitably present a wide variety of alternative designs for the proposed Roberts Bank Terminal 2 Project.

Where factors considered by individual work streams have no impact on other work streams, there was clearly no need for an integrated approach; in contrast, where engineering recommendations may have implications affecting the environmental regulatory process or public and First Nations interest, for example, then the sustainable development approach to integrating economic and financial, environmental and community and First Nations considerations was applied.

This summary documents the alternatives considered, differentiating factors, and alternatives carried forward into subsequent phases of study. Its objective is to demonstrate how sustainability considerations map into differentiators between those alternatives to provide balance between financial, economic and social considerations for the Terminal 2 Project and was a primary focus for the Project Definition Phase of project development. All project elements will be evaluated as part of the environmental assessment process for the proposed project, and therefore may be subject to change.

2. SUMMARY OF T2 TRADE-OFF STUDIES

2.1 Identification of T2 Project Definition Phase Trade-Offs and Considerations

The particular issues requiring application of the Trade-Off process were identified in a joint workshop of work stream leads:

- **Trade-Off study** requiring the integration of multiple technical inputs from separately documented engineering, economic, environmental and consultation reports and from a number of Subject Matter Experts and work stream leads. The T2 Orientation and Offset Trade-Off is the primary Trade-Off study in this phase of the Project.
- **Related Trade-Off considerations** are predominantly single-discipline studies where considerations are dominated by a particular discipline (Transportation or Terminal Planning, for example) supported by inputs from other work streams. For Related Trade-Offs, the Trade-Off is documented in the summary material produced by the current process and in the technical report. The process was followed for the following Related Trade-Offs:
  - T2 Berth Structures.
  - Causeway Expansion concepts.
  - Tug Basin.
  - Short-Sea Shipping.
  - Terminal Planning (Footprint, Automation).

2.2 Terminal 2 Orientation and Offset Trade-Off Study

2.2.1 Overview

The Terminal 2 Orientation and Offset Trade-off was the primary Trade-Off study in this phase of the CCIP.

2.2.2 Alternatives

Previous Terminal 2 studies, discussions with Fisheries and Oceans Canada (DFO) and environmental work relating to the original construction of Deltaport, the Deltaport Third Berth Project and the Adaptive Management Strategy reduced potential sites for the new Terminal 2 to those immediately west of the existing Roberts Bank facilities.

Two layouts were distinguished by their berth orientations (referred to as W1 and W2). Orientation W1 faced offshore and W2 was perpendicular to the shoreline.

For each orientation, studies examined advantages and disadvantages of positioning the terminal in a range of positions, from the furthest practical offshore position on the -10 m depth contour, constrained by practical design limitations for seismic events, to a setback of 500 m from the -10 m contour, which would align the offshore edge of fill with the offshore edge of the existing terminal. Greater setback distances came with greater encroachment on to intertidal habitat. Recognizing that an optimum might exist in between the limiting positions, the trade-off also included intermediate setback in the range of

275 m to 350 m from the -10 m contour. All six alternatives were determined to be technically feasible (Figure A).

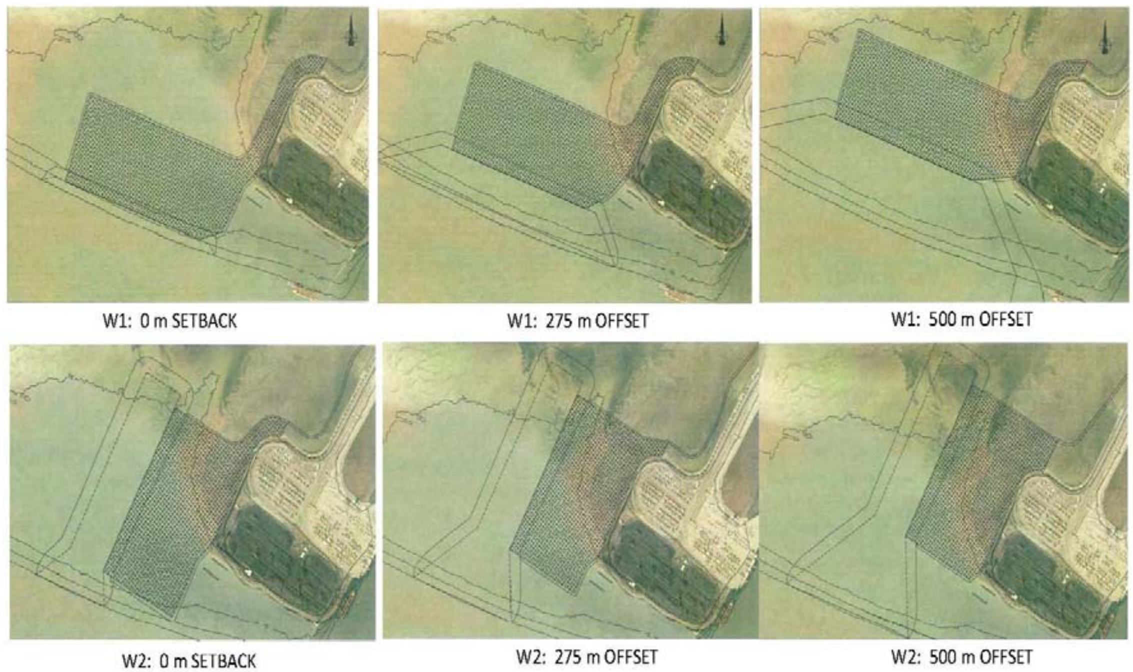

Figure A Alternatives for T2 Orientation and Offset

2.2.3 Differentiators

The key differentiators in evaluating the six alternatives included construction cost and schedule and environmental considerations.

Construction costs were primarily driven by dredge and fill and soil improvement requirements, and environmental considerations primarily focused on the direct impact to the intertidal foreshore habitat..

Economic and financial considerations were driven by cost of construction comparisons from Engineering and Planning work. Highlights were as follows:

- Soil improvements necessary to meet seismic design requirements for berth and perimeter dykes drive construction cost and schedule. Soil improvement costs were estimated to be higher for the W1 orientation than for W2, as a result of the orientation of the berth parallel to the foreshore slope, and longer perimeter dykes.
- Dredge and disposal volumes increase with increased setback from the 0 m contour. For all options, excess dredged material requires disposal at sea. The amount is least for W1 (0 m) with the lowest dredge volume. The volume is substantially greater for all the other options with dredge volumes roughly three times greater for the 'W1 – 275 m' orientation, and more than five times larger for the 'W2 – 500 m' orientation.
- Fill volume for land reclamation affected construction cost and schedule. All options required import of fill for perimeter dikes and causeway fill.

- When construction costs for dredge and fill were combined with those for soil improvement, the combined cost was within estimate uncertainty bounds for all options.
- All options allowed staging of construction.
- Constructability considerations did not show a consistent advantage in a particular alternative. Disposal at sea of surplus or unsuitable dredge material carries the least risk for options with lower dredge volumes – 'W1 orientation, 0 m' setback. In contrast, weather risk is lower for the W2 orientations because construction activities would be less exposed.
- Dynamic mooring analysis showed that the W1 orientation offers an advantage with respect to operational downtime due to wind- and wave-induced vessel movement, and navigation issues. The W2 orientation aligns berthed vessels perpendicular to south-easterly storms.
- Barges for short-sea shipping could be accommodated on the main berth for W2 configurations but could be accommodated on a separate berth for W1 orientations (see Related Trade-Off in Section 3.3.4).
- Potential for interference with Westshore or Deltaport operations was low for all alternatives except 'W1 – 500 m' offset which would have approached close to Westshore Terminal Berth 1 and possible conflict should Westshore want to extend its berths at some point in the future..
- Effects on the arrangement of road, rail, container yard and intermodal yard were generally neutral with slightly more efficient layout of road and rail links between intermodal yard and causeway yards possible with 'W1 – 275 m' and 'W2 – 0 m' offsets.
- The W2 configurations would have a higher potential for rapid sedimentation requiring regular maintenance dredging, whereas W1 options would require minimal dredging, with the 'W1 – 0 m' offset having the least risk of sedimentation.
- Shipping and navigation desk work confirmed that pilots and tug operators favoured W1 over W2 because of more favourable alignment with respect to predominant storm winds and currents.

Environmental considerations in the trade-off were assessed within the context of the marine sub-tidal and intertidal habitats supporting a large number of species of concern. These included the biofilm habitat supporting seabirds, eelgrass and other habitats supporting fish and crab populations, and critical habitat for the endangered Southern Resident Killer Whales. The specific considerations were assessed in terms of direct impacts to sub-tidal and intertidal habitats associated with the terminal footprint and the dredge area, and potential indirect impacts arising from coastal geomorphology processes.

Key environmental differentiators were as follows:

- Expected habitat offsetting (compensation) and adaptive management costs were highest for 'W2 – 500 m' offset and lowest for 'W1 – 0 m' offset. The estimates for compensation costs included direct and indirect effects and were based on conservative assumptions to reflect uncertainty of offsetting requirements.
- Different habitat types have ecological value based on relative productive capacity. These would be affected to different degrees depending on the proposed terminal layouts and the locations of specific habitat types within the footprint of each alternative. The alternatives offset 500 m from the -10 m contour would have the highest impact on higher value habitat relevant for a number

of species of concern (intertidal zone). For this reason, the 500 m offset alternatives were removed from further consideration.

- The footprint of the ‘W2 – 0 m’ and ‘W2 – 275 m’ offset alternative was also found to intrude on the higher value intertidal habitat.
- Interactions with several habitats supporting specific species including juvenile fish, and sea pens confirmed that the ‘W1 – 500 m’ offset, ‘W2 – 0 m’ and ‘W2 – 500 m’ offset alternatives should be dropped from consideration.
- Potential for on-site eelgrass offsetting favoured the W1 options, with a slight preference for ‘W1 – 0 m’ offset for this consideration.
- Coastal geomorphology considerations included tidal currents, waves, and dendritic channel formation. The potential for the formation of dendritic channels was deemed unacceptably high for all W2 configurations.

The environmental considerations indicated a clear preference for the ‘W1 – 0 m’ offset alternative as it offered:

- Least impact to productive and critical habitats; it is furthest away from sensitive near shore habitats (bird feeding biofilm habitat and eelgrass in particular).
- Highest potential for onsite habitat compensation
- It best minimizes the potential for seabed erosion adjacent to the terminal footprint. Other design options are more likely to result in (large) seabed changes and ensuing changes to more important biological habitats.

Differentiators based on the impact of the alternatives on the community and First Nations interests considered noise, visual aesthetics, light, and traditional access to crab and fishing areas. These did not show significant differences across alternatives orientations. It was therefore concluded that while these issues would be retained as important considerations, they would not drive the assessment of alternatives. Further detail on all considerations will form part of the Alternative Means section of the Environmental Impact Statement, a future phase as part of the environmental assessment of the proposed project.

As a final summary differentiator, the total PMV infrastructure cost including dredge, fill, soil improvement, berth structures, and potential direct/indirect impacts to habitat were compared. Relative differences between the total expected cost estimate for the alternatives were directionally consistent, with W1 (0) expected to have the lowest total capital cost.

2.2.4 Recommended Alternative

As currently conceived, the W1 orientation has been identified as preferred option. Further considerations to determine a preferred offset between 0 m - 275 m from the 10 m contour were then considered.

Further assessment of the impact of dredge, fill and soil improvement on the reclamation schedules did not produce an obvious favourite between W1 (0 m) and W1 (275 m) from the dredging and land reclamation costs, constructability and schedule. The lower potential direct/indirect impacts to intertidal habitat associated with W1 (0 m) confirmed the 0 m offset as the preferred alternative for the proposed Roberts Bank Terminal 2 Project.

2.3 Related Trade-Off Considerations

2.3.1 Berth Structures

Overview

Conceptual designs were developed for the marginal wharf structure for T2 to a degree sufficient to recommend a system for each of the W1 and W2 terminal configurations. Order-of-magnitude comparative costs were based on these designs.

Alternatives

Two alternatives were considered:

- Reinforced concrete caisson type gravity structures relying on self-weight to resist lateral loads from retained soils and berthing impact. Extensive dredging is required to remove in-situ soils susceptible to liquefaction. Extensive works associated with soil improvements are required including densification, removal of poor quality soils and replacement with a substantial crushed rock mattress. These are required to achieve seismic performance criteria and resist bearing pressures resulting from loads imposed by the self-weight of the caissons, ship-to-shore gantry cranes, storage and container handling equipment.
- Pile supported deck relying on driven piles to resist both vertical and horizontal loads transmitted through a reinforced concrete deck and pile caps. A sheet pile bulkhead wall is provided immediately behind the piled wharf structure to retain the fill soils. Significant ground improvement is required to achieve seismic performance criteria.

Differentiators

Significant financial differentiators included construction cost, risk and schedule impact. Seismic performance was an important factor driving the design for both structural systems.

Consideration of the environmental differentiators revealed a tension between two factors. Fisheries habitat impact favours the pile and deck system because the pile and deck structures allow replacement of fish habitat through a change in the total water column. In contrast, waterborne noise generated during the driving of the piles is an important issue for killer whales, strongly favouring the caisson solution.

Airborne noise during construction also has an important impact on the community, again favouring the caisson alternative.

Recommended Alternative

This work identified the caisson berth structural system as the recommended alternative. The main drivers for this preference were:

- Lower cost (~20% lower than piled supported deck).
- Lower constructability risks (caissons constructed off-site; lower exposure to extreme weather conditions, no pile driving).

- Lower schedule risks (caissons constructed off-site; not susceptible to weather conditions at site).
- Performs better under seismic events.
- More durable with less maintenance.
- Waterborne noise is lower (constructed off-site, no pile driving).
- Airborne noise and community impact is lower.

2.3.2 Causeway Expansion Concepts

Overview

Alternative causeway expansion concepts were investigated for their potential for reducing impact on sensitive habitat on the north-west side of the existing causeway. This trade-off was driven primarily by the environmental considerations, complemented by construction cost and First Nations considerations.

Alternatives

The trade-off considered three layout concepts, including construction of a new causeway parallel to the existing one, incorporating a lagoon by splitting the causeway linking to Terminal 2 from the Deltaport / Westshore access, and simply widening the existing causeway. Three structural concepts; fill construction, pile and deck, and elevated road and rail structures, were combined with these layouts to produce the five alternatives considered.

Differentiators

The differentiators considered included:

- The parallel causeway would have the greatest direct impact on adjacent mudflats and known biofilm seabird habitat. It was therefore excluded.
- A lagoon concept would disturb First Nations crab and bivalve harvesting area, and was therefore excluded.
- A widened causeway provided flexibility and redundancy for road and rail traffic, allowing sharing and inter-connection between terminals.
- Although the pile and deck structure would have a slight advantage over the fill structure in preserving inter-tidal habitat, such advantage would be reduced by shading effects.
- Construction costs for the pile and deck were found to be higher than the caisson option.

Recommended Alternative

Widening the existing causeway with fill construction emerged as the preferred alternative.

It was noted that environmental considerations required that road and rail layouts minimize the additional width required, and be configured to avoid impacting habitat.

2.3.3 Tug Basin

Overview

An initial study was conducted to develop concepts for provision of tug mooring facilities for a second tug operator to service the new T2 terminal, and to compare the concepts with respect to capital cost and general arrangement functionality. Detailed construction details, mooring and wave analysis were excluded from the scope of this preliminary study.

Alternatives

The conceptual study examined the following alternatives:

- Options were proposed to expand the existing tug basin facility at Deltaport.
- An option was proposed for a new tug basin on the W1 configuration.

Differentiators

Expanding the existing tug basin had operational advantages with respect to accommodating two tug operators. Access from shore and pontoons would not be shared. Capital cost differences between the options considered were marginal.

Creating a new tug basin was the most expensive option, with potential construction costs over twice as much as the potential cost of expanding the existing basin.

Recommended Alternative

The findings of this study, which prepared conceptual vessel mooring options sufficient for the proposed tug operators required to serve the proposed T2 terminal and existing Roberts Bank port facilities, concludes that the preferable development option is to expand the existing tug basin facility.

2.3.4 Short Sea Shipping

Overview

The Short Sea Shipping trade-off was reduced to consideration of how to make provision for possible future implementation of short-sea shipping in the Terminal 2 design.

Alternatives

The trade-off was conducted relative to a “do nothing” alternative, making no allowance for barge loading in the Terminal 2 design.

The alternatives relevant to the W1 orientation involved including barge loading on the W1 main berth or providing a dedicated facility on the NW face of W1.

Differentiators

Financial considerations indicated that viability of, and demand for; short sea shipping has not been confirmed. There are however environmental and community benefits in reducing truck traffic with short-sea shipping. The case for making provision for the barge berth is then driven by this option value.

Dynamic mooring analysis showed that accommodation of barges on the main berth face is not feasible due to exposure to wind and waves and consequent excessive downtime when loading operations, berthing and mooring would be compromised. Analysis indicated that a berth located on the NW face of the terminal would be protected from the worst wind and waves, and provides a viable location for barge berths.

Recommended Alternative

The combination of considerations identified that the preferred alternative will be to ensure that terminal design allows for future construction of a dedicated short-sea shipping facility on the NW face of W1, as and when a clear case for implementation emerges.

2.3.5 Terminal Planning (Footprint, Automation)

Overview

The Roberts Bank Terminal 2 Project will ultimately be designed and built by a concessionaire, subject to environmental approval and permitting, so final layout, equipment and operating philosophy may differ from the alternatives described in the planning work. All preliminary conceptual level terminal layouts considered have recognized the need to minimize cost, environmental and social impact by focussing planning on high density storage options in order to minimize the terminal footprint.

Alternatives

The AECOM work focussed on high yard-density alternatives:

- Conventional Rubber-Tyre Gantry (RTG) based layout using similar operating principles to Deltaport: this alternative is characterised by manual operations with high labour cost.
- A proven automated layout with Automated Stacking Cranes serviced by Shuttle Carriers.
- An unproven automated layout using Cantilevered Rail-Mounted Gantry (CRMG) cranes and offering optimized operations.
- A variation of all the above alternatives examined the possibility of moving the Intermodal Yard off the terminal on to the up-lands, to reduce the terminal footprint.
- Lastly, Seaport Canada Consultants also examined a semi-automated configuration with manual transfer from CY to IY stacks with reduced technical operating risks.

Differentiators

The worldwide trend in container terminals is moving towards automation. As automated terminals would require more land, a degree of automation has been assumed for Terminal 2. This assumption was used to complete the assessment of other trade-offs.

The driver for environmental and community considerations were as follows:

- Terminal footprint influenced habitat impact. The RTG layout offered potential for a slightly smaller footprint (terminal width of approximately 610 m instead of approximately 700 m for automated options). If the larger footprint for the automated ASC layout is used as the basis for further design work and the EIS, then all alternatives can be accommodated.
- Analysis of emissions from equipment operation clearly showed the advantage of electric operations for all options, driven by the availability of low-emissions power in British Columbia.
- An automated terminal offers the possibility of reduced light pollution into the community.

Recommended Alternative

The automated ASC layout was carried forward since using this footprint offers flexibility to the future concessionaire in future design phases.

2.3.6 Emergency Access

Overview

Sustainability considerations were applied as constraints and design criteria in layout of road and rail. For example, design objectives included minimizing causeway footprint and impact on ALR agricultural land.

A case where a trade-off between operational capacity and environmental considerations was overtly made involved the provision in the layout of redundant access routes to provide emergency access and commercial continuity in the event of blockages to primary access. Providing this access came at the cost of a wider causeway, with greater habitat impact.

Alternatives

Alternatives for providing access included using maintenance roads, improving those maintenance roads at the cost of an additional 5 m of causeway width, and providing fully redundant access by mirroring Roberts Bank Way on the north side of the causeway.

Differentiators

The main economic drivers were economic: cost of construction, and the potential cost of interrupted operations due to access blockages.

The environmental consideration of habitat impact from widening the causeway dominated: any causeway width that is not essential to the viability and safety of Terminal 2 is unlikely to be approved through the EA process. This differentiator results in the elimination of the alternative with fully redundant access.

Recommended Alternative

The preferred alternative taken into the Environmental Assessment process is the second alternative with improved access. This alternative offered an appropriate balance between operational requirements and minimising impacts on environmental factors.