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Attachment 3

MEMORANDUM

DATE:	2021-11-16	**RWDI Reference No.:** 2104113
TO:	Justin Hart, P.Eng., GSI Project Manager – Major Projects City of Pitt Meadows	**EMAIL:** JHart@pittmeadows.ca
FROM:	Matthew Johnston, P.Eng. Ben Coulson, P.Eng., M.A.Sc. Laura Dailyde, P.Eng., PMP	**EMAIL:** matthew.johnston@rwdi.com **EMAIL:** ben.coulson@rwdi.com **EMAIL:** laura.dailyde@rwdi.com
RE:	**Modelling, Analysis and Mitigation Summary** **City of Pitt Meadows** **Pitt Meadows, BC**	

The City of Pitt Meadows retained RWDI to conduct noise and vibration modelling at residences next to the rail corridor within Pitt Meadows, BC from the Vancouver Intermodal Facility (VIF) in the west, to Golden Ears Way in the east. The study purpose is to provide a comparison to modelling that was conducted as part of the 2020 BKL Consultants Ltd. (BKL) study entitled "Pitt Meadows Road and Rail Improvements Environmental Noise and Vibration Assessment" (i.e., the "BKL Study"). The BKL Study was prepared to assess the predicted noise and vibration levels from the Pitt Meadows Road and Rail Improvements Project (i.e., the "Project"). The proposed Project, also referred to as "North Build", entails the following:

- A 6,000-foot (1,829 meters) extension of the existing lead track that accesses the VIF, east of Harris Road
- An additional 10,000-foot (3,048 meters) of new siding track on the north side of the existing tracks between Harris Road and Kennedy Road

In 2021, RWDI completed noise and vibration monitoring at seven (7) locations along the corridor. Six (6) of the locations included noise monitoring while five (5) of the locations included vibration monitoring. The findings of the monitoring are provided in a separate monitoring summary memo. The results of this monitoring were used to validate the modelling results presented in this analysis. As part of this analysis, RWDI has modelled the following scenarios:

- Existing 2021 conditions;
- 2030 – No Project (As per information provided within the BKL Study);
- 2030 – North Build Scenario (As per information provided within the BKL Study).

The modelled results are compared to applicable criteria. There are existing barriers in place for select areas of the corridor, with additional proposed mitigation being considered as part of the future Project. The effectiveness of the proposed mitigation is assessed as part of this analysis.

Noise and vibration terminology within this memo is consistent with the BKL Study unless otherwise stated. Please refer to the BKL Study for noise and vibration terminology definitions.

Analysis

Details of the noise and vibration analysis are provided below.

Noise Analysis

To predict the sound levels at the surrounding receivers, noise modelling was conducted using the Cadna/A noise prediction software using the U.S. FTA/FRA algorithm for freight traffic and the ISO 9613 algorithm for train pass-by levels using Cadna/A's moving point source technique. In contrast, BKL's Study utilized the Dutch SRM II algorithm for freight trains. The SRM II model has been shown in some studies[1] to under-predict sound levels relative to measurements and is based on European train reference sound levels. Although a detailed comparison of the models is beyond the scope of this assessment, SRM II is an unusual choice, does not appear to be as accurate as other European models, and may not produce sound levels representative of a North American fleet.

For road sources, the Cadna/A implementation of the German RLS-90 model is used in this analysis while BKL's study utilized the French NMPB-Routes-1996 model. A more recent version of NMPB exists which has been shown to produce results closer to measurements[2] compared to the 1996 version and includes several corrections to the theoretical calculations. RLS-90 has been demonstrated to appropriately represent road traffic sound levels relative to North American vehicles through various comparisons in Ontario[3] and is implemented in Cadna/A to be able to handle elevation and topography changes; RWDI has found that it reflects measurement results well. Practically, NMPB-Routes-1996 compares similarly to results from RLS-90, but appears to over-predict barrier attenuation in some cases compared to other models[3]. In practice, both NMPB and RLS-90 should reasonably represent road traffic noise levels and the model difference is not expected to appreciably bias the

[1] Szwarc, M. et al. (2011); *Problems of Railway Noise – A Case Study*; International Journal of Occ. Safety and Ergonomics (JOSE); Vol. 17, No. 3, pp 309-325; http://www.ciop.eu/CIOPPortalWAR/file/45008/szwarc17(3).pdf

[2] Dutilleux, G. et al. (2010); NMPB-Routes-2008: *The Revision of the French Method for Road Traffic Noise Prediction*; Acta Acustica united with Acustica; Vol. 96, pp 452-462; https://www.researchgate.net/publication/233515425_NMPB-Routes-2008_The_Revision_of_the_French_Method_for_Road_Traffic_Noise_Prediction

[3] Carr, K., Penton, S., Li, M. (2012); *Road Traffic Noise Modelling: Future Trends in Ontario*; Presented at May 2012 Noise Conference; Air & Waste Management Association, Ontario Section; https://donald-cudmore.squarespace.com/s/09SPentonRoadNoiseModeling.pdf

results. The U.S. FHWA model TMN has been shown to under-predict sound levels in some instances[4] and has shown some problematic behavior in its implementation in Cadna/A[3], so was not applied here. RWDI's road model takes into consideration natural and man-made barriers as well as variances in ground absorption. Topographical data was provided by the City of Pitt Meadows.

The noise analysis considers the following:

- Freight train traffic along the mainline:
  - Existing levels based on volumes observed during RWDI's monitoring (i.e., counted trains); and
  - 2030 (No Project and North Build) levels based on volumes presented in BKL's Study;
- Passenger train traffic (West Coast Express):
  - Existing levels based on volumes during RWDI's monitoring; and
  - 2030 (No Project and North Build) levels based on volumes presented in BKL's Study;
- Train building/shunting activity:
  - Existing and 2030 (No Project) activities within VIF and train building between Harris Road and Golden Ears Way; and
  - 2030 (North Build) activity within VIF and train building between 120 m west of Harris Road to Golden Ears Way.
- Train whistle at Kennedy Road crossing for the existing model and 2030 (No Project);
- Train crossing signal at Harris Road for the existing model and 2030 (No Project);
- Kennedy Road overpass and Harris Road underpass for 2030 (north build) scenario;
- New switches near Kennedy Road, Harris Road, and Golden Ears Way for 2030 (North Build) scenario; and
- Local roadway contributions from Harris Road, Kennedy Road and Golden Ears Way.

For RWDI's analysis, train speeds are consistent with the BKL Study which is 26 to 41 km/hr for freight traffic and 47 to 49 km/hr for the West Coast Express traffic.

As mentioned above, for existing trains RWDI used observed weekday train traffic levels during monitoring which resulted in 18 freight trains per day and 6 daily west coast express trains. In the BKL Study, 2017 train volumes provided by CP were used, which included 28 freight trains and 10 west coast express trains.

Within the BKL Study, all receivers within 100 m of the corridor were considered as well as the closest receivers on the west side of the corridor close to Kennedy Road (within at least 350 m). A 400 m study area was chosen for this analysis to help assess the potential extent of noise impact at father distances. The first 2 to 3 rows of buildings near the rail line were included in the model as these

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[4] Hankard, M., Cerjan, J., Leasure, J. (2006); *Evaluation of the FHWA Traffic Noise Model (TNM) for Highway Traffic Noise Prediction in the State of Colorado*; Report No. CDOT-2005-21; Colorado Department of Transportation, Research Branch; https://www.codot.gov/programs/research/pdfs/2005/tnm.pdf

structures are considered to have the greatest potential to effect noise propagation and produce representative results based on experience.

RWDI created the noise contours using the Cadna/A modelling software. These contours were then processed using GIS software to estimate the number of homes that exceed the applicable criterion. This approach provides an estimate of the affected residential buildings.

The model was calibrated using the results of noise monitoring at the six (6) noise monitoring locations.

Vibration Analysis

To predict vibration levels, the procedures included in the U.S. Federal Transit Administration (FTA) transit noise and vibration impact assessment manual were used. This approach is consistent with the vibration modelling method used by BKL.

Within the FTA manual, there is a generalized ground surface vibration equation that can be used to estimate vibration levels at various distances (Table 6-10 of FTA). Source adjustment factors (Table 6-11 of FTA) and path adjustment factors (Table 6-12 of FTA) are utilized to account for all possible variables.

RWDI's monitoring results showed good agreement (i.e., within 1-2 dBV, ref. 1 nm/s) with the generalized ground surface vibration equation. Therefore, no adjustment factors were universally applied when predicting vibration levels throughout the corridor.

However, vibration monitoring at one location (i.e., 11768 Herring Place, R7) was found to be significantly higher than the values from the generalized ground surface vibration equation. It is believed that this variance is most likely related to subsurface soil conditions that lead to a highly efficient transfer of vibration from the rail line to the receiver. Hence, a path adjustment factor of +17 dBV is applied for this receiver and conservatively to the receivers along this portion of Herring Place. It is unknown to what extent the particular subsurface conditions may extend in the area. A detailed ground investigation (e.g., boreholes or scanning radar) would be necessary to confirm the presence and extent of any subsurface features.

Modelling Results

The noise and vibration modelling contours are shown in the attached figures and are summarized in Table 1, 2, 3 and 4 below, which display the existing scenario, 2030 (No Project) scenario, the 2030 (North Build) scenario, the 2030 (North Build) scenario with mitigation respectively. The receiver counts include adjustments to account for multi-unit buildings.

Table 1: Noise and Vibration Modelling Results (Existing Scenario)

Potential Effect	Threshold Criterion (Parameter)	Number of receivers above criterion [1]	
		RWDI Modelling Results (400 m study area)	BKL Study Results (100 m study area)
Noise			
Speech Interference	>55 dBA (L_d)	411	371
Sleep Disturbance	>40 dBA (L_n)	3102	591
Sleep Disturbance (Windows Closed)	>72 dBA (L_{max})	430	397
Sleep Disturbance (Windows Open)	>60 dBA (L_{max})	2228	n/a [2]
Annoyance (Strong Appeals to Authorities)	>75 dBA (L_{dn})	4	6
Annoyance (Widespread Complaints)	>62 dBA (L_{dn})	308	n/a [2]
Annoyance (Sporadic Complaints)	>55 dBA (L_{dn})	1000	n/a [2]
Annoyance (Rattle Criterion)	>70 dB (L_{LF})	1427	117
Vibration			
High Annoyance	>103 dBV ($RMS_{1s,max}$) [3]	168 [4]	52

Notes:

[1] Receiver counts include adjustments to account for multi-unit buildings.
[2] Not evaluated in the BKL Study.
[3] ref. 1 nm/s.
[4] The criterion is expected to be exceeded for all residences within 43 m of the corridor and seven of the residences along Herring Place that face the corridor which are assumed to have subsurface soil conditions similar to 11768 Herring Place.

Table 2: Noise and Vibration Modelling Results (2030 – No Project Scenario)

Potential Effect	Threshold Criterion (Parameter)	Number of receivers above criterion [1]	
		RWDI Modelling Results (400 m study area)	BKL Study Results (100 m study area)
Noise			
Speech Interference	>55 dBA (L_d)	701	454
Sleep Disturbance	>40 dBA (L_n)	3102	591
Sleep Disturbance (Windows Closed)	>72 dBA (L_{max})	430	397
Sleep Disturbance (Windows Open)	>60 dBA (L_{max})	2228	n/a [2]
Annoyance (Strong Appeals to Authorities)	>75 dBA (L_{dn})	24	24
Annoyance (Widespread Complaints)	>62 dBA (L_{dn})	493	n/a [2]
Annoyance (Sporadic Complaints)	>55 dBA (L_{dn})	2378	n/a [2]
Annoyance (Rattle Criterion)	>70 dB (L_{LF})	1427	117
Vibration			
High Annoyance	>103 dBV ($RMS_{1s,max}$) [3]	168 [4]	52

Notes:

[1] Receiver counts include adjustments to account for multi-unit buildings.
[2] Not evaluated in the BKL Study.
[3] ref. 1 nm/s.
[4] The criterion is expected to be exceeded for all residences within 43 m of the corridor and seven of the residences along Herring Place that face the corridor which are assumed to have subsurface soil conditions similar to 11768 Herring Place.

Table 3: Noise and Vibration Modelling Results (2030 – North Build Scenario)

Potential Effect	Threshold Criterion (Parameter)	Number of receivers above criterion [1]	
		RWDI Modelling Results (400 m study area)	BKL Study Results (100 m study area)
Noise			
Speech Interference	>55 dBA (L_d)	730	457
Sleep Disturbance	>40 dBA (L_n)	3102	591
Sleep Disturbance (Windows Closed)	>72 dBA (L_{max})	461	397
Sleep Disturbance (Windows Open)	>60 dBA (L_{max})	2298	n/a [2]
Annoyance (Strong Appeals to Authorities)	>75 dBA (L_{dn})	34	33
Annoyance (Widespread Complaints)	>62 dBA (L_{dn})	513	n/a [2]
Annoyance (Sporadic Complaints)	>55 dBA (L_{dn})	2512	n/a [2]
Annoyance (Rattle Criterion)	>70 dB (L_{LF})	1427	117
Vibration			
High Annoyance	>103 dBV ($RMS_{1s,max}$) [3]	168 [4]	52

Notes:

[1] Receiver counts include adjustments to account for multi-unit buildings.
[2] Not evaluated in the BKL Study.
[3] ref. 1 nm/s.
[4] The criterion is expected to be exceeded for all residences within 43 m of the corridor and seven of the residences along Herring Place that face the corridor which are assumed to have subsurface soil conditions similar to 11768 Herring Place.

Modelling Results Discussion

Based on the results presented above, there is generally good agreement with between RWDI's findings and the finding in BKL's Study. Variations in receiver counts would be attributed to the following factors:

- Study area size – RWDI expanded the study area size to 400 m from BKL's 100 m. This effect can be seen in the difference in receivers greater than 40 dBA (L_{dn}). Virtually all (greater than 95%) receivers within 400 m are expected to exceed 40 dBA (L_n).
- Existing freight traffic volumes – RWDI used existing traffic volumes based on the 2021 monitoring program (18 trains per day) while BKL used existing traffic data provided by CP Rail (i.e., 28 trains per day).
- Difference in modelling techniques – RWDI and BKL used a different prediction model for train traffic. BKL did not provide details around sound levels and duration of sources such as switches, train building, crossing signals used. Differences in how these sources were assessed may result in differences in the predicted sound levels.

Speech Interference

The number of receivers predicted to exceed existing speech interference criteria (55 dBA L_d) in the existing scenario are higher based on RWDI's analysis compared to BKL's findings, but considered comparable given differences in modelling techniques. For the 2030 scenarios, RWDI predicts more receivers will exceed speech interference criteria compared to BKL which is mainly attributed do differences in the study area.

Sleep Disturbance and Annoyance

The number of receivers predicted to exceed sleep disturbance pass-by criteria (72 dBA L_{max}) and high annoyance criteria (75 dBA L_{dn}) is comparable between RWDI's analysis and BKL's findings. The difference is typically small and is assumed to be attributed to different modelling techniques.

Low Frequency Noise

RWDI predicts that approximately 12 times more receivers exceed the annoyance low frequency "rattle" criterion (L_{LF} = 70 dB). In addition to the modelling and study area differences noted, since this criterion is based on sound energy less than 200 Hz it is possible the sound source profile contained in the BKL model (i.e., SRM II) may contain less energy compared to the U.S. FTA/FRA model used here. As noted, the U.S. FTA/FRA model is expected to more closely represent sound emissions of a North American rail fleet.

Vibration

There is a notable difference between the receivers predicted to exceed the vibration criterion. This result is expected to relate to the decoupling factor (i.e., between house foundation and soil) that BKL assumed for different house types which reduces the vibration level. It is expected that there will be some reduction of vibration level due to decoupling of ground from the receivers. However, RWDI did not apply a decoupling reduction since monitoring results better aligned to the model without it. The decoupling may occur in reality, but more efficient transmission may be responsible for the monitored results. For modelling purposes, this distinction is not consequential.

Overall Results

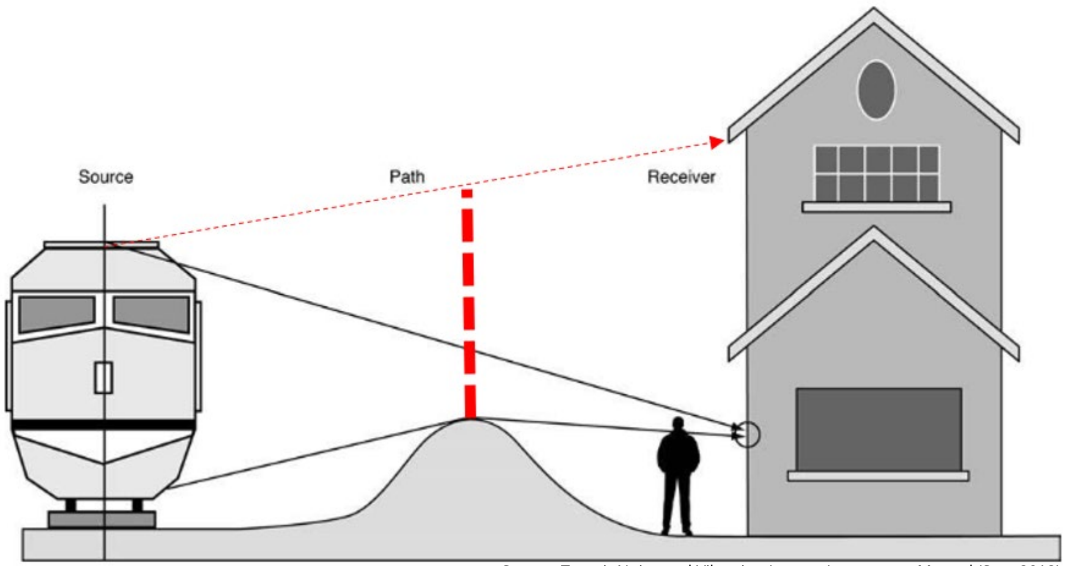
As demonstrated by the BKL Study and RWDI's analysis, impacts at receivers surrounding the corridor from rail activity are predicted to exceed many acceptable thresholds. These excesses occur over a wide area based on RWDI's expanded study area. BKL identified nine (9) receivers warranted mitigation based on their assessment framework.

For vibration, there are mitigation options which can be explored upon review of local track and ground-specific information. These options would involve reconstruction of the tracks (e.g., track isolators or ballast mats) or installation of significant below-grade attenuation materials (foundation wrapping or slurry trench). Expected reductions will be tied to specific design details which cannot easily be assessed within this analysis given available information. Additional review of potential vibration mitigation may be warranted in specific areas, subject to detailed assessment.

Mitigation Discussion

For noise mitigation, the most practical solution for rail sources is adequate sound barriers. A sound barrier can be an earthen berm, a wall, or a combination of both. To be effective, a sound barrier must have no gaps or cracks where sound can easily pass through; hence maintenance issues can be a notable concern for ongoing protection from the barrier.

The height of the sound barrier must, at a minimum, block the line-of-sight from the noise source to the receiver to be considered effective. This configuration is generally expected to produce a reduction of 5 dB based on standard industry practices. Configurations that do not break the line-of-sight may produce a reduction less than 5 dB in practice, but the 5 dB threshold is generally considered a minimum acceptable standard. For rail, the sources include the train wheels, brakes/suspension, and engine (i.e., exhaust and surface-radiated sound) which then propagate to the homes adjacent to the corridor, including the upper floor windows which are typically 4.5 m above grade. The height of a typical locomotive (and its engine exhaust) is approximately 4.6 m. Therefore, where the track height and a dwelling base height are at the same elevation, a minimum 5 m tall sound barrier would be required to break the line-of-sight to 4.5 m high second-storey windows. The required sound barrier height will vary depending on local topography and grading. Figure 7 below demonstrates the height required to break the line-of-sight to second-storey windows.



Source: Transit Noise and Vibration Impact Assessment Manual (Sept 2018)

Figure 7: Optimum Sound Wall Height to Break Line-of-Sight

Existing Barriers

Based on a 2021 Stantec survey of barriers along the corridor, there were six (6) walls identified. The walls were composed of either concrete, wood or chain-link. Walls that are composed of concrete or wood will have acoustic value if they are designed and maintained properly. The chain-link fences identified do not have any acoustic value and are not considered sound walls. The height of the sound walls is typically 2.4 m above grade although Stantec acknowledges that walls are as low as 0.6 m above ground in some locations. There is a 6 m tall concrete wall within the VIF.

The Stantec survey indicates that the sound walls are generally in good condition with some gaps. RWDI did not complete a detailed existing barrier review but did find examples of walls in good condition based on field spot checks. RWDI did however find some walls which are in disrepair and will have limited effectiveness for noise reduction. Picture 1 shows the condition of a barrier wall located close to R2 (19034 McMyn Road), approximately 350 m west of the Harris Road crossing.

Picture 1: Barrier wall at 19034 McMyn Road (R2). Barriers must be free of gaps and cracks to be effective.

The existing barrier heights are typically 2.4 m above local grade which is not expected to be adequate to block the primary source of noise associated with the rail traffic (i.e., the locomotive engine), although it will mitigate some of the wheel and suspension noise which is more commonly centered about 1 m above rail. Further, this 2.4 m wall height does not seem to consider the changes in elevation throughout the corridor. Picture 2 shows an instance where the base of the wall is at the same grade as the base of the dwelling. However, the track is elevated such that the train is almost entirely exposed to the dwelling. In this instance, the barrier wall should be significantly higher to shield the home from the rail traffic. Required barrier heights should be referenced to top-of-rail when placed along a corridor and constructed to meet this overall height accounting for local terrain.

Picture 2: Barrier wall at McMyn Ave. Barriers must break the line-of-sight between source and receiver to be effective.

Noise Mitigation Analysis

According to VFPA's Spring 2021 Project[5] update document, the proposed mitigation includes the following:

1. 'Warranted' Mitigation – 245 m of noise mitigation walls (4-5 m tall) for dwellings where the L_{dn} is predicted to exceed 75 dBA due to the Project for nine (9) properties. This option will result in an additional fourteen (14) benefited dwellings for a total of 23.
2. 'Supplementary' Mitigation – An additional 365 m of noise mitigation walls (2.5 m tall) over and above the 'warranted' 245 m of walls. This option will result in an additional twenty-two (22) benefited dwellings which will see average reductions of 6 dB.

RWDI modelled the 'Warranted' plus 'Supplementary' mitigation in one scenario to assess the mitigation effectiveness. The results are summarized in Table 4 which compares the total number of receivers affected versus the applicable criteria. Similar to prior comparisons (see Tables 1 to 3), the

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[5] Vancouver Fraser Port Authority. April 2021. "Pitt Meadows Road and Rail Improvements Project: Spring 2021 update". https://www.portvancouver.com/wp-content/uploads/2021/04/2021-04-26-Noise-and-vibration-brochure-Pitt-Meadows-Road-and-Rail-Improvements-Spring-update.pdf

RWDI results affect a consistently higher number of receivers for most criteria compared to BKL, which is likely due to the modelling differences noted previously for the unmitigated scenarios. The results both show a modest reduction in the affected receivers due to the addition of the proposed mitigation (i.e., compared to Table 3) which are similar in magnitude to the BKL results (i.e., 1-4% of receivers benefit from the mitigation in both sets of results). The one exception is the high annoyance criterion (i.e., L_{dn} >75 dBA, "strong appeals to authorities") where the RWDI results show only 3 receivers benefitting from the mitigation (i.e., 34 receivers affected in the unmitigated scenario per Table 3, vs. 31 receivers in Table 4 below) compared to 23 for BKL (i.e., 33 receivers in Table 3 vs. 10 in Table 4 below). This difference in results is expected to be linked to the barrier performance near the corridor, and particularly how the models used consider the influence of barrier height. Taller walls are expected to reduce the number of affected receivers to be more in line with the BKL results.

Table 4: Noise and Vibration Modelling Results (2030 – North Build Scenario with Warranted and Supplementary Mitigation)

Potential Effect	Threshold Criterion (Parameter)	Number of receivers above criterion [1]	
		RWDI Modelling Results (400 m study area)	BKL Study* Results (100 m study area)
Noise			
Speech Interference	>55 dBA (L_d)	721	438
Sleep Disturbance	>40 dBA (L_n)	3102	591
Sleep Disturbance (Windows Closed)	>72 dBA (L_{max})	449	385
Sleep Disturbance (Windows Open)	>60 dBA (L_{max})	2298	n/a [2]
Annoyance (Strong Appeals to Authorities)	>75 dBA (L_{dn})	31	10
Annoyance (Widespread Complaints)	>62 dBA (L_{dn})	507	n/a [2]
Annoyance (Sporadic Complaints)	>55 dBA (L_{dn})	2510	n/a [2]
Annoyance (Rattle Criterion)	>70 dB (L_{LF})	1401	112
Vibration			
High Annoyance	>103 dBV ($RMS_{1s,max}$) [3]	168 [4]	53 [5]

Notes:

* From "Pitt Meadows Road and Rail Improvements Project: Spring 2021 update", April 2021, VFPA.
[1] Receiver counts include adjustments to account for multi-unit buildings.
[2] Not evaluated in the BKL Study.
[3] ref. 1 nm/s.
[4] The criterion is expected to be exceeded for all residences within 43 m of the corridor and seven of the residences along Herring Place that face the corridor which are assumed to have subsurface soil conditions similar to 11768 Herring Place.
[5] The BKL assessment identified 52 receivers that currently exceed the 103 dBV criterion, plus one receiver impacted with the addition of the project for a total of 53. The April 2021 VFPA Spring Update does not indicate a total number of receivers affected after mitigation, only that one continues to be impacted; it is expected the same 52 receivers are also affected (total of 53) since no vibration mitigation is proposed.

To investigate the barrier performance further, the nine (9) receivers that were identified to warrant mitigation in the BKL Study (i.e., “warranted” mitigation) were specifically evaluated to understand the predicted benefit from the proposed mitigation. The results of the analysis are summarized in Table 5.

Table 5: 2030 (North Build) Noise Mitigation Results

Receiver	Receiver Height (m)	BKL Study 2030 (No Project) (L_{dn} dBA)	BKL Study 2030 (North Build) (L_{dn} dBA)	Exceeds 75 dBA L_{dn} Criterion?	RWDI Estimated Sound Reduction due to Barriers (dB)	
					4 m tall barrier	5 m tall barrier
D1-55	4.3	75	76	Yes	0	1
D1-56	4.3	74	76	Yes	0	1
D1-57	4.3	74	76	Yes	0	1
D1-58	4.3	74	76	Yes	0	1
D1-59	4.3	74	76	Yes	0	1
D1-60	4.3	75	77	Yes	0	1
D1-61	4.3	75	77	Yes	0	1
E1-014	7.3	75	76	Yes	1	2
E1-015	10.1	75	76	Yes	1	2

Based on the findings presented in Table 5, the proposed 4-5 m high barriers are predicted to provide a small reduction in sound level of 1-2 dB at these receivers. Such reductions are considered uncertain as they reflect the expected model accuracy for mitigation (i.e., 1-2 dB) and may be attributed to model artefacts rather than reflect actual mitigation performance. Generally, a reduction of at least 5 dB is considered a minimum standard for modelled mitigation to be effective which is achieved when barriers break the line-of-sight between the source and receiver. In this case, taller noise walls would be required to have an appreciable reduction in modelled sound levels at these receivers.

The VFPA information suggests that average reductions of 6 dB are expected for these barrier heights. The differences in results may be attributed to how receiver geometry was assessed or differences in how the models (i.e., SRM II vs. U.S. FTA/FRA) assess the source heights. However, given that locomotives are typically on the order of 4 to 5 m high, the RWDI results using FTA reflect expected barrier performance (i.e., 1-2 dB at best). The final barrier design should be at a height and length that will achieve a minimum 5 dB reduction for the assessed receptors.

The modelling considers the physical dimensions of all proposed barriers, including local elevation, barrier height, and propagation around the ends of walls where the walls may be non-continuous (e.g., segmented). Such gaps will not make noise levels worse beyond (e.g., no amplification, directing or focusing effect). Continuous barriers will generally provide a greater attenuation for more receivers compared to barriers that are “segmented” (i.e., built with gaps in some sections). Additional barriers and higher barriers will reduce sound levels in the community if designed and installed appropriately. “Appropriate” means free of gaps and holes to ensure effectiveness (per Picture 1) and located in the right-of-way at the required heights relative to top-of-rail, not local grade (i.e., per Picture 2). In some unique cases of elevated receivers, sound can reflect off adjacent buildings or barriers towards the elevated receivers limiting barrier effectiveness. In these situations, barriers constructed with sound-absorbing materials should be considered. However, even reflective barriers will reduce sound levels for near-grade receivers (e.g., first storey).

Since the 'warranted' plus 'supplementary' mitigation is predicted to be limited in effectiveness as proposed and as there are a series of other health risk indicators that are predicted to be exceeded herein at many homes, mitigation should be considered beyond the 'warranted' and 'supplementary' options.

RWDI recommends that additional mitigation be considered along the corridor as well as a detailed review of the effectiveness of existing mitigation to identify inefficient existing walls. All proposed barriers should be evaluated to determine if they are administratively, technically, and economically feasible. A wall is administratively feasible if the geology and space allow for it, technically feasible if it can typically achieve a minimum 5 dB reduction at the receiver, and economically feasible if it can be built for a target cost per benefited dwelling.

For reference, the BC Ministry of Transportation and Infrastructure (MoTI) defines feasibility benchmarks for barrier design for numbered highways. MoTI deems a barrier effective if there is a minimum mitigation effect of 5 dB (i.e., breaks the line of sight). Further, MoTI has set benchmark costs for mitigation at $25,000 to $40,000 per directly benefited residence depending on the severity of the impacts. If the impacts are more severe, the benchmark value is higher. These values are in 2014 dollars and should be considered in the context of differences in the cost of building sound walls along a rail corridor compared to a highway.

Conclusions and Recommendations

Based on the results of this assessment, the BKL results were reasonably reproduced in most cases, with a few notable exceptions:

- RWDI predicted that more receivers will exceed the speech disturbance criteria for 2030 scenarios
- RWDI predicts that more receivers will exceed the annoyance low frequency "rattle" criterion (LLF = 70 dB)
- RWDI predicts that more receivers will exceed the vibration criterion

RWDI recommends that a detailed review of all existing noise walls be considered to ensure their effectiveness and to properly engage in the evaluation of any required repairs, alterations, or reconstructions to make them effective.

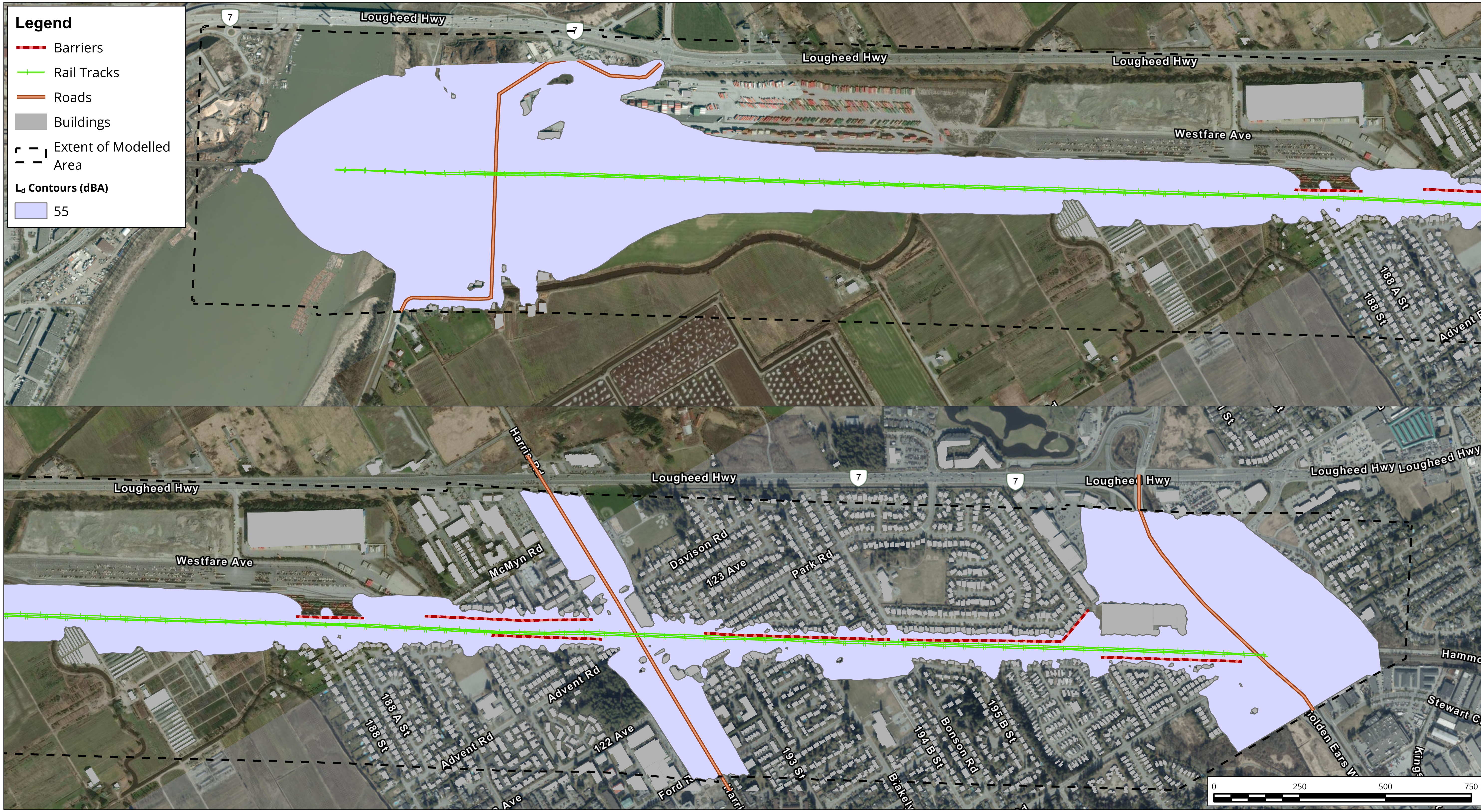
The 'warranted' and 'supplementary' barriers proposed by the VFPA need additional consideration based on this assessment since there is a noted difference in the expected barrier performance. Barrier location and height (above top of rail), source parameters, and model differences should be closely considered at minimum. Barriers should be confirmed at a height and length to achieve a minimum 5 dB reduction for the intended benefited receivers during barrier design. Precise dimensions and locations should be identified and detailed in final barrier design.

Despite the proposed barriers, there are widespread exceedances predicted from existing rail operations. Hence, RWDI recommends that discretionary mitigation over and above the minimum 'warranted' and 'supplementary' suggested by VFPA be considered as part of the Road and Rail Improvements Project, as well as recommending that the City explore options to pursue additional barriers to address these exceedances, such as engaging the Canadian Transportation Agency through their complaint resolution process.

Additional items that may warrant consideration include:

1. Utilize future scenario noise model to evaluate the effectiveness of additional proposed mitigation options proposed by VFPA, as required.
2. Develop parameters related to mitigation feasibility to engage meaningfully with VFPA (e.g., barrier heights specified relative to top of rail, cost target per benefitted receiver).
3. Perform additional detailed analysis to investigate the high vibration levels measured in the vicinity of 11768 Herring Place. This investigation may include a review of any relevant documentation (such as borehole records or ground radar scans), additional vibration monitoring at various intervals between the residence and rail corridor, a detailed review of any special trackwork (e.g., switches and frogs), and/or in-home vibration testing. If the results are validated, detailed mitigation design at track or receiver would be necessary.
4. Future additional data collection to ensure the effectiveness of any installed mitigation post-construction.

FIGURES



Predicted Speech Interference Effects (L_d = 55 dBA)

Existing Scenario

Map Projection: NAD 1983 UTM Zone 10N

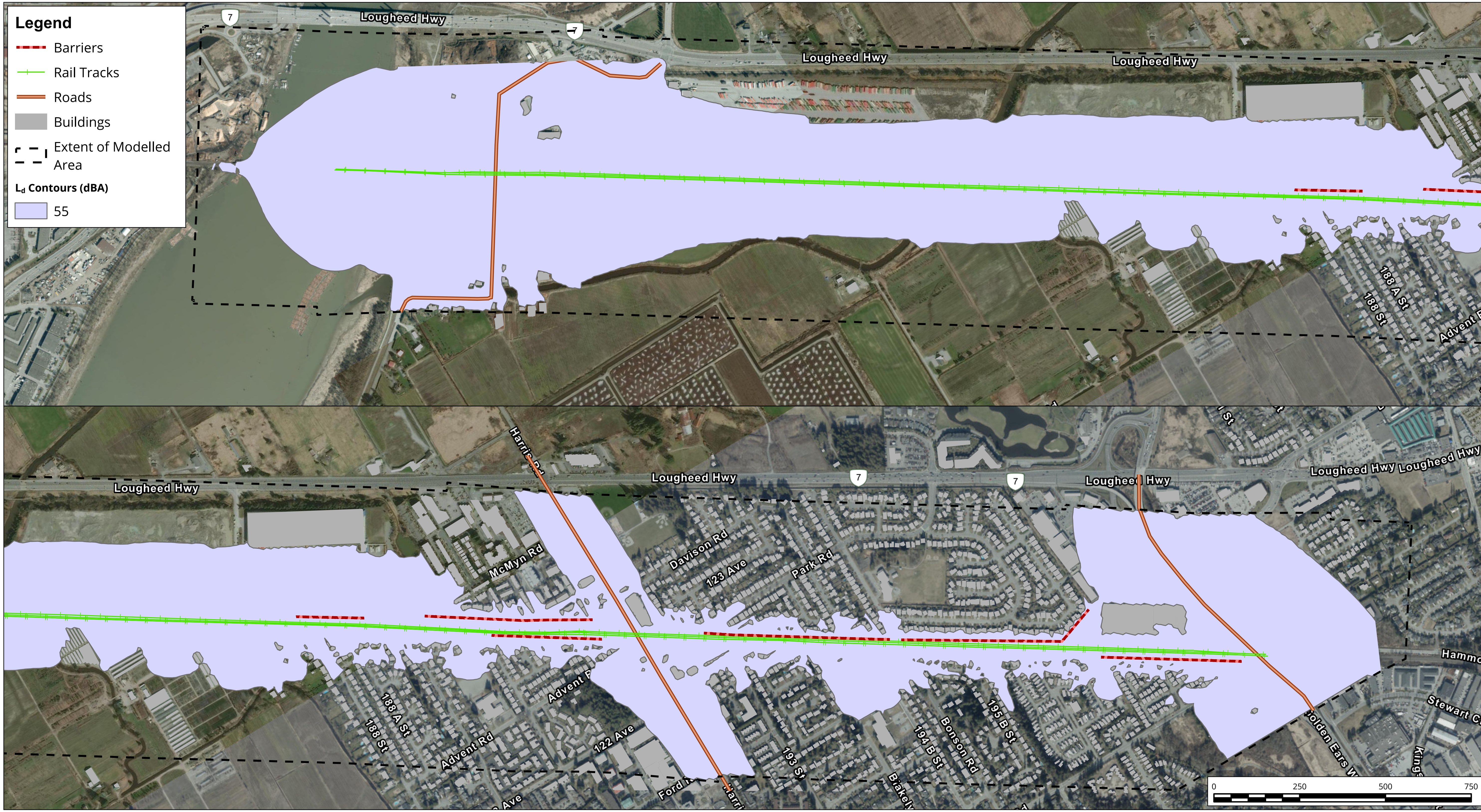
City of Pitt Meadows - Pitt Meadows, B.C.

Service Layer Credits: World Imagery: City of Surrey, Maxar
Hybrid Reference Layer (road and water labels only): Esri Community Maps Contributors, Esri Canada, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA,

Project #: 2104113

True North

Drawn by: LJN	Figure: 1a
Approx. Scale: 1:11,000	
Date Revised: Nov 5, 2021	



Predicted Speech Interference Effects (L_d = 55 dBA)

2030 (No Project) Scenario

Map Projection: NAD 1983 UTM Zone 10N

City of Pitt Meadows - Pitt Meadows, B.C.

Service Layer Credits: World Imagery: City of Surrey, Maxar
Hybrid Reference Layer (road and water labels only): Esri Community Maps Contributors, Esri Canada, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA,

True North

Project #: 2104113

Drawn by: LJN	Figure: 1b
Approx. Scale: 1:11,000	
Date Revised: Nov 5, 2021	

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Predicted Speech Interference Effects (L_d = 55 dBA)

2030 (North Build) Scenario

Map Projection: NAD 1983 UTM Zone 10N

City of Pitt Meadows - Pitt Meadows, B.C.

Service Layer Credits: World Imagery: City of Surrey, Maxar
Hybrid Reference Layer (road and water labels only): Esri Community Maps Contributors, Esri Canada, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA,

True North

Project #: 2104113

Drawn by: LJN	Figure: 1c
Approx. Scale: 1:11,000	
Date Revised: Nov 5, 2021	

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Predicted Sleep Disturbance Effects (L_n = 40 dBA)

Existing, 2030 (No Project), and 2030 (North Build) Scenarios

Map Projection: NAD 1983 UTM Zone 10N

City of Pitt Meadows - Pitt Meadows, B.C.

Service Layer Credits: World Imagery: City of Surrey, Maxar
Hybrid Reference Layer (road and water labels only): Esri Community Maps Contributors, Esri Canada, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA,

True North

Project #: 2104113

Drawn by: LJN	Figure: 2
Approx. Scale: 1:11,000	
Date Revised: Nov 5, 2021	

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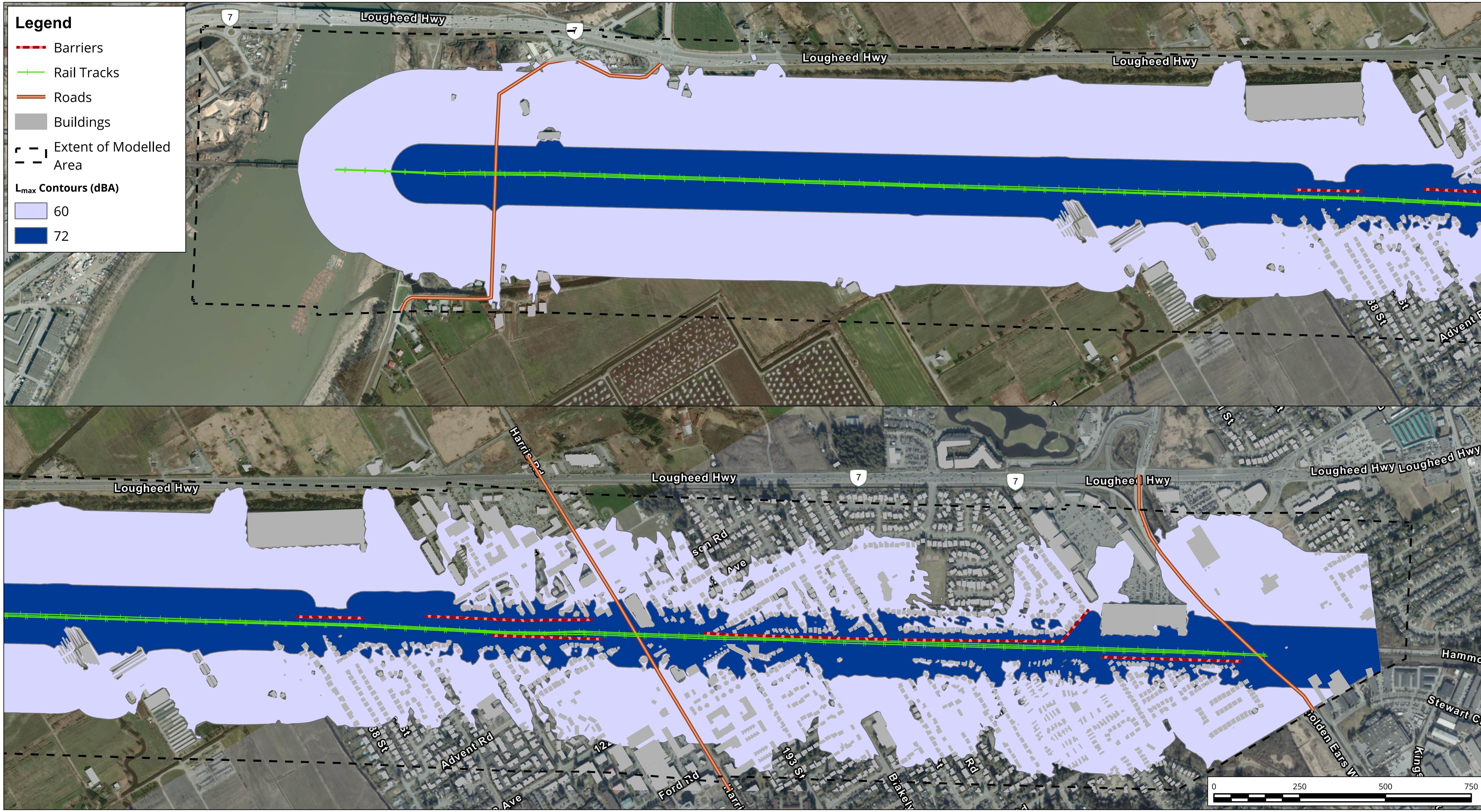

Predicted Sleep Disturbance Effects (L_{max} = 60, 72 dBA)

Existing, 2030 (No Project) and 2030 (North Build) Scenarios

Map Projection: NAD 1983 UTM Zone 10N

City of Pitt Meadows - Pitt Meadows, B.C.

Service Layer Credits: World Imagery: City of Surrey, Maxar
Hybrid Reference Layer (road and water labels only): Esri Community Maps Contributors, Esri Canada, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA,

True North

Project #: 2104113

Drawn by: LJN	Figure: 3
Approx. Scale: 1:11,000	
Date Revised: Nov 5, 2021	

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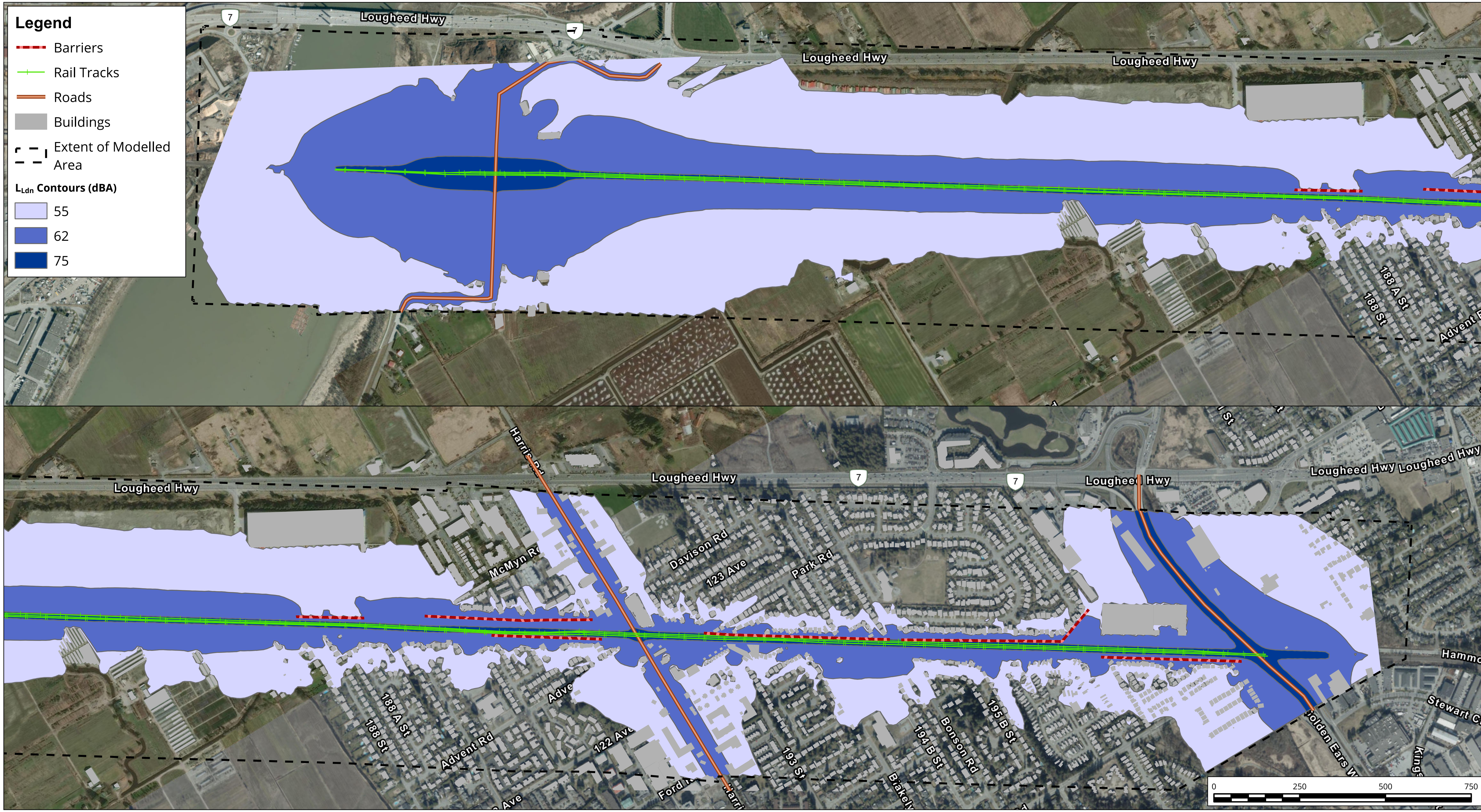

Predicted Annoyance Effects (L_{dn} = 55, 62, 75 dBA)

Existing Scenario

Map Projection: NAD 1983 UTM Zone 10N

City of Pitt Meadows - Pitt Meadows, B.C.

Service Layer Credits: World Imagery: City of Surrey, Maxar
Hybrid Reference Layer (road and water labels only): Esri Community Maps Contributors, Esri Canada, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA,

True North

Project #: 2104113

Drawn by: LJN	Figure: 4a
Approx. Scale: 1:11,000	
Date Revised: Nov 5, 2021	

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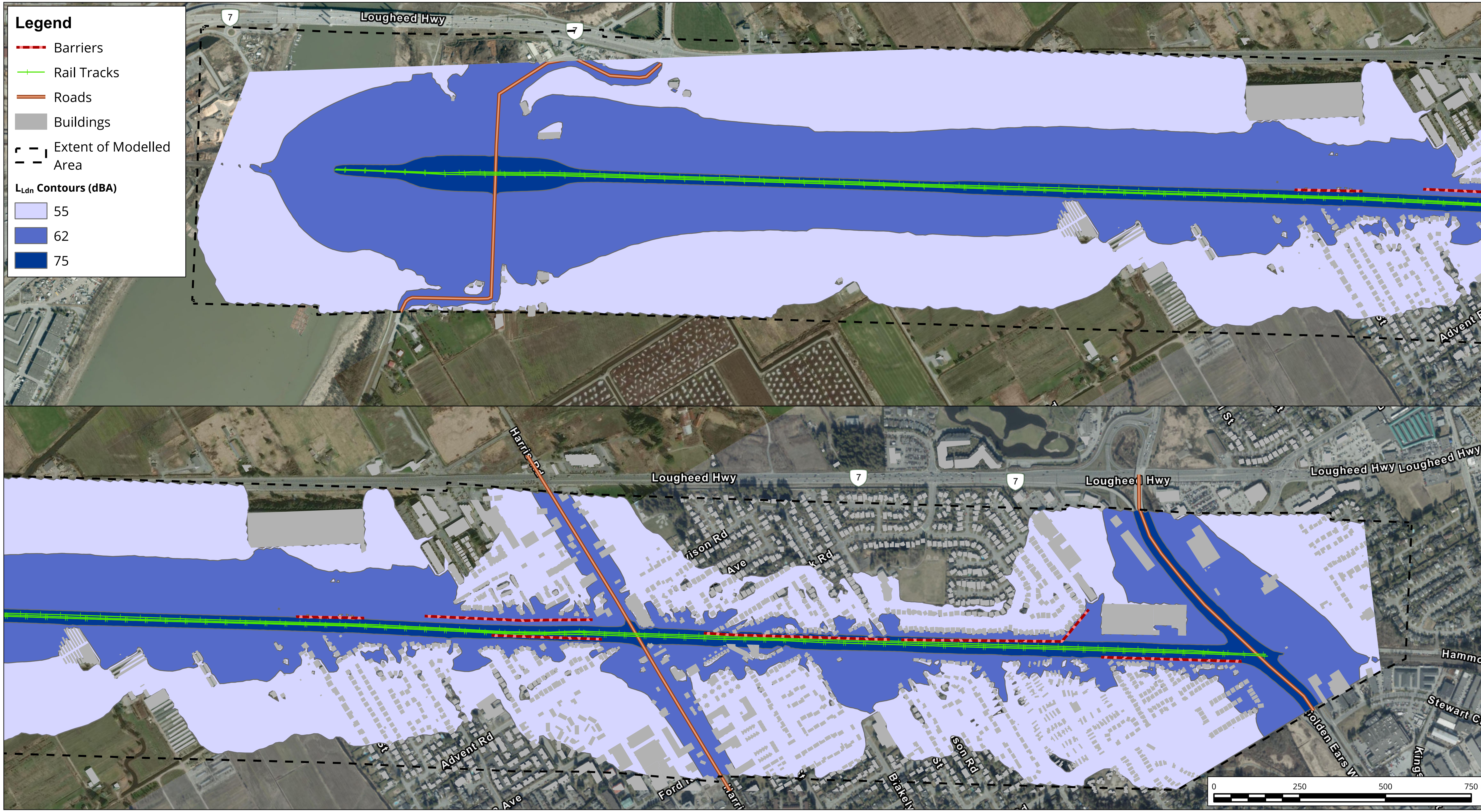


Predicted Annoyance Effects (L_{dn} = 55, 62, 75 dBA)

2030 (No Project) Scenario

Map Projection: NAD 1983 UTM Zone 10N

City of Pitt Meadows - Pitt Meadows, B.C.

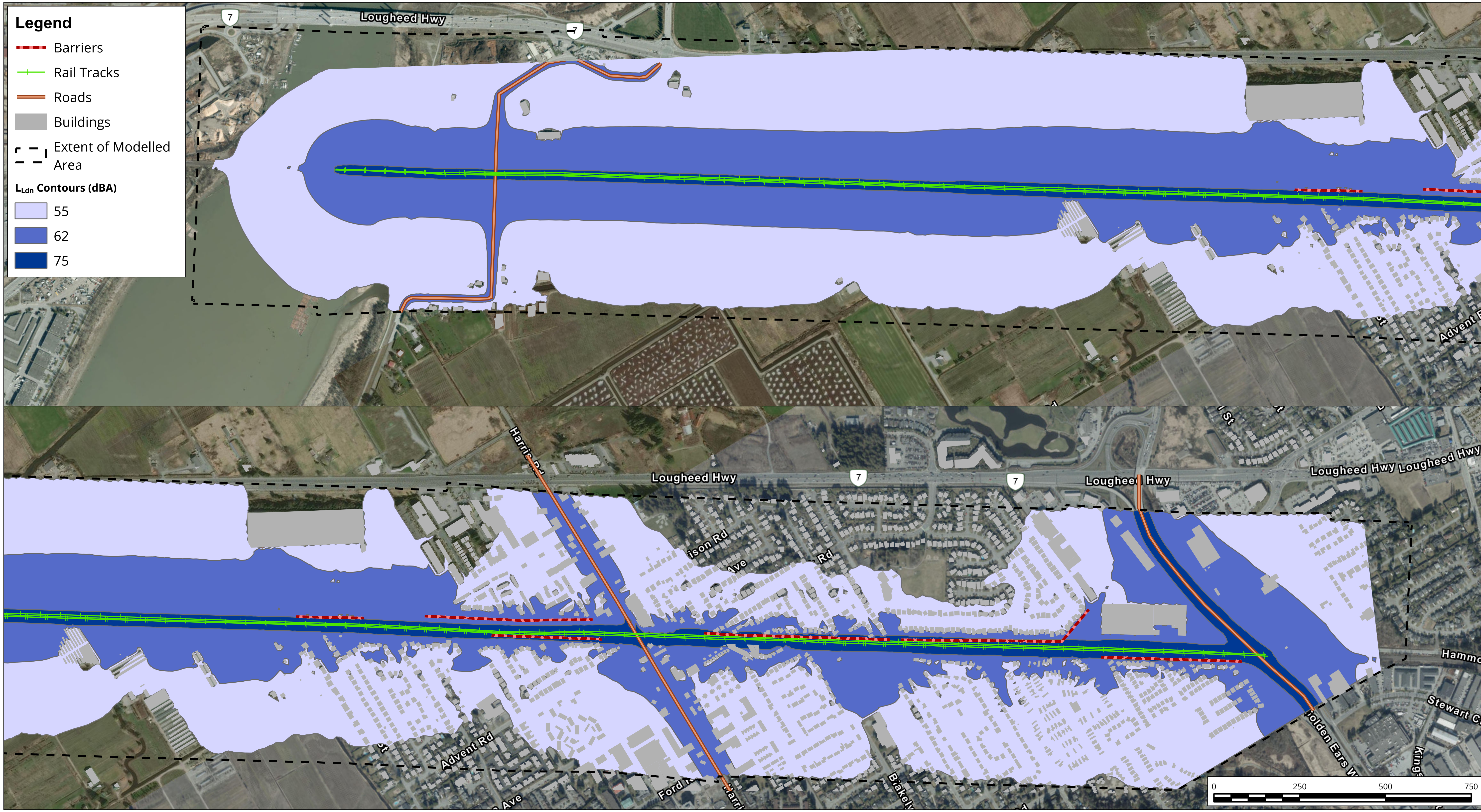
Service Layer Credits: World Imagery: City of Surrey, Maxar
Hybrid Reference Layer (road and water labels only): Esri Community Maps Contributors, Esri Canada, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA,

True North

Project #: 2104113

Drawn by: LJN	Figure: 4b
Approx. Scale:	1:11,000
Date Revised:	Nov 5, 2021

Map Document: C:\Users\LJN\OneDrive - ROWAN WILLIAMS DAVIES & IRWIN INC\Desktop\GIS\Pitt Meadows\P2104113_Pitt_Meadows.aprx



Predicted Annoyance Effects (L_{dn} = 55, 62, 75 dBA)

2030 (North Build) Scenario

Map Projection: NAD 1983 UTM Zone 10N

City of Pitt Meadows - Pitt Meadows, B.C.

Service Layer Credits: World Imagery: City of Surrey, Maxar
Hybrid Reference Layer (road and water labels only): Esri Community Maps Contributors, Esri Canada, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA,

True North

Project #: 2104113

Drawn by: LJN	Figure: 4c
Approx. Scale: 1:11,000	
Date Revised: Nov 5, 2021	

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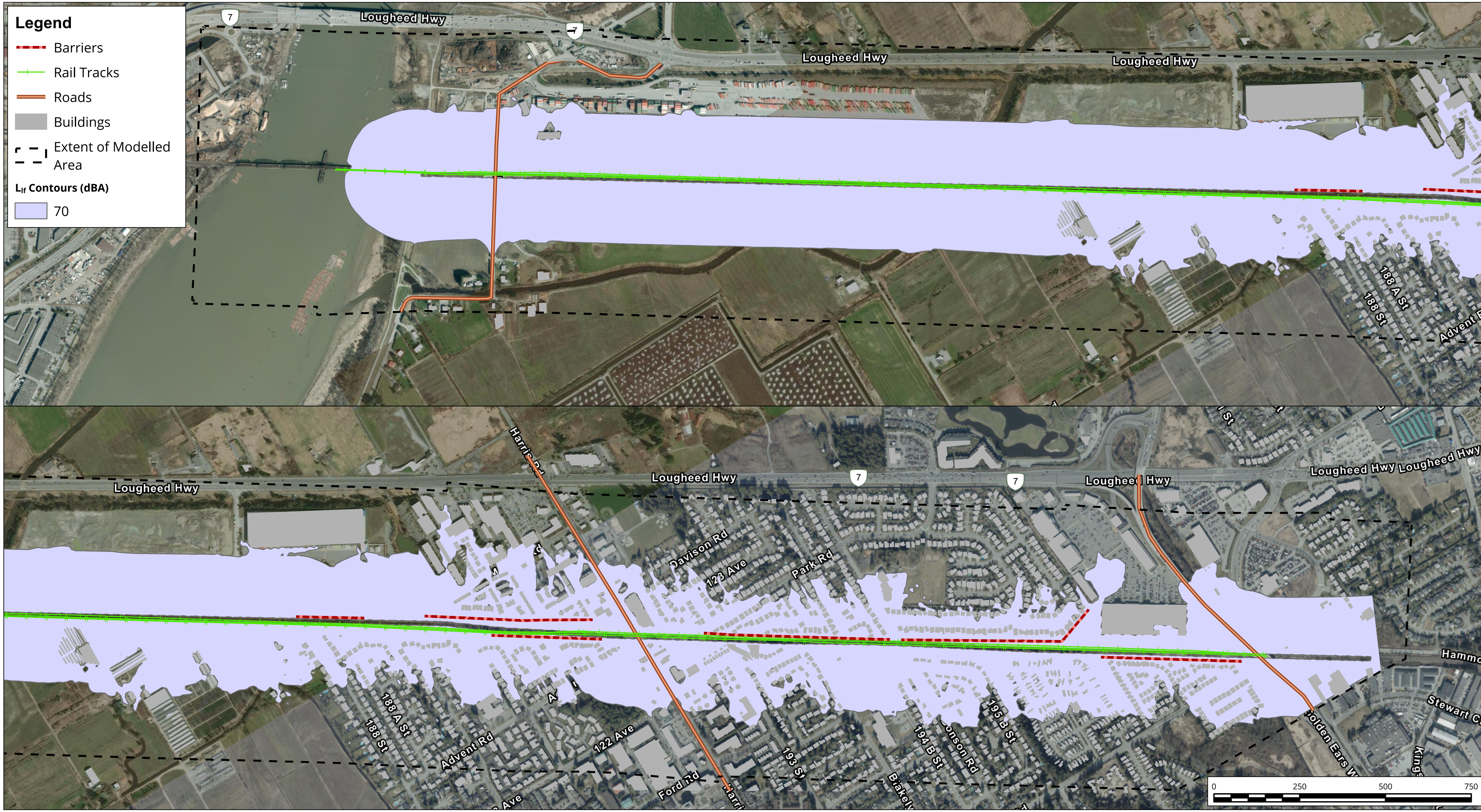


Predicted Low Frequency Annoyance Effects (L_{LF} = 70 dBA)

Existing, 2030 (No Project), and 2030 (North Build) Scenarios

Map Projection: NAD 1983 UTM Zone 10N

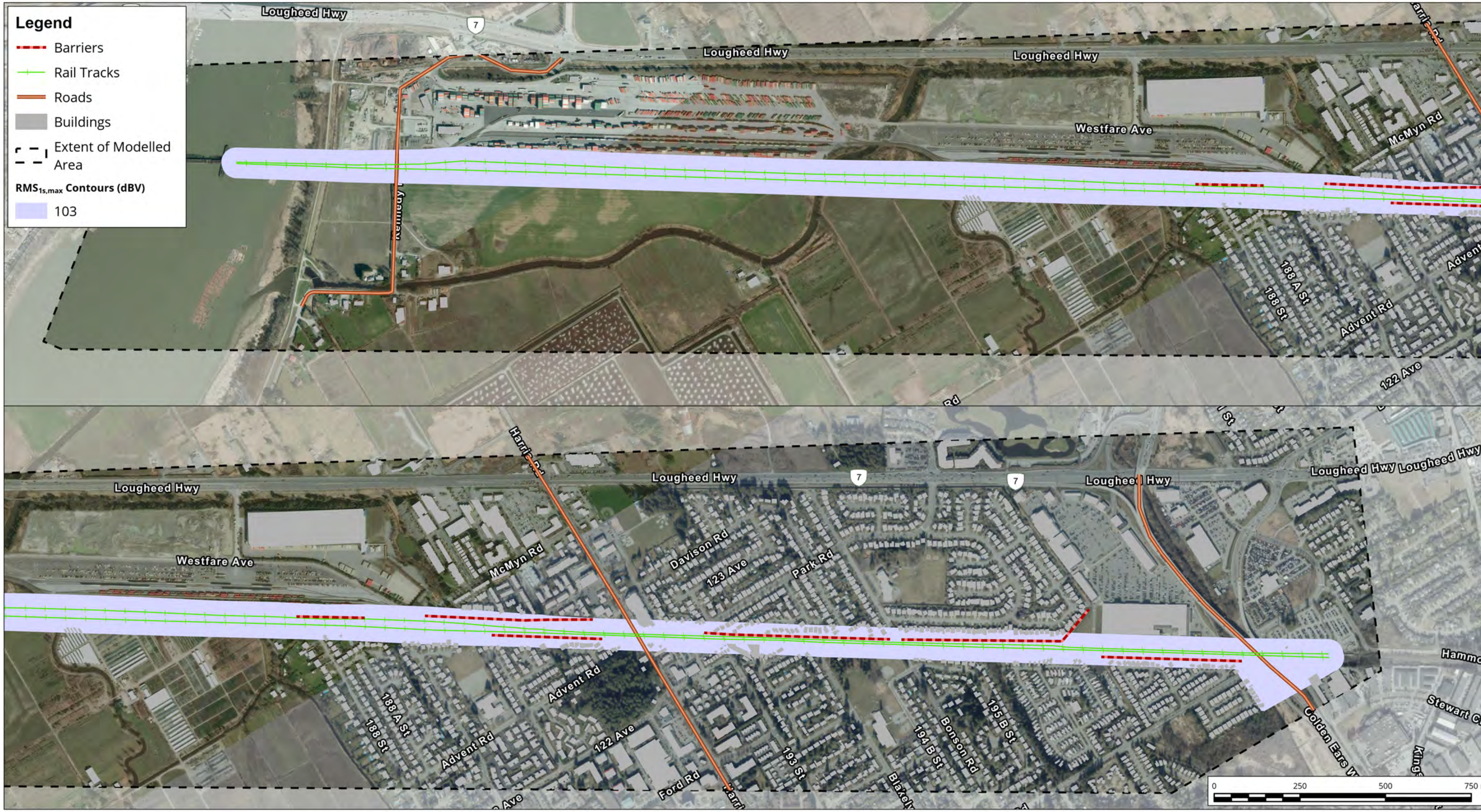
City of Pitt Meadows - Pitt Meadows, B.C.

Service Layer Credits: World Imagery: City of Surrey, Maxar
Hybrid Reference Layer (road and water labels only): Esri Community Maps Contributors, Esri Canada, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA,

True North

Project #: 2104113

Drawn by: LJN	Figure: 5
Approx. Scale: 1:11,000	
Date Revised: Nov 5, 2021	



Predicted Vibration Annoyance Effects ($RMS_{1s,max}$ = 103 dBV)

Existing, 2030 (No Project), and 2030 (North Build) Scenarios

Map Projection: NAD 1983 UTM Zone 10N

City of Pitt Meadows - Pitt Meadows, B.C.

Service Layer Credits: World Imagery: City of Surrey, Maxar
Hybrid Reference Layer (road and water labels only): Esri Community Maps Contributors, Esri Canada, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA,

True North

Project #: 2104113

Drawn by: LJN	Figure: 6
Approx. Scale:	1:11,000
Date Revised:	Oct 29, 2021

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