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Review of Operational Noise & Vibration Effects**

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Introduction

Styles Group has been engaged by the Auckland Council, (the Council) to undertake a review of the noise and vibration effects likely to arise from the works and activities that will be authorised by the Designations sought by Auckland Transport for the Notices of Requirement (NoR) comprising the City Rail Link (CRL) proposal.

The CRL project comprises a 3.4km rail line that will link Britomart Station with the North Auckland Line (NAL) at approximately the Mt Eden Station. Most of the project is underground, with the majority of the construction comprising bored tunnel along with limited cut and cover sections and some above ground rail around the integration with the NAL. There are three stations along the route, being Aotea, Karangahape & Newton, all of which require above-ground works. The construction period is expected to last 5-6 years with activities staggered over the various construction sites. The main construction yard is at the NAL end of the project.

This report comprises a review of only the operational noise and vibration effects of the CRL. The review of construction-related effects has been provided to the Council in a separate review report.

The principal document referred to in this review is the report entitled *City Rail Link, Noise & Vibration Assessment – Report No.: 001R07 2012068A* (Marshall Day Acoustics 13th August 2012) – the MDA Report.

Additional documents that are referred to herein include the substantive Assessment of Environmental Effects, (AEE) the Built Heritage Report and the Structural Report.

For a full understanding of the project and to avoid any misunderstanding or ambiguity, the reports noted above must be referred to in-full along with the NoR documentation and full plans. These documents provide a full description of the proposal and its effects.

This review has been prepared following some considerable involvement with the project, including preliminary meetings with Auckland Transport to discuss assessment methodologies and to provide a full understanding of the project.

I note that the noise and vibration assessments that have been prepared for Auckland Transport are very comprehensive. The methods and predictions are thorough and I consider that the work that has been undertaken is generally to a very high standard. The comments presented herein are generally restricted to the most important issues where it is critical to record agreement with Auckland Transport and to those areas of disagreement.

The lapse period sought by Auckland Transport is 20 years. A lapse period of this duration presents considerable challenges for the assessment of potential effects at this stage because the receiving environment could change significantly in that timeframe, or indeed 10 years. To

some extent I consider that this moderates the level of detail required in the assessments for each individual receiver of noise or vibration. Assessing the nature and magnitude of the effects along with determining the best methods to avoid, remedy or mitigate them whether works start next year or in 20 years (in a different receiving environment) is important.

Scope of Work

The scope of our involvement is described in the scope of services required by the Council as follows:

Contributing to the preparation of the “officer’s report” for the Council Hearing including:

- a) Providing specialist input into the report (in the form of a comprehensive report) on noise and vibration matters.*
- b) Review of submissions to identify key noise and vibration issues.*
- c) Assisting with the development of noise and vibration designation conditions (as required).*
- d) Meetings with Council (as required).*
- e) Meetings with the Applicant and Submitters (as required).*
- f) Attendance at the Council Hearing (as required)*
- g) Assistance with drafting the Hearing Panel’s recommendation report and conditions (as required).*

The scope of this report is essentially limited to satisfying items (a) and (b).

Statutory Context

The potential noise and vibration effects of the project are to be assessed primarily in terms of s16 of the Resource Management Act, (the Act). Subsection (1) states:

Every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on, or under a water body or the coastal marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level.

This section introduces the duty that requires requiring authorities (and indeed all occupiers of land) to adopt the Best Practicable Option (BPO) to ensure that the levels of noise and vibration generated by the construction and operation of the rail link are no greater than *reasonable*.

With reference to noise and vibration effects, the requirement of s(5)(2)(c) of the Act is also particularly relevant, requiring the adverse effects of activities to be adequately avoided, remedied or mitigated.

This review will focus on whether the noise and vibration effects associated with the works and activities that will be authorised by the confirmation of the Designations will be practicably able to be adequately avoided, remedied or mitigated to the extent that the noise and vibration levels will remain *reasonable* with reference to appropriate criteria for the protection of health and amenity.

Noise Performance Criteria

Operational Noise

Section 6.3.1 of the MDA Report sets out the proposed operational noise criteria for the project and refers to its' Appendix B for the supporting literature review. I consider that the criteria that have been selected are generally appropriate subject to my comments herein.

There are three general sources associated with the operation of the CRL which will generate noise that may be experienced by receivers. These include:

- (i) The surface rail section near the NAL where the noise from the additional trains on the NAL and the beginning of the CRL Designation require assessment;
- (ii) The noise from stations; in particular the ventilation and mechanical services and to a lesser extent the noise from PA systems other patron amenities; and
- (iii) The regenerated noise inside buildings above the CRL that is generated by the radiation of structurally-borne vibration arising from train movements along the line.

Surface Rail

The noise generated by trains on the surface portion of the project is mostly dealt with by the conditions on the existing Kiwirail NAL Designation. The MDA Report provides a very brief assessment of the change in noise level in the NAL area arising from CRL operations, but then states that the noise effects generated therein do not require assessment as part the CRL proposal.

Given that the tunnel portals are either within the NAL Designation or extremely close to it, the assessment of surface rail noise within the CRL footprint alone becomes practically unnecessary, as the emissions from such a small source will be insignificant in terms of emissions from the NAL and Mt Eden Station. For this reason, I agree with the MDA Report

that there need be no controls in the CRL Designation in respect of noise generated by surface rail.

Notwithstanding, I note that Kiwirail and Auckland Transport both have an obligation under s16 of the Act to ensure that noise levels arising from the movement of trains on the NAL and CRL line do not exceed a reasonable level and that the BPO is adopted to ensure this. This is a matter best dealt with outside of this process, but it is important that submitters (in particular) are aware of this duty. The Council has the ability to enforce the duty and should noise levels from surface rail at the NAL / CRL interface (or indeed any part of the network) become an issue then it may investigate. The critical element related to this project is the potentially significantly greater number of trains that will be operating on other parts of the network as a result of the opening of the CRL. This has the potential to generate concomitant effects for receivers around the wider network, but as above it is not being considered here.

Station Noise – Mechanical Plant

The MDA Report suggests that the Permitted Activity noise criteria in the Operative Central Area and Isthmus sections of the Auckland District Plan should be adopted for the control of noise from mechanical plant associated with the stations and tunnel ventilation infrastructure. The limits are set out in Table 6.3.1 of the MDA Report.

The noise limits from the District Plan are somewhat liberal compared to criteria normally adopted for the protection of health and amenity of people, especially with reference to World Health Organisation criteria and the guidance found in the NZS6802 series of standards. However, these limits have been set by the Council as a balance between a number of important factors present in the city centre and mixed use zones, such as:

- (i) The existing relatively high ambient noise levels, (in most areas);
- (ii) The high cost to businesses in mitigating noise emissions to comply with lower noise limits; and
- (iii) The inclusion of rules requiring residential activity in these areas to be insulated from outdoor noises.

However, although the Permitted Activity criteria in the District Plan are designed to control noise emissions from operational noise sources, it is arguable that they were not designed to control the emissions from ventilation plant that will be working all day and effectively in perpetuity. I am not aware of any information to describe any diurnal variations in noise levels from the plant, perhaps relative to the frequency of train movements etc. For this review I have assumed that the plant will operate at a continuous 24 hour duty.

Of relevance to the determination of appropriate noise levels are the results of the ambient noise measurements undertaken as part of the MDA assessment. Of particular note are the measurement results for four locations outside of the Central Area as described in Appendices E7, E10, E11 and E12 of the MDA Report. These are locations where a noise limit of L_{Aeq} 55dB is proposed to apply between the hours of 10pm and 7am. The ambient noise measurement results show that for these four sites, the ambient background noise levels are regularly as low as L_{A90} 40dB, or very close to it in the quiet hours of the night; some 15dB below the proposed noise limit. It is my opinion that if the noise from mechanical plant were permitted to generate up to L_{Aeq} 55dB in this environment, the noise emissions would dominate the environment and would likely be unreasonable, especially when considering the emissions on a cumulative basis with other local sources such as traffic, other mechanical plant and surface rail, with particular reference to the increase in the latter as a result of the completion of the CRL.

It is my view that with respect to the ambient noise measurements, the proposed noise limits for non-rail sources is too high for receivers outside the Central Area. I suggest that the noise limits should be set no higher than 5dB above the lowest 90th percentile level of the 15 minute L_{A90} noise that have been measured between 10pm and 7am. My preliminary assessment of the ambient noise measurement results suggests that the resulting limit would be approximately L_{Aeq} 48dB. This method of determining an appropriate noise limit is not the only method that can be applied; indeed there are numerous ways of deriving an appropriate control. However, I suggest this method as I consider that it provides a good balance between achieving a limit that will be reasonable and also one that should be able to be practicably complied with.

Additionally, I consider that the low frequency noise limits for all receiving areas should be discarded in favour of the 5dB penalty as set out in New Zealand Standard NZS6802:2008. This is because the low frequency limits were first introduced in the Central Area Section of the District Plan to deal with music noise, and also because they do not control other tonal issues such as high pitched noises which can commonly occur with ventilation plant. There is no change to the conditions required except to remove the low frequency limits and to ensure that it is clear that noise emissions are assessed in accordance with NZS6802:2008.

Taking account of the 20 year lapse period that is sought by Auckland Transport and the change in ambient noise levels that may occur over several years, it may not be appropriate to set an operational noise limit based on contemporary noise measurements. Alternatively, if the noise limits are to be determined with regard to the ambient noise levels, the necessary assessment could be required by a condition whereby the noise monitoring is undertaken no earlier than 1 year from the anticipated construction start date.

It is my opinion that the issue would be best dealt with by a Designation condition requiring ambient noise measurements no earlier than 1 year prior to the construction start date, and for the noise limit to be determined in accordance with the method I have suggested above.

Reradiated Noise

Section 6.3.2 of the MDA Report sets out their suggested controls for reradiated noise and operational vibration and the origin thereof. As set out earlier in this review, I have worked with Auckland Transport on the adoption and appropriateness of the FTA method and some considerable discussion has taken place around the imperial to metric conversions of the units and the noise measurement methods.

Overall it is my view that the FTA criteria are appropriate for adoption on the CRL project, both in terms of the noise and vibration limits it recommends and also the prediction and assessment methods. For the avoidance of doubt, the reradiated noise criteria set out in the right-most column of Table 6.3.2 of the MDA Report are L_{Amax} values. The L_{Amax} metric represents the short term (< 1 second) noise level for each train pass-by and is not an average over any extended period of time.

I note that the MDA Report states that the FTA reradiated noise criterion for dwellings is the same as the KiwiRail guidelines for the control of reverse sensitivity (as set out in Appendix C to the MDA Report). This is not the case however; the two criteria do in fact permit a considerably different level of noise. As discussed above, the FTA criterion is a L_{Amax} value, (L_{Amax} 35dB) whereas the Kiwirail guidelines are a 1 hour long average ($L_{Aeq(1hr)}$ 35dB). The two criteria happen to share the same numerical value. The margin between the two will be larger where there are fewer trains over a period of one hour, and will be smaller where train movements increase, [as the average level increases and approaches (but will never meet) the maximum level]. Notwithstanding, I note that compliance with the FTA vibration limits should in most cases result in compliance with the FTA reradiated noise criteria, so the point becomes relatively moot from a design and compliance point of view. With respect to the assessment of noise effects, the FTA reradiated noise criteria are relatively low and if compliance with them is achieved the noise levels will be entirely *reasonable*.

Vibration Performance Criteria

Section 6.3.2 of the MDA Report also sets out the operational vibration performance criteria from the FTA method. The values in Table 6.3.2 are derived from the imperial units based on VdB with a reference value of $1\mu\text{in}/\text{sec}$ as used in the FTA method. I confirm that the metric equivalents are appropriate to use but that the derivation of reradiated noise criteria as set out in the FTA method must be done using the original imperially-based VdB values.

If compliance with the criteria set out in Table 6.3.2 is achieved, I consider that the vibration levels will be entirely *reasonable* and that the effects will be quite acceptable. The MDA Report provides a good background discussion of the criteria and the FTA method that I concur with.

Assessment of Operational Effects

Surface Rail

The only section of the CRL where there will be surface rail is the connection to the NAL. As discussed earlier, the surface sections of the CRL track are very short and the noise emissions from those alone will not give rise to any appreciable increase in the overall levels when considered in the context of the existing (and future) NAL emissions. There are however some realignments necessary within the NAL Designation to tie in with the CRL. These will result in trains passing closer to edge of the Designation and receivers than they do currently and this may give rise to slightly higher noise and vibration levels. However, as these effects are not generated within the CRL footprint, I understand that it is not appropriate to assess them as part of this NoR process. In this respect I agree with section 8.1.3 of the MDA Report.

Section 8.1.3 also states that maintenance of the turnouts, rails and rolling stock generally will be critical in ensuring that noise emissions remain reasonable. Such maintenance will be most critical for surface rail, but also for enclosed sections of the tracks that are near tunnel openings or near to the three most sensitive receivers, (Aotea, Roundhead & TV3).

Overall, I agree with the assessment of noise emissions from the NAL connection as described in the MDA Report.

Station Noise

The noise emissions from the stations will generally be restricted to that generated by the mechanical plant associated with ventilation of the stations and tunnel. This discussion must be considered in terms of the variation to the noise limits for receivers outside of the Central Area as discussed earlier in this review.

As discussed in the noise limits section, it is not uncommon for the noise generated by ventilation plant to exhibit Special Audible Characteristics (tonal whines or hums etc). It is vital that the provisions of NZS6802:2008 dealing with such problems are retained in their entirety to deal with any peculiar noise emissions that may arise.

Table 8.1.2 of the MDA Report sets out the noise levels that are expected from the ventilation stacks with reference to the nearest receivers based on approximate separation distances. The reduction in noise levels that I have suggested for receivers located outside of the Central Area will potentially increase the amount of attenuation that is introduced to the design of the plant. Without undertaking the detailed calculations that have been done by Auckland Transport, (as I do not have the detailed source data) it appears that compliance with the lower noise limits is likely to be practicable. In order to demonstrate that the lower noise limits are not appropriate, it would be necessary for Auckland Transport to prove that compliance is not practicable to

achieve and that the limits they propose are indeed *reasonable* having (regard to the discussion presented herein).

It is my view that if compliance is achieved with the noise limits that are proposed, (along with my suggested variations) the emissions from the stations and associated mechanical plant will be *reasonable*.

I note that in the conclusion of the MDA Report, it quite correctly states that the noise emissions are likely to be no greater than any major road in the city. Whilst this may be correct, it does not absolve Auckland Transport from having to adopt the BPO to ensure those levels are *reasonable*, especially when considering the cumulative noise effects of the CRL and other sources, including road traffic noise.

Vibration & Reradiated Noise

As described in the discussion of noise limits above, I consider that the FTA criteria that have been adopted for reradiated noise are appropriately low, and will be achieved in most cases where the operational vibration criteria are also complied with. There may be some situations where particular structural characteristics of the receiving building introduce variations where reradiated noise levels are not in proportion to the vibration immissions. It is important however that the limits are applied separately so that such circumstances can be properly dealt with.

I have reviewed the adoption of the FTA prediction methods as detailed in the MDA Report and I consider that the predictions appear commensurate with the accurate implementation of its methods. I agree with section 8.2.2 of the MDA Report which states that it is compliance with the reradiated noise limits that controls the safe distances, and not compliance with the FTA vibration limits.

Table 8.2.3 of the MDA Report sets out the emission radii for compliance with the FTA criteria and the variations thereto depending on the nature of the rail, whether it is surface, driven-tunnel or cut & cover. I agree with this section of the MDA Report.

Section 8.2.4 discusses the effects on three receivers where the FTA limits may be exceeded, being the Aotea Centre, Roundhead Studios and the TV3 buildings. This section also acknowledges that there are other buildings in the Eden Terrace area that may experience vibration levels beyond the FTA criteria but that they are currently subject to “some degree” of train vibration from the NAL and that the operation of the CRL will not increase this. Whilst this assessment for the other receivers is very light, I agree with it.

In terms of the three critical receivers, section 8.3.2 of the MDA Report sets out the mitigation that will be applied to the rail way lines and rolling stock that will “reduce” the effects. The MDA Report does not appear to go so far as to state that the mitigation will afford compliance with the

FTA criteria, nor does it provide any prediction of vibration levels that may be experienced following the application of mitigation. I acknowledge that the prediction of such levels is very complicated and fraught with uncertainties.

I consider it critical that the effects are well understood before the design is finalised and construction starts, and this requires some understanding of the level of vibration and reradiated noise that the receivers will experience. It is also critical that the effects are well understood at this time to inform the decision making process and conditions. Section 8.2.4 of the MDA Report states that “*Once mitigation is in place, sensitive receivers along the route may still perceive vibration or reradiated noise, but the levels are likely to be suitable for their building use and consistent with the existing ambient vibration environment*” (emphasis added).

I consider at this stage that the risk of vibration levels being higher than the FTA limits and indeed higher than what could be tolerated by very sensitive activities (such as studios or auditoria) is considerable, especially in the absence of the mitigation noted in section 8.3.2 of the MDA Report. Even with the mitigation proposed in that section there is insufficient certainty that the effect on the receivers will be tolerable.

The cost of installing resilient rail fasteners, floating track slabs and (to a lesser extent) continuously welded tracks is significant. The cost of remediating an alignment where vibration is an issue, (once already operational) would likely be prohibitive when considering the direct financial costs and the downtime of an operational rail line during the upgrade.

If the effects are to be adequately mitigated, Auckland Transport must take a conservative approach and install the mitigation necessary to achieve the FTA limits with a good degree of certainty. This is a balance of the following matters:

- i) The direct additional cost of the specific mitigation required to enable compliance;
- ii) When considering the uncertainties associated with vibration predictions of this nature, the risk of the measures being over-engineered and costing more than was necessary;
- iii) Conversely and taking account of the same uncertainties, the risk of not achieving the FTA criteria and/or a level that allows the sensitive activities to operate; and therefore
- iv) The cost of relocating those sensitive activities where (within the realms of practicability) physical mitigation alone cannot bring about vibration and/or reradiated noise levels that are sufficiently low to be *reasonable* in the receiving environment.

It is my view therefore, that the degree of effects on the most sensitive receivers is uncertain; the MDA Report does not provide a sufficient degree of certainty that a reasonable level of vibration and/or reradiated noise will be achieved using the mitigation suggested.

The continual maintenance of rolling stock and rail infrastructure will also be critical in maintaining an acceptable noise and vibration environment for the receivers, especially around curves in the alignment. I therefore firmly agree with the recommendation made at the end of section 8.3.2 of the MDA Report.

Submissions

I have read the submissions that are relevant to the operational noise and vibration effects. I consider that they raise no new issues that have not been addressed in the MDA Report or in this review. For station, (mechanical plant) noise, I consider that if compliance is achieved with the noise limits recommended in the MDA Report, (varied according to the recommendations made herein) the noise levels will be *reasonable*. It is my opinion that if compliance with FTA guidelines for reradiated noise and vibration are achieved at all receivers, then the levels will be *reasonable*. If such compliance was achieved, the concerns raised by the submitters regarding the ongoing operational effects of rail movements and station noise would be satisfied.

However, in respect of the most affected receivers, (TV3 in particular) I consider that the Auckland Transport assessment lacks certainty that the potential adverse effects can be adequately and practicably avoided. I therefore agree with the Mediaworks submission in several respects. I do not consider though that the mitigation of operational effects to a degree that would allow TV3 to continue operating is impossible, but it may indeed be impracticable. This issue would perhaps be best explored at the hearing.

Conclusion

Auckland Transport are seeking Designations for the construction and operation of the City Rail Link that will permit a range of effects to be generated, including noise and vibration.

This advice comprises a review of the operational noise and vibration assessment prepared to support the Notices of Requirement lodged by Auckland Transport.

Overall, I consider that the submissions raise no new issues that are not addressed in the MDA Report or associated NoR documentation or in this review. No further assessment is required to address the submissions except where recommended in this review.

Surface Rail

For the surface rail portion of the CRL, the MDA Report rightly states that the contribution to the overall noise levels from the NAL will be so minimal as to not require a detailed assessment. There will be some realignment of the lines in the NAL Designation that may bring trains closer to sensitive receivers, and there will therefore be an increase in the noise and vibration levels. I understand that these will however occur in the NAL Designation so are not to be considered as part of the CRL NoRs.

The opening of the CRL will result in more frequent train movements on the wider network and will therefore increase rail noise levels for a much larger set of receivers than just those proximate to the CRL. However, the wider network is not the subject of these NoRs and I understand that the concomitant effect of the operation of the CRL on other parts of the network is not to be considered here.

Overall, I agree with the assessment of effects in the MDA Report relative to surface rail.

Station Noise / Mechanical Plant

The MDA Report sets out a reasonably general assessment of the noise levels expected from the ventilation plant associated with the station and tunnel ventilation. The assessment is necessarily general owing to the low level of technical detail and equipment specifications available at this time.

I have recommended that for the plant outside of the Central Area, a lower set of noise limits should apply that are based on the ambient noise levels in the area, and that the final limits would be best assessed just prior to construction commencing to ensure that they are based on the most contemporary data available, (in light of the 20 year lapse period sought by Auckland Transport). I have also recommended that the low frequency noise limits are removed in favour of the application of the traditional 5dB penalty (where Special Audible Characteristics are evident) according with the New Zealand Standard NZS6802:2008. Based on the data supplied

in the MDA Report and my own provisional calculations, I consider that such limits can be practicably complied with.

Overall, if the noise limits (with my variations incorporated) can be complied with, I consider that the noise levels from the mechanical plant will be *reasonable*.

Vibration / Reradiated Noise

I agree with the selection of limits for vibration and reradiated noise as they are set out in the MDA Report. If compliance with these is achieved, the levels will be entirely *reasonable*. It is my view that for the vast majority of the route the criteria will be achieved.

However there are several very sensitive receivers along the route for which compliance is not demonstrated with sufficient certainty in the MDA Report. TV3, Roundhead Studios and the Aotea Centre are all very sensitive receivers that are close to the alignment. Without any specific mitigation, the vibration levels at these receivers will likely be *unreasonable*. Some mitigation is proposed, comprising continuously welded track, floating slab track and resilient rail fasteners, but the MDA Report does not provide a set of predicted vibration levels following the installation of such measures, nor does it go so far as to state that compliance with the FTA criteria will be achieved.

I consider that in order to assess the degree of effects arising from the proposal, it is necessary to understand what the vibration levels will be at these receivers, and/or whether Auckland Transport is committed to achieving a *reasonable* level, and if so what that level is going to be if not the FTA criteria. This matter requires resolve.