WELLINGTON NETWORK CAPACITY CONSTRAINTS STUDY

Network Constraints and Initial Implementation Roadmap

SUMMARY REPORT

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REPORT STRUCTURE

This Summary Report provides high-level commentary with supporting information contained in both the Appendix A - Data Sheets and separate technical memos and reports. The bibliography lists all consulted and supporting documentation.

Document reference numbers are allocated in the bibliography (extract below) and in some cases are noted in the report to guide the reader to the relevant data sheets and support documentation.

The bibliography references the relevant technical memo and the infrastructure solution reference which has an associated Appendix A Data Sheet.

Doc Ref.	Report Title	Consultant	Date of Issue	Version	Infrastructure Solution Reference	Project Name
24	Network Stabling	RIC Limited	November 2022	3	KPL-RS2-7	Plimmerton/ Paremata Increase stabling

The document reference numbers in the bibliography are noted in the text as follows:

e.g. Stabling capacity for inner tier trains (assessed at Plimmerton, alternative Paremata or Mana)(24)

Individual infrastructure solution references have been allocated and take the following format:

Line – RS timetable – Project Number
e.g. KPL – RS2 – 7

The same information on required infrastructure improvements to remove constraints is packaged in three ways. First in 7 by Rail Scenario, by position in the overall programme (roadmap) in 8 and then by location in 9.

REVISION HISTORY

Rev.	Revision Date	Details	Edited By
0.1	19/09/22	Preliminary for KR Review	Desiree French
0.2	08/11/22	Reviewed version in KR format	Kevin McConnell
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1.1	31/01/23	Pre-liminary KR comments incorporated	Desiree French
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3.1	1/12/2023	Draft Issue 1	Michael McKeon
3.2	25/01/2024	Issue 1	Michael McKeon

APPROVAL FOR ISSUE

Role	Name	Organisation	Signature	Date
Project Director, Future Rail	Michael McKeon	KiwiRail	MM	25/01/2024

TECHNICAL CONTRIBUTORS

This WNCCS study was undertaken as a collaborative effort between KiwiRail and a number of industry leading consultants.

Operational modelling was completed by a specialist consultant to identify constraints and to check or refine the proposed solutions.

Component	Organisation
Operational Modelling	KSP Consulting Ltd
Peer Review of Operational Modelling	R Donaldson Rail Ltd
WRS Precinct Master Plan	RIC
Network Stabling	KSP Consulting Ltd / RIC
Electrification proposals north of Waikanae	EXP & Beca-Systra
Waikanae Precinct changes	RIC / Vitruvius
Duplication, loop extensions & curve easements north of Waikanae	Vitruvius
North-South Junction	Aurecon / WSP / RIC
Tawa Basin & Hutt Valley Third Mains	RIC
Melling Junction to WRS Third Main	RIC
Melling Line and Junction Duplication Options	RIC
Woburn – Gracefield Junction Upgrades	RIC
Manor Park to Melling Link (bypass concept)	RIC
Post WMUP 6B Upper Hutt - Masterton loops and platforms	RIC
Locations and concept designs for bi-directional wrong line running crossovers	KiwiRail / RIC
Level crossing solutions (Vehicle & Ped)	RIC
Inundation Risk Mitigation / Sea Level Rise	RIC
Remutaka Tunnel ventilation	WSP
Slope Stability	Aurecon
Maintenance and Access Planning	RIC

1. EXECUTIVE SUMMARY

This study identifies the infrastructure required for increased rail passenger and freight traffic volumes on the Wellington network and provides a costed road map to support progressively more intense operations. This work will inform and guide development of more detailed business cases to make a case for increasing service capacity.

INTRODUCTION

This study identifies capacity constraints across the Wellington Network and sets out potential infrastructure solutions to remove them in a staged fashion coordinated with proposed service frequency improvements. It gives a high-level overview of capex requirements and programme, identifying when further business case and funding approval work is required to allow sufficient time to delivery aligned to progressive timetable improvements envisaged for the Greater Wellington region.

The operational modelling used for this study is being applied in parallel by Greater Wellington Regional Council (GWRC) and KiwiRail across several projects. Timetables referred to in this document are the same RS1 – RS6[1] range of "Rail Scenarios" referred to in the Wellington Regional Rail Plan Programme Business Case (Rail Plan)[2]. Each higher RS number increases the frequency of services over the previous. Freight capacity is provided by regular interval "slots" throughout the timetable.

The extents of the study include:

- NIMT – Wellington to Palmerston North
- WL – Wellington to Masterton (including Melling Line)
- Masterton – Pahiatua – Palmerston North (as freight diversionary or bypass route)
- JVL – Johnsonville Line

[1] Noting (1) sub options for RS4 are represented by a decimal point, and (2) Infrastructure required to enable RS3 also enables RS4 and that for RS5 enables RS6, thus these intermediate timetables are not mentioned as separate scenarios in this study.

[2] The Wellington Regional Rail Plan Programme Business Case (Rail Plan) is a Greater Wellington Regional Council (GWRC) initiative to set out the long-term direction of investment in the rail network. This investment is a cornerstone of the draft Regional Land Transport Plan (RLTP), draft Regional Public Transport Plan (RPTP), and draft Regional Mode Shift Plan (MSP), and it will help enable the outcomes sought by the preferred direction of the Wellington Regional Growth Framework (RGF). The Rail Plan has a 30-year timeframe for investment and is expected to be updated throughout this period.

A comprehensive implementation roadmap for the infrastructure required to support staged increases in service frequency from the current schedule to a 6-minute timetable, and to extend its reach, has been developed.

This roadmap will significantly inform planning for improved rail and transport services in Wellington. An informed decision on the way to best meet future demands will allow infrastructure improvements to be planned and phased as logical steps towards this.

This document does not represent or infer any formal cost / benefit analysis. Initial observations in this regard are at a macro level and for discussion purposes only.

KEY FINDINGS

Aspirational Implementation Dates	2022	2025	2030	2035	2045
RS Timetable	**Current**	**RS1**	**RS2**	**RS4**	**RS6**
Nominal frequency	**15 to 20 min**	**Approx. 15 min**	**15 min**	**10 min**	**6 min**
Per stage rough order infrastructure cost ($billiion)	-	**0.02**	**2.0**	**5.2**[3]	**10.2**
Cumulative rough order infrastructure cost ($billion)	-	**0.02**	**2.0**	**7.2**	**17.4**

The results show that the cost of frequency improvements increases very rapidly with the reduction in times between services, suggesting a practical limit to the affordability and value[4] of a frequency-based service improvement. The point of inflection comes when the two-track railway needs further tracks to carry the required frequency of trains, either a third or fourth track or a relief route on another alignment.

This step change in investment is triggered by the move to increase service frequency beyond ten minutes. While this study makes no effort to determine the benefits of such an improvement, the size of the investment step suggests that this is a limit that will require very careful consideration and that an intermediate approach to increasing capacity beyond RS4 may be worthwhile.

A decision needs to be made if 6-minute RS6 is to be the aspiration or not, as it influences the layout in several areas of the network (especially WRS Precinct) where space proofing or not-precluding RS6 has significant impact on land and track/facilities layout. If a timely decision is not made, the result could be a compromised RS4 layout, to enable an RS6 that is very far in the future.

If it is decided RS6 is not the ultimate aspiration, there may be some infrastructure improvements not required until RS6 for capacity, that may still be implemented to instead achieve increased resilience and create a more robust network for the RS4 timetable. Duplication of North – South Junction is the prime example.

Further work needs to be done to understand how to build resilience against climate change and other natural disasters into the overall strategy for developing Wellington's railway network, especially within key areas such as the Wellington Railway Station Precinct, as many of the investments proposed in this study could be undermined by future inundation and / or other natural disasters such

[3] Includes the recommended for resilience single bore NSJ tunnel. $4.4b for RS4 without this.

[4] To be demonstrated by BCR values calculated in future business cases.

as earthquakes. Other infrastructure and land use planning streams should apply the same scrutiny – this should not just be limited to rail.

CONCLUSIONS

A comprehensive scheme for the infrastructure required to support staged increases in service frequency from the current schedule to six minutes has been developed. There is scope to greatly improve the capacity and capability of the Wellington network but, as an existing and operating network in an established and geographically constrained built up area, each tranche of improvement becomes increasingly expensive and disruptive.

There is a major step change in the infrastructure required following RS4. Ahead of a longer term commitment to RS6, in the event of further capacity being required beyond RS4, an intermediate option is to:

- increase passenger capacity via higher capacity consists, and
- invest in a robust network to provide a highly reliable 10-minute timetable. (It is expected this will be more attractive to customers than a less reliable 6-minute service.), and
- reduce the cost and construction disruption of a 10-minute network by judicious investment in capacity maximising signalling, combined with a reduced investment in physical works. Advance these options through the Wellington ETCS project studies.

The implementation of optimised ETCS signalling could provide a way to provide a service frequency at or near to RS4 levels but with less physical infrastructure required, allowing this to be more affordable and less disruptive.

Investments to improve the productivity of works when on track and to allow some level of timetabled train operations during works should be a focus of the planning phase for any infrastructure improvements. Again this a fruitful area for the Wellington ETCS project studies to advance.

Further work in relation to network resilience (earthquakes and climate) is required before finalising the strategy for the infrastructure and operations of the rail network. This should be addressed prior to delivery funding release for the infrastructure projects proposed in this study.

RECOMMENDED ACTIONS

It is recommended key studies are continued and action is taken to ensure an appropriate level of momentum (to avoid ‘put it down, pick it up’ inefficiencies). These actions should include:

- Stakeholder engagement (including Local Authorities & Riverlink project)
- Making decisions around feasibility of achieving aspirational timetables and delivery dates
- Project team set up to progress planning for RS2 and beyond
- Ensuring the Wellington ETCS project lays the groundwork for capacity increase and enables less disruptive construction.
- Progressing Master Planning for WRS and other key areas
- Early focus on providing for cost effective and less disruptive network access in the face of significant coming investment
- Commissioning a serious study of the implications of climate change and resilience on this investment.
- Addressing the potential change in usage of the railway away from the basic historic tidal flow to/from Wellington CBD as part of a separate study.

2. OBJECTIVE AND CONTEXT

Projections are that the passenger and freight capacity of the Wellington rail network will need to increase in coming decades. The purpose of this document is to identify the network improvements required to reduce existing constraints and service steadily increasing traffic volumes.

OBJECTIVE

Like any transport network, the Wellington rail network has limits to its capacity. These limits are progressively exposed as traffic increases or new services are introduced.

The Greater Wellington Programme Business Case (Rail Plan) identifies a series of specific scenarios RS1 – RS6 for additional passenger services to meet modelled increasing demand.

The objective of this study is to identify the constraints preventing such higher capacity passenger train services being achieved, develop and cost a solution for each, and lay this out in a logical fashion that assists with decision making. All users are considered, local passenger, freight, and long-distance passenger services.

It is expected that this document will provide a clear road map to guide the commissioning of further detailed work, including business case development, to secure funding for infrastructure improvement work in time to deliver the timetable improvements forecast to be required by growth in the Greater Wellington area.

It is not intended to financially justify these works. Rather the capacity added and the cost of this serve to inform other business cases for implementing improved services and capacity.

It is anticipated that this document will provide a clear road map to guide the commissioning of further detailed work, including business case development, to secure funding for infrastructure improvement work to deliver the timetable improvements forecast to be required to meet demand growth in the Wellington area.

While this document does not represent a cost / benefit analysis, initial observations at a macro level are made for discussion and direction purposes only.

WIDER CONTEXT

The Rail Plan work has been mentioned and referenced where relevant, however this Capacity Constraints Study has been specifically structured to support longer term planning from the perspective of KiwiRail as the infrastructure asset owner and operator of non-metro services.

LNIRIM infrastructure required beyond that being provided by existing projects[5] is included for both the NIMT and Wairarapa Line. Otherwise, it is assumed that all existing live programmes are delivered.

[5] Under WMUP6B

3. PERSPECTIVES ON INCREASING CAPACITY

Capacity can be increased by higher capacity trains, more trains, or a combination of the two. On a legacy network, harking back to the last major scheme (1930-1961), there is limited opportunity to do these without significant land impacts and improvements to infrastructure.

APPROACHES TO INCREASED CAPACITY

Capacity on a rail system can be increased by improvements in frequency, by increasing the capacity of each train service or by a combination of the two. Improvements in frequency also serve to drive demand, as the more frequent service is more attractive to users, so long as it is dependable.

Increasing the carrying capacity of each train requires maximising the capacity of each carriage and then making the train longer. This drives:

- New or modified trains
- Longer passenger platforms
- Longer storage sidings
- Potentially increased power supplies (driven by increases in size of each train)

Increasing frequency drives:

- Increased power supplies[6]
- Building in operational resilience to work around and recover from disruption without complete service failure (cross overs, bi-directional running)
- Reducing the likelihood of service disruption from issues like slope stability (slips)
- Streamlining and increasing the approaches to/from Wellington Railway Station (WRS)
- Duplication of remaining single-track sections
- Provision of additional mainline tracks to allow express trains to overtake stopping trains.
- Potentially bypassing lines to achieve a similar result.
- More platforms at critical locations, to accommodate more than two trains at once
- Investment to allow freight trains to join and leave the mainline at Wellington (and Woburn) in far less time than they currently do
- Maintenance and Access Planning (how the network will be maintained – more maintenance required and less available access to do it in)
- Level crossing public safety (Grade separation of vehicle and pedestrian level crossings)
- Level crossing disruption of road traffic (longer ‘barrier down’ times – grade separation)

There is only limited scope to increase the capacity of Wellington rail without increasing the capacity of its infrastructure and few of the actions above are easy or “low hanging fruit”.

[6] Being partly delivered by RS1 or follow on works under negotiation.

The Wellington Region Public Transport Plan (2021) strategy is to drive increased commuter service demand by the provision of improved service and reduced waiting time. For this reason, this study focuses on the impacts of increased frequency.

AN EXISTING ASSET

The Wellington rail network is long established and is constrained by both topography and urban development around the rail corridor. The development is often a consequence of the railway and the service it provided.

The network is also used around the clock, with a busy commuter service and time critical inter-regional freight operations. These factors combine to make major infrastructure improvements challenging; disruption of services, increased cost, extended duration of works and impact on existing development around the railway.

Key areas of the rail corridor, such as the Wellington Railway Station Precinct, have grown from the 1930-1961 planned scheme to more recent reconfigurations with functionality being added by working around existing infrastructure and getting ‘squeezing operations into an increasingly constrained layout.

4. METHODOLOGY

The need to remove capacity constraints is driven by demand forecasts being met by progressive increases in train frequency. Operational modelling has been used to determine where infrastructure solutions are required, and these have been costed and programmed at a high level to give an overall picture of requirements to implement successive time timetables.

IDENTIFYING AND RESOLVING CONSTRAINTS

- The Greater Wellington Rail Plan meets and stimulates demand by increased frequency of services.
- For the purposes of this study a series of increasing intensity timetables were set up. These were based around clockface services of progressively reducing interval.
- Operations were modelled for each increased intensity timetable using the OpenTrack simulation programme.
- Each round of simulated services loaded up the infrastructure and highlighted the infrastructure constraints needing to be resolved before each successive timetable could be successfully modelled.
- Specialist consultants were used to prepare concept proposals for removing each constraint. Where a consultant or predecessor had previously studied a constraint, that consultant was engaged to review and update previous studies.
- Each proposed solution was reviewed and re-modelled to confirm removal of constraint and subsequent ability to deliver the relevant timetable.
- Rough order cost estimates and indicative programme timeframes were prepared for solutions using unit rates or experience with recent similar works.
- Applying professional judgement, the most effective solution was selected as preferred.
- Packages or groups of solutions were then scheduled to support each step increase in frequency and provide an overall roadmap for implementation (including business case process timeframes to secure funding).

CONFIDENCE LEVELS

The constraints to increased frequency on the network are well understood. Some proposed solutions have been considered in detail and others only conceptually.

To enable the reader to quickly establish the context in which the information relating to a particular solution should be read, a simple (1 to 5) confidence scale has been developed.

The confidence level reflects engineering judgement and experience in conjunction with feedback from the consultants regarding the relative certainty of scope, programme and cost, resulting in a high-level relative comparison across solutions.

The scope contingency (noted below) added to each estimate reflects a conservative view of the impact of scope change[7] once further levels of design are undertaken.

1	60%	Blue sky - Order of magnitude costs based on an idea or objective
2	40%	Pre-feasibility - Rough order of costs based on macro infrastructure requirements
3	30%	Feasibility - Indicative estimates based on feasibility level design
4	20%	Concept - Indicative estimates based on concept level design
5	10%	Scope Definition – Indicative estimates based on a higher level of scope certainty

The confidence level for each individual project is given in the summary table at the top of each project's Data Sheet in Appendix 1.

It is important to note that this study aims to inform the reader of the relative quantum of work and programme rather than provide budget estimates, which will need to be developed as part of future Business Case work.

COST, CONTINGENCY, AND PROGRAMME MODERATION

Each of the individual consultants have included a local contingency allowance in their cost estimates to cover matters such as Approvals, Technical/ Design, Programme, Statutory Authorities, Construction, Programme, Safety, and other risks of this nature.

An additional scope contingency has been added subsequently to reflect scope confidence as outlined in the previous section.

PROGRAMME ESTIMATION

The construction duration for each solution has been largely based on programme duration for equivalent spend on other recent rail projects.

Broad categories have been defined as:

- **Major Projects** – unique programme timeframes as set out in consultant reports.
- **Projects** – expected spend of $50M/18mths, constrained by KR resources and live rail working.

[7] One specific item this scope contingency will need to cover is climate change mitigation engineering and design, which has not been considered in great detail to date and may necessitate a different design approach than that taken in scoping the infrastructure requirements for this study.

- **Other projects** – expected spend of $50m/12mths, constrained by KR resources but no / minimal interface with live rail.

Some programme contingency is inherent in the method of assessing duration above though it is recommended a more detailed scheduling exercise is undertaken in the early stages of future design development.

MOBILISATION PERIOD ESTIMATION

For construction works to commence in line with the start dates suggested by the Implementation Roadmap, the package will need to mobilise in time to allow for preconstruction/ funding activities, including but not limited to those listed below:

- Develop and gain approval of Business Case establishing funding and delivery requirements.
- Identify and acquire land parcels required to accommodate the package spatial and access requirements.
- Appoint of a package Project Manager who will take responsibility for the following activities:
  - Review Next Steps identified in Section 10 of this report and in Appendix 1 - Data Sheets.
  - Development of a Master Programme and Master Budget.
  - Establishment of project controls including reporting processes.
  - Establish risk/ opportunities register.
  - Establish procurement and contract management strategies.
  - Establish approvals/ consents required strategy.
  - Establish Statutory Authorities interface strategy.
  - Develop a stakeholder management strategy.
  - Procure consultant and design team.
  - Develop KR approvals and interface programme.
  - Procure contracting team.
  - Mobilise and agree delivery plan.
  - Manage works and above strategies through to agreed point in time and ensure succession plan is in place.
- Identify and procure long-lead procurement items that need to be procured prior to appointment of contractor to maintain programme.

The time spent to deliver the above will vary dependent on the complexity and scale of the package. Set out below is a standardised framework setting out criteria which can be applied on a package-by-package basis to determine mobilisation timeframes:

- **Significant Project** – start mobilisation **7 years** prior to commencement on site (significant land acquisition, highly complex works in strategic locations and with high values)
- **Major Project** – start mobilisation **5 years** prior to commencement on site (land acquisition and / or large scale / complex works in strategic locations and package value greater than $50 million)
- **Project** – start mobilisation **3 years** prior to commencement on site (no land or minimal land acquisition with package value greater than $50million)
- **Other Project** – start mobilisation **18 months** prior to commencement on site (no land or minimal land acquisition with package value less than $50million)

Mobilisation periods using these criteria are marked on the Implementation Roadmap. Note that these mobilisation dates should be reviewed regularly to ensure that any changes to the business case assumptions are considered with appropriate adjustments to mobilisation dates made as necessary.

COST ESTIMATION

Cost estimates for infrastructure solutions presented in this study have varying degrees of accuracy based on the level of design undertaken and should be taken as indicative only.

TRACK, CIVILS, OLE AND STATION INFRASTRUCTURE COSTS

Individual consultants have estimated the cost of the solutions proposed. All consultants were asked to include an appropriate local contingency based on the level of design undertaken. A global contingency has then been added to each project based on overall scope confidence.

SIGNALLING COSTS

Cost estimates for all signalling works in this study have used the SEU component rates developed for the Wellington ETCS IBC (escalated).

Depending on complexity of the project and the level of design undertaken in determining the proposed layouts, signalling costs have been estimated in one of three ways, either:

- Existing S&I diagrams have been marked up with an indicative proposed signalling layout which has been costed and presented as part of the technical note or report,
- Existing S&I diagrams have been used as working documents to hand mark up where new or modified signalling is required to provide an estimate with similar accuracy with respect to functionality but less certainty around specific locations of equipment, or
- A less accurate estimate has been generated by using a more generic method of assessing equipment requirements based on groups of equipment required for certain functionality or average costs per distance.

PROPERTY COSTS

The KR Property Group have informed the property cost estimates for most solutions proposed. Where individual consultants have estimated property costs this is noted in their technical notes / reports and their methodology has been reviewed and agreed by KR Property Group.

EXCLUSIONS

- Wider station upgrades i.e., parking (only track layout upgrades and platform construction at stations is included)
- Train upgrades
- New Rolling Stock

ASSUMPTIONS

- Works that are already funded e.g., PACE, T2UH, WMUP6A, WMUP6B are assumed complete to full scope prior to RS1 and no programme or cost estimation work in relation to these projects has been undertaken as part of this study.
- Traction power supplies for RS100[8] are assumed complete and able to support all the scenarios through to RS6.
- The Wellington ETCS L2 project is implemented prior to implementation of the RS4 timetable and the ETCS implementation is optimised so it does not reduce network capacity.
- Level crossings not specifically triggered by RSs are tied in with projects in the area.
- The start date of the programme is 2024.
- A mobilisation period for Design, Consenting and Procurement of between 18 months and 7 years has been allowed depending on project scale, level of complexity, and cost estimate.
- Development of the required Business Case for each component is expected to run for at least 18 months in parallel with the Design and Consenting phase for all projects.
- Where additional mains are being delivered it has been assumed that all new rail infrastructure will be delivered together.
- No more than one grade separation per line per year will be planned, to manage road traffic.
- Grade separation of level crossings is undertaken prior to the arrival of a new third main.
- No infrastructure improvements have been considered at this stage on the Johnsonville Branch Line, as the existing potential frequency will remain the same, although the potential to increase resilience by increasing speed through the WRS precinct area will be considered as part of any reconfiguration.
- Stabling is to be available prior to it being required to implement the next RS timetable.

SPECIFIC PROPERTY COST ASSUMPTIONS

- A high-level assessment only has been made on whether there would need to be a full or partial land requirement.
- Where part of a property needs to be acquired, a partial purchase allowance has been made plus an additional 15% contingency.
- Where a full property needs to be acquired the Rating Value plus 15% contingency has been relied upon to give the indicative cost.
- An allowance has been made for Solatium and Costs which are payable under the Public Works Act being $75,000 per property for partial land purchases and $100,000 per property for full purchases.
- Review of any titles or done further research to identify whether there are any potential registered or unregistered interests that may also be compensable under the Public Works Act (easements, leases etc), has not been undertaken.

[8] RS100 refers to an electrical power demand scenario where 100 Matangi trains are in service.

5. OPERATIONAL MODELLING OF TIMETABLE EVOLUTION

An operational model has been used to progressively test infrastructure capacity using passenger service scenarios increased in steps to a six-minute frequency. Regular interval “timetable slots” are provided to fit increased freight services.

PASSENGER NETWORK PURPOSE AND ORIENTATION

The report does not question the basic layout of the Wellington Network and seek to alleviate the limitations this imposes on passenger service patterns and capacity. This basic configuration is:

- The passenger network is centred on Wellington CBD – terminating at Wellington Railway Station.
- There is no through service south of WRS.
- There is no east-west connection except at the southern end of network, at WRS.

This configuration supports a service concept based on providing tidal flow transport to/from Wellington CBD. This reflects historic travel patterns which appear under pressure from static or declining CBD employment, retail, and entertainment.

This study has not addressed this potential change in usage, which may be worth consideration as part of a separate future study.

CLOCKFACE

The provision of a clockface service is a fundamental component of any modern transportation system. This ensures consistency and predictability for passengers and operators, which facilitates high timetable performance and customer satisfaction. All proposed timetables are clockface on any given service tier - trains depart from origin stations at a fixed interval throughout each peak period.

TIMING OF SERVICE INCREASES

Implementation of future timetables is dependent on prior delivery of required infrastructure. The years referred to in the KSP operational modelling papers are the aspirational implementation dates set out in the Greater Wellington Rail Plan.

This study seeks to demonstrate the quantum of work to be achieved and the associated spend profile to deliver infrastructure prior to the aspirational implementation dates for successive Rail Scenario timetables.

Further assessment of resource requirements and construction assess needs to be carried out to confirm if infrastructure can be delivered in time to meet the Rail Plan timetable implementation aspirations. The initial programme of required work identified in this study indicates these aspirations are significantly optimistic.

METRO TIMETABLE EVOLUTION

The Greater Wellington Rail Plan “Rail Scenario” RS nomenclature is used to label each timetable scenario for the metro area. These scenarios have been adopted in the operational model for the purpose of loading up the infrastructure and identifying constraints.

The scenario references used for this study are generally in line with the Rail Plan definitions though several required refinements have been identified for achieving the RS4 10-minute timetable. These are differentiated by a decimal point i.e., RS4.1, 4.2 & 4.3.

Rail Scenarios RS3 & RS5 are not considered as separate scenarios in this study as operational modelling has found that infrastructure required to implement RS3 will also allow the RS4 timetable and similarly that required to implement RS5 will also allow RS6 to be implemented.

The service levels to be achieved at each RS are set out in Figure 1 below.

The KSP operational modelling papers[9] define these scenarios and their associated existing implementation constraints in more detail:

- Preliminary Wellington Timetable Evolution and Infrastructure Roadmap Issue 1 (First cut 01-08-2022)
- KZ139-02 Wellington Timetable Evolution and Infrastructure Roadmap Issue 2 (Second Draft 22-12-2022)

Extracts from these papers have been used throughout this report but the full papers should be consulted for both background information and further detail on all aspects of the operational modeling undertaken.

[9] Some early consultant engineering technical notes setting out infrastructure solutions respond to requirements set out in KSP Issue 1 and have been subsequently updated via addendum to incorporate additional requirements outlined in Issue 2, other later notes have been prepared to directly address the requirements of Issue 2.

TIMETABLE:	RS1	RS2	RS4.1	RS4.2 (TB3M, HVL3M)	RS4.3 (MPML) + RS4.2 KPL	RS6
Year:	2025	2025-2030	2030-2035	2030-2035	2030-2035	2040-2045
KPL service: [mins] – outer tier	14-16-14 (30 counterpeak) Express	15 (15 counterpeak) Express	10 (10 counterpeak) All-stop	10 (10 counterpeak) Express (saves 3 mins)		6 (6 counterpeak) Express
KPL service: [mins] – inner tier	14-16-14	15	10 (Offset 4-6-4 to outer tier to create 6 min freight paths) 4-6-4 south of Plimmerton is close to clockface	10 (TB3M allows express to overtake all-stop, resulting in 7 to 8 min freight paths) 8-2-8 south of Plimmerton is not clockface		6
HVL service: [mins] – outer tier	15	15	10 All-stop	10 Express (saves 5 mins)	10 (Upper Hutt to Wellington via MPML) Express equivalent (saves 5 mins)	6 Express equivalent (saves 5 mins)
HVL service: [mins] – inner tier	15	15	10 (Offset 4-6-4 to outer tier to create 6 min LNIRIM paths) 4-6-4 south of Taita is close to clockface	10 (HVL3M allows express to overtake all-stop, resulting in 7 min LNIRIM paths) 7-3-7 south of Taita is not clockface	10 (Manor Park to Wellington via WL) Clockface south of Manor Park	6 (Manor Park to Wellington via WL) Clockface south of Manor Park
MEL service: [mins]	Approx. 20 irregular	15	Riverlink commits Melling service to continue to improve: (i) 20 (do minimum, backwards step – unlikely acceptable to stakeholders) (ii) 10 (full duplication of MEL + high-capacity ETCS, not robust) (iii) 10 (full duplication of MEL + MJW3M 3rd Main to WLG) (iv) 10 (build MPML)			6 (MEL now part of Upper Hutt service)
JVL service: [mins]	15	15	15	15	15	12
Wairarapa service: [mins]	30 to 45 (diesel)	15 to 30 (LNIRIM)	20 (LNIRIM)	20 (LNIRIM)	20 (LNIRIM)	18 (LNIRIM)
Manawatu service including W2O/L [mins]	1 off per peak (CC diesel)	60 (LNIRIM Lite), progressing to…. 15 to 30 (LINRIM Full) W2O + W2L Lite, progressing to… W2L	10 to 20 (LNIRIM) No more W2O/L (integrated into LNIRIM)	10 to 20 (LNIRIM) No more W2O/L (integrated into LNIRIM)	10 to 20 (LNIRIM) No more W2O/L (integrated into LNIRIM)	12 to 18 (LNIRIM)
NIMT Freight service [mins]	30	15 to 30	20 to 30	20 to 30	20 to 30	18 to 24
WL Freight service [mins]	Outside peaks	Outside peaks	Outside peaks	Outside peaks	Outside peaks	Outside peaks

Figure 1 – RS Timetable service levels

LNIRIM AND WOL SHUTTLE TIMETABLE EVOLUTION

At present, the area north of Waikanae has limited rail connection to the Greater Wellington (GW) rail network. The only commuter rail service available, which stops at Otaki, Levin, and Shannon, is the Capital Connection between Palmerston North and Wellington. This provides only one train in the morning and afternoon peaks.

GWRC and Horizons Regional Council have separately proposed an improvement to the existing Palmerston North to Wellington timetable. They have produced a business case (LNIRIM[10] November 2021) to provide passenger services at a 15 to 45-minute frequency on this route during the morning and afternoon peaks, including stops at Waikanae, Otaki, and Levin.

To determine the infrastructure required for an all-day improved commuter frequency Waikanae-Otaki-Levin (WOL) service, a concept timetable has been developed that meshes with the LNIRIM proposal and the proposed RS improvements south of Waikanae.

This is summarised in Figure 2 below. This provides a basis for calculating progressive infrastructure development north of Waikanae.

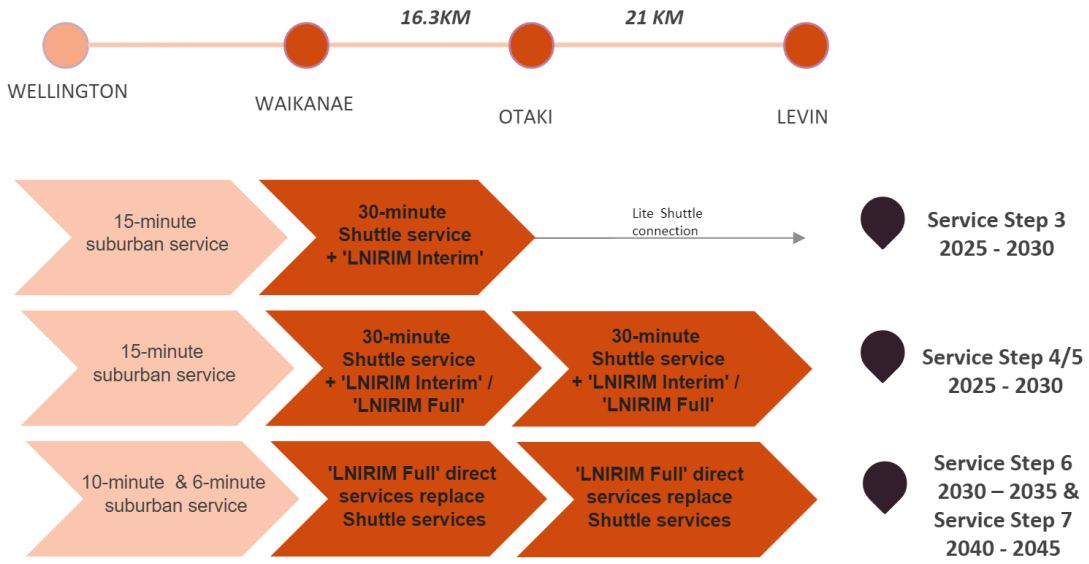


Figure 2 – Progressive Service Steps in the WOL Shuttle concept timetable evolution

[10] Lower North Island Rail Integrated Mobility project.

OPERATIONAL MODELLING

OPERATIONAL MODELLING REPORTS

The full list of operational modelling papers that support this study are listed below:

- Preliminary Wellington Timetable Evolution and Infrastructure Roadmap Issue 1 (First cut 01-08-2022)
- KZ139-01 W2L paper V3
- KZ139-02 Wellington Timetable Evolution and Infrastructure Roadmap Issue 2 (Second Draft 22-12-2022)
- KZ139-02 Appendix 2: Train Graphs
- KZ139-03 Woburn Junction Modelling Report Issue 1
- KZ139-05 LNIRIM on NIMT, DRAFT 2
- KZ139-06 LNIRIM Lite on NIMT DRAFT 2
- KZ139-07 Waikanae to Levin Evolution Table DRAFT 4
- KZ139-08 Resilience Crossovers Modelling Report
- KZ139-09 Identifying Curve Easing Opportunities, DRAFT 1
- KZ139-10 Stabling Evolution Excel File V1
- KZ139-11 NSJ Line Speed Modelling for Stage 2 Upgrade

PEER REVIEW OF OPERATIONAL MODELLING

A peer review of the KSP Consultants Ltd operational modelling work was undertaken by R Donaldson Rail Ltd(1) as part of this study.

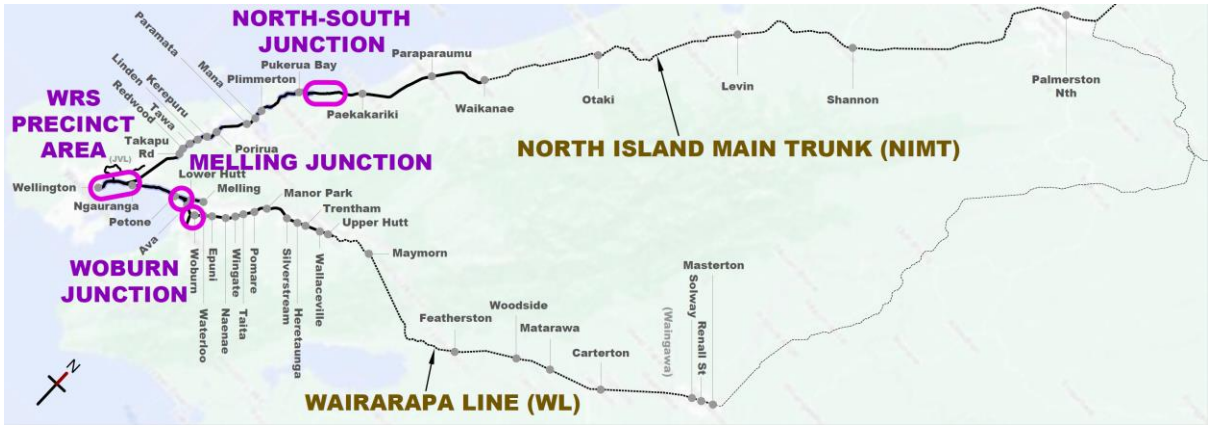
6. NETWORK CONSTRAINTS

Passenger and freight growth on the network is constrained by the existing infrastructure and the timetables that can be reliably operated on it. Infrastructure changes are required to remove these constraints and allow higher frequency timetables to be serviced.

KiwiRail as asset owner has reviewed the capacity required as part of the Rail Plan's aspirational timetables and has assessed the constraints on the network that, without intervention, would prevent this capacity from being reached.

The primary existing network constraints, that hinder implementation of progressive Rail Scenario timetables, are:

- The constrained WRS Precinct area containing multiple overlapping functions.
- The North-South Junction (NSJ) single track section.
- Station and platform infrastructure (especially at turnback locations).
- Signalling configuration and functionality.
- Insufficient main tracks to allow express services to pass other slower services.
- Stabling capacity & maintenance facilities suitable for an increased fleet.



In addition, as train frequency increases there are other network wide constraints that need to be considered such as:

- Maintenance and Access Planning (how the network will be maintained and improved – more maintenance and construction access required with higher frequency operations)
- Vehicle and pedestrian level crossings (Grade separation for public safety)
- Slope stability, Inundation Risk etc (Operational resilience)
- Crossovers for bi-directional running (Constructability while minimising impact on operations, service resilience)

7. SOLUTIONS BY RAIL SCENARIO

This section provides an overview of the potential projects required to be delivered to remove constraints and enable implementation of successive higher frequency timetables as set out in the Rail Plan.

RS1 – INFRASTRUCTURE CHANGES REQUIRED

RS1 is a more consistent timetable relative to today, providing a nominal 15-minute service, mostly requiring infrastructure upgrades that have already been budgeted, designed, and are being constructed. Frequency is not exactly 15 minutes; a small imbalance being provided to accommodate a freight train path each hour.

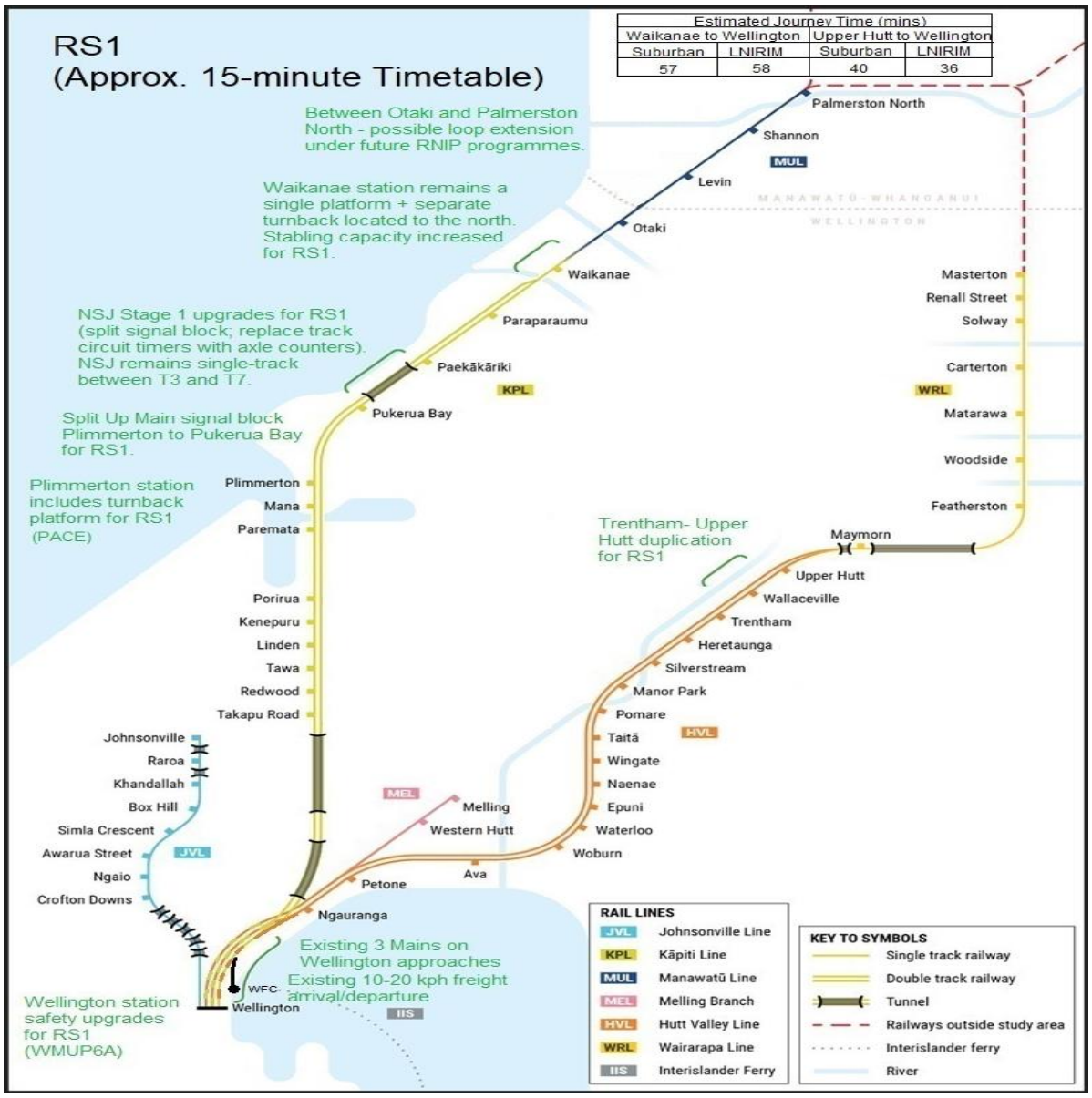


Figure 3 – Diagram of infrastructure changes required for RS1

Figure 4 – Geographic extent of works required for RS1

Summary of new infrastructure requirements (not included in current WMUP projects):

North Island Main Trunk (NIMT) & Kapiti Line (KL)

KPL-RS1-1	Waikanae - Increase Stabling	Increasing stabling capacity from 12 to 20 cars
KPL-RS1-2	NSJ & Pukerua Bay - Split Signal Block	Split Up Main signal blocks to allow shorter headway between following passenger trains

Wairarapa Line (WL), Hutt Valley Line (HVL) & Melling Line (MEL)

HVL-RS1-3	Woburn Junction Upgrades	To minimise interference with the main line from train movements across Woburn Junction to and from the Gracefield Branch Line

Wellington Railway Station Precinct (WRS)

No further infrastructure changes required beyond current WMUP works.

Johnsonville Line (JVL)

No infrastructure changes required.

Network Wide Upgrades

It is not expected any specific network wide upgrades identified in this study will be undertaken prior to the implementation of RS1.

RS2 – INFRASTRUCTURE CHANGES REQUIRED

RS2 is an enhancement of the RS1 timetable, with further infrastructure upgrades allowing a consistent and exact 15-minute timetable throughout all corridors.

Upgrades include North-South Junction (NSJ) Stage 2 with double-tracking extension to Tunnel 3 portal and Wellington Freight Centre (WFC) 40kph entry/exit upgrades for longer freight trains operating under iReX. LNIRIM Lite places reduced demand on infrastructure relative to the full LNIRIM timetable, but still requires multiple passing loop upgrades north of Waikanae.

The Lower Hutt Riverlink project is due to be completed 2028 with a relocated Melling Line terminus station (about 480m south from current location) with an associated expectation for a significantly improved service on this branch line. Figure 3 shows the infrastructure changes required prior to implementation of RS2.

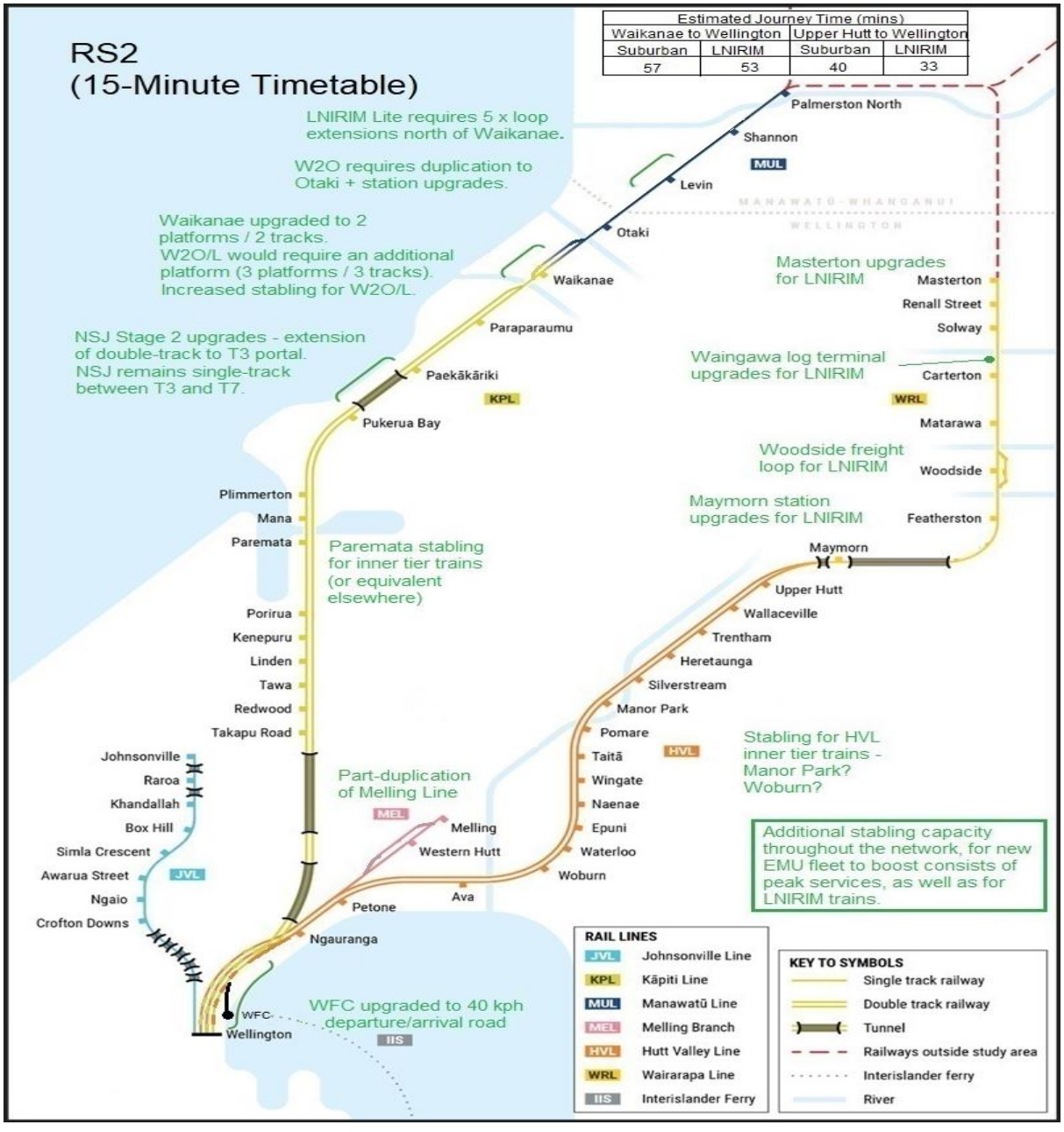


Figure 5 – Diagram of infrastructure changes required for RS2

Figure 6 – Geographic extent of works required for RS2

Summary of infrastructure requirements:

North Island Main Trunk (NIMT) & Kapiti Line (KL)

NIMT-RS2-1	Levin to PNth (LNIRIM Lite) - Linton and Koputaroa loops extended to 900m	Extension of passing loops at Linton and Koputaroa to let full length freights to clear the line and enable LNIRIM trains to pass.
NIMT-RS2-2	Levin to PNth (LNIRIM Full) - Full duplication Levin to Shannon	Duplication between Levin and Shannon to avoid freights becoming stuck in passing loops between a more frequent LNIRIM service.
NIMT-RS2-3	Waikanae to Levin (LNIRIM & WOL Shuttle) - Full duplication	Duplication of single track between Waikanae and Levin to prevent LNIRIM and WOL services holding up freight services and each other.
NIMT-RS2-4	Waikanae to Levin (LNIRIM & WOL) - Electrification	Overhead line electrification between Waikanae and Levin to support an electrified WOL commuter shuttle service.
KPL-RS2-5	Paekakariki / Waikanae - Increase Stabling	Additional stabling for 50 cars for overnight storage (to cover RS2 & RS4 stabling requirements).
KPL-RS2-6	NSJ (South Junction) - Extend double track to Tunnel 3	Reduce length of North South Junction single track section by 400-500m
KPL-RS2-7	Plimmerton / Paremata - Stabling capacity for inner tier trains	New stabling in Paremata / Plimmerton area for inner tier trains (30 cars) to reduce conflicts in Wellington Station throat. (For RS2 & RS4)

Note: NIMT-RS2-4 Waikanae to Levin (LNIRIM & WOL) – Electrification, will not be required if battery equipped EMUs are used beyond Waikanae.

Wairarapa Line (WL), Hutt Valley Line (HVL) & Melling Line (ML)

WL-RS2-9	Masterton - Increase Stabling for LNIRIM Trains	Increase stabling by 56 cars to be integrated with maintenance depot (for RS2 to RS6)
WL-RS2-10	Platform Lengthening at Matarawa, Solway and Renall St	Platforms need lengthening to accommodate 8-car consists for LNIRIM peak to prevent ongoing use of operational workarounds.
HVL-RS2-11	Taita / Manor park / Woburn - outstabling for inner tier trains	New out-stabling for 48 cars to reduce conflicts in Wellington Station throat (for RS2 & RS4, not required for RS6)
ML-RS2-12	Melling Line - Partial Duplication (Km0+500 - Km1+700)	New section of double track on the Melling Line where trains can cross allowing an increased frequency timetable.

Wellington Railway Station Precinct (WRS)

WRS-RS2-13	WRS Precinct - 40kph Freight Yard Access & separate arrival and departure roads	Increase speed to 40kph and separate arrival and departure roads to minimise time freights block main line when entering freight yard.
WRS-RS2-14	WRS Precinct - East Stabling for LNIRIM Trains	Additional stabling for 42 cars for overnight storage and interpeak layover.

Johnsonville Line (JVL)

No infrastructure changes required.

Network Wide Upgrades

Upgrades in the following areas will run in parallel with other projects to be delivered at RS2:

- Maintenance and Access Planning (Hi-rail vehicle on-tracking pads, crossovers for bi-directional running)
- Level Crossing grade separation works – Vehicle (one per year to minimise road network congestion) & Pedestrian (under / over passes)
- Delivery of the Wellington ETCS L2 project in critical safety areas.
- Inundation Risk (Major flooding)
- Planned slope stability programme (15 slopes)

RS4 – INFRASTRUCTURE CHANGES REQUIRED FOR 10-MINUTE TIMETABLE – OPTIONS

All versions of RS4 require duplication of T7NIMT, substantial upgrades at Wellington Railway Station and approaches, additional platform(s) at Taita and Waikanae, and ETCS Level 2 on at least some sections of corridor where existing signalling doesn't allow the reduced headways required. The full LNIRIM is expected to operate by 2035 which requires extension of duplication to Shannon. Any WOL service is then expected to largely cease and be absorbed into the frequent LNIRIM direct services to Wellington.

There are several different infrastructure solutions that could satisfy the operational requirements for implementing the RS4 10-minute timetable. Each option has different advantages from a cost and operational perspective.

All options for the delivery of the RS4 10-minute timetable will need to be analysed further at Business Case stage to allow a comparative Benefit Cost Ratio (BCR) to be calculated for each.

The following sections give context to the various infrastructure solutions that could support the implementation of RS4 by:

- Providing reasoning behind why particular scenarios have been modelled and others not.
- Demonstrating how the introduction of a 10-minute timetable on the Melling Line impacts the infrastructure required for some of those scenarios.
- Setting out the infrastructure required for each of the mainline options.
- Suggesting a preferred option based on the level of study carried out to date across each of the options.

A largely cost based approach has been used to determine a preferred option for the implementation roadmap and subsequent discussion for this capacity study, though operational benefits have also been considered where known.

10-MINUTE TIMETABLE KPL & HVL / 20-MINUTE TIMETABLE MELLING LINE

There are several different infrastructure solutions that could satisfy the operational requirements for implementing the RS4 10-minute timetable on the KPL & HVL and running a 20-minute[11] timetable on the Melling Line, including:

- Timetable solutions – no express services (all trains all stops)
- Third main solutions – construction of a section of additional main on both WL and NIMT to allow expresses to overtake all-stop services.
- A bypass solution – construction of a new bypass line in Hutt Valley from Manor Park to Melling Junction to allow expresses to avoid all-stop services.

The matrix below identifies the three most plausible sub-scenarios of the options for implementing RS4 on the KPL and HVL that have been selected for operational modelling purposes:

- 4.1 Timetable solutions on both KPL & HVL
- 4.2 Third Main sections on both KPL & HVL
- 4.3 Third Main section on KPL and Bypass on HVL between Manor Park and Melling

		Hutt Valley Line Solutions		
		Timetable solution – no express services (all trains all stops)	Hutt Valley 3rd Main (South Waterloo to North Taita)[12]	Manor Park Melling Link (MPML)
Kapiti Line	Timetable solution – no express service (all trains all stops, and potentially close Redwood station)	**RS4.1**	Not considered specifically as a scenario – building blocks available though, for future combination	Not considered plausible – likely investment would be made into TB3M before MPML.
	Tawa Basin 3rd Main (TB3M)	Not considered specifically as a scenario – building blocks available though, for future combination	**RS4.2**	**RS4.3**

A comprehensive benefit analysis has not been undertaken but the operational benefits of each option can be summarised as follows:

- Third main solutions are expected to be preferred operationally by GWRC over the timetable solution, which is a reduction in service level for some, due to increased journey times.
- The Manor Park to Melling Link would provide greater resilience and the Upper Hutt express journey time of 40 minutes becomes the all-day journey time. One new stop is assumed between Melling and Manor Park – at Belmont which is potentially a high-patronage catchment area. Overall, this provides significant network benefits.

The Manor Park to Melling Link has the advantage of being built largely offline from the live railway.

[11] A 20-minute timetable requires no further infrastructure to dovetail with 10-minute WL service but it is a regression from the 15-minute Melling timetable at RS2,.

[12] HVL3M from south of Waterloo (15.00) to north of Taita (21.200)

ACHIEVING A 10-MINUTE TIMETABLE ON MELLING LINE

With only the infrastructure improvements described in the previous section for the 10-minute timetable on the KPL and HVL, the Melling Line would need to revert back to a 20-minute timetable at RS4 from the 15-minute at RS2. As this is unlikely to be acceptable[13] all options for the Melling Line are shown below including the additional infrastructure required to provide a 10-minute service.

The Melling Line timetable must dovetail with an RS4 10-minute service on the HVL and connect via an at grade single lead junction. There are several options to achieve this:

In conjunction with RS4.1 (timetable solution HVL) or RS4.2 (third main solution for HVL):

A. Melling Line timetable solution – revert to a 20-minute service

B. Implement 'Fully Optimised' ETCS L2[14] (to reduce headway requirements and allow an additional service to be run on existing mains)

C. Construct a third main from Melling Junction to Wellington (to provide an additional main for the Melling Service).

In conjunction with RS4.3 (bypass for HVL):

D. Use the Manor Park to Melling Link and Upper Hutt trains to provide the 10-minute Melling service (RS4.3)

The matrix below sets out the key infrastructure requirements for each of the options.

	RS4.1/4.2 Option A	RS4.1/4.2 Option B	RS4.1/4.2 Option C	RS4.3 Option D
Timetable solution (no additional infrastructure required)	Yes (20-minute)	No	No	No
Fully Optimised ETCS	No	Yes	No	No
Melling Junction to Wellington 3rd Main (MJ2W3M)	No	No	$607	No
Manor Park to Melling Link (MPML)	No	No	No	$566
Requires HVL3M at RS4 (becomes redundant at RS6 – sunk cost)	No	$214	$214	No
Comparative cost estimates ($M) ***(key differential infrastructure only)***	**$0**	**$214**	**$821**	**$566**

Operational benefits of each option:

- Fully Optimised ETCS L2 offers less resilience than a third main Melling Junction to WRS
- The Manor Park to Melling Link offers more resilience then either Highly Optimised ETCS L2 or the Melling Junction to WRS third main and provides more service benefits.

[13] The Riverlink Project is anticipated to require a frequent reliable service to Melling and will expect service improvements at RS4 rather than the less frequent service that would be provided by a 20-minute timetable. In general, it is not desirable from a customer service perspective to reduce frequency, unless this is the only means of achieving dependability.

[14] It is assumed the Wellington ETCS Project will deliver an Optimised ETCS L2 solution. To achieve sufficient capacity via the signalling system alone (Option B), it will need to be detail designed to deliver the highest capacity possible i.e., 'Fully Optimised'.

At RS6 both the Manor Park to Melling Link **and** Petone to Wellington third main are required. A grade separated Melling junction will also be required. (At RS4 grade separation of the junction provides a resilience benefit only – a flat junction is adequate from an operational perspective.)

Considerable savings could be made if the Option A timetable solution was selected, though this may be unacceptable from a service perspective, or if the Option B 'Fully Optimised ETCS' were selected, although this offers less operational resilience.

The Benefit Cost Ratio (BCR) of each option will need to be calculated at Business Case stage but for the purposes of determining a reasonable scenario to present in the overall roadmap:

- **RS4.3 Option D from the table above has been selected as preferred**, as construction of the Manor Park to Melling Link for RS4 removes the need for a HVL3M which becomes redundant at RS6 and the cost estimate for the Link is roughly equivalent to the Melling Junction to Wellington third main. Additionally, this option provides operational benefits over the other options proposed.

In the following sections the infrastructure for each of the options is presented in its own section along with a summary table at the end to summarise infrastructure requirements for each option.

All options are detailed in the following sections as no definitive preference can be identified in absence of formal benefit assessment. But RS4.3 Option D has been selected at this stage as preferred, by inspection, and as such will be taken forward into the initial Implementation Roadmap.

RS4.1 – INFRASTRUCTURE CHANGES REQUIRED (TIMETABLE SOLUTION ON KPL & HVL, 20-MINUTE ML)

GWRC patronage growth forecast triggers the 10-minute timetable during the early 2030s. For RS4.1, the timetable structure is changed so both the outer tier and inner tier become all-stopping service patterns, which avoids the need for additional tracks. This negatively impacts journey time by adding at least 3 to 7 minutes to the journey between Waikanae / Upper Hutt and Wellington, which in turn could constrain patronage growth. Thus, RS4.1 represents a compromise in the evolution of the rail service.

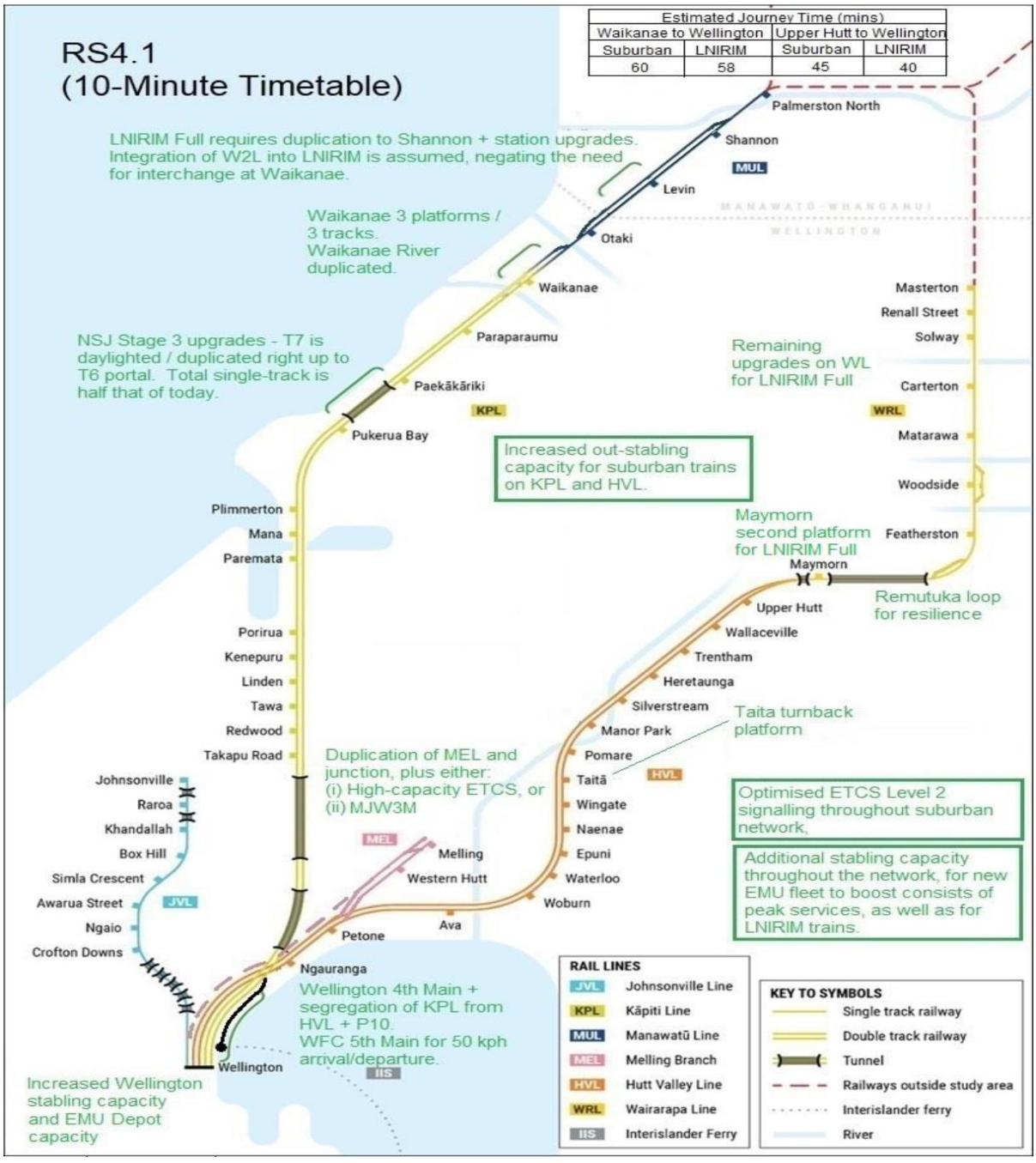


Figure 7 – Diagram of infrastructure changes required for RS4.1

RS4.2 – INFRASTRUCTURE CHANGES REQUIRED (THIRD MAINS SOLUTION ON KPL AND HVL)

For RS4.2 sections of 3rd main on the KPL and HVL are used to preserve the same basic timetable structure, allowing outer tier express services to overtake inner tier all-stop services. This provides two significant benefits: (i) it saves 3 to 5 minutes journey time between Waikanae / Upper Hutt and Wellington relative to RS4.1; (ii) and it releases capacity for use by freight and inter-regional passenger trains. Thus, RS4.2 is preferrable over RS4.1. As for RS4.1, earthworks are required at NSJ where T7 needs to be duplicated, there are upgrades at Wellington Railway Station, Taita and Waikanae, and ETCS Level 2 signalling is needed. However, besides the extra sections of 3rd main, the overall demand for infrastructure is less than in RS4.1. Fewer platforms are required at Wellington Railway Station, WFC entry speed could be 40 kph so a 5th Main can be avoided, and lower signal headway capacity is needed reducing the sections where fully optimised ETCS L2 signalling is required and thus potentially reducing signalling costs.

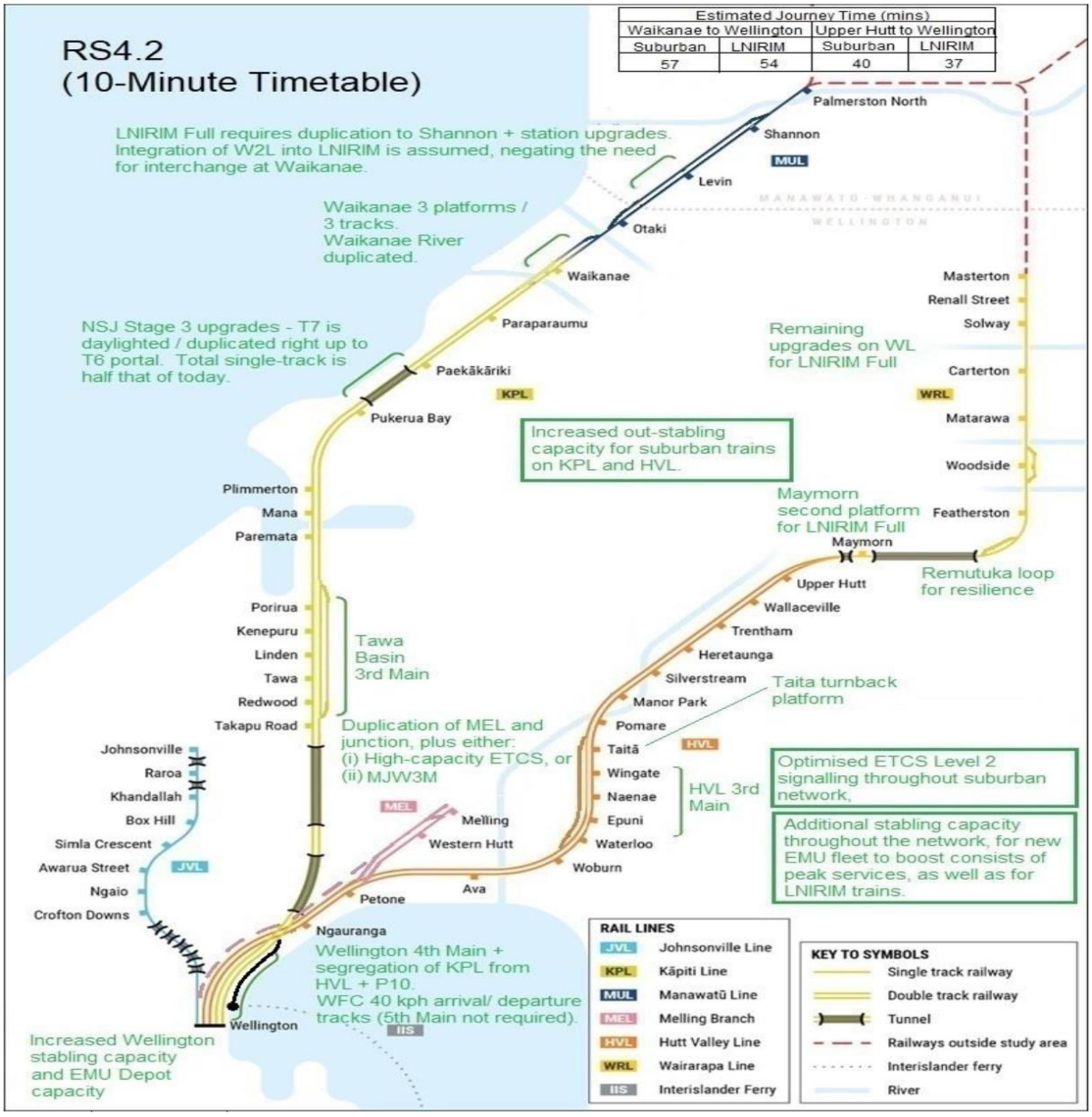


Figure 8 – Diagram of infrastructure changes required for RS4.2

RS4.3 – INFRASTRUCTURE CHANGES REQUIRED (THIRD MAIN ON KPL & BYPASS ON HVL)

RS4.3 has a specific change for the HVL set out below which is combined with the all the features of RS4.2 on the Kapiti Line including the Tawa Basin 3rd Main.

This concept extends the Melling Line to connect with the Wairarapa Line at Manor Park via a double track Manor Park to Melling Link. This means the Taita service now becomes a Manor Park to Wellington service via the current eastern line, stopping at all stops, all day.

The Upper Hutt service would travel between Upper Hutt and Wellington via the MPML Link, stopping at all stops, all day. In effect this achieves the same as RS4.2 in that the Upper Hutt service journey time is preserved, but this advantage is extended because the basic running time is reduced to 40 minutes all-day. Inner tier services travel between Wellington and Manor Park via the existing route, interchanging with outer tier services at Manor Park and Petone. Timetables would allow for efficient interchange between the services (serving passengers to/from Eastern Hutt). On the Upper Hutt service, one new stop is assumed between Melling and Manor Park – at Belmont (located near Fairway Drive Bridge) which is potentially a high-patronage catchment area. Overall, this provides significant network benefits:

- It shortens journey time for all through passengers in the Upper Hutt valley area by 5 minutes (run time about 40 minutes).
- It shortens journey time all day for LNIRIM Wairarapa passengers by 6 minutes relative to RS4.1(run time from Upper Hutt 34 minutes).
- It eliminates the separate Melling Line service which significantly reduces the demand on capacity south of Petone (6 tph less in a 10-minute timetable), including requirement for platforms at Wellington station.
- It locks in a high-quality frequent service for the Lower Hutt Valley / Riverlink area.
- It provides wider and more frequent paths for LNIRIM services compared with other timetables so is more robust.
- It provides useful resilience for outage and maintenance.
- It can be built away from existing rail operations.

To ensure this remains an option in the Wellington Region future master plan, Riverlink must allow for the Manor Park to Melling Link extension north from Melling.

The Manor Park to Melling link is not required for RS4 if the Taita – Waterloo duplication is provided (along with a third main between Melling Junction and WRS) but is essential to RS6, as well as delivering other benefits. When provided for RS6 it renders the Taita – Waterloo duplication redundant. A strategic approach would meet the RS4 requirement with the Manor Park to Melling link and begin delivering the benefits early.

Figure 9 – Diagram of infrastructure changes required for RS4.3

The maps below show a geographical comparison of infrastructure required for each option:

Figure 10 – Geographic extent of works required for RS4.1

Figure 11 – Geographic extent of works required for RS4.2

Figure 12 – Geographic extent of works required for RS4.3

Summary of infrastructure requirements for each main line option (RS4.3 preferred):

Package Ref.	Decription	Primary Purpose	RS4.1	RS4.2	RS4.3
KPL-RS4-1	Waikanae River Bridge Duplication	Remove single track section to achieve full duplication south of Waikanae required to facilitate higher frequency timetables.	●	●	●
KPL-RS4-2	NSJ - (North Junction) Extend double track to Tunnel 6	Reduce length of North South Junction single track section to half what it is in 2022.	●	●	●
KPL-RS4-3	Pukerua Bay - Shorten Signal Block	Shorten signal block to allow closer following moves through North South Junction single track section	●	●	●
KPL-RS4.23-4	Tawa Basin 3rd Main (RS4.2 & RS4.3)	To allow the express to pass the all-stop service.		●	●
WL-RS4-21	Masteron to Pahiatua	Reopening of section to provide freight route resilience between Masterton and Pahiatua	●	●	●
WL-RS4-5	Remutaka loop resilience (Post WMUP 6B scope)	New resilience loop to allow trains to pass each other.	●	●	●
WL-RS4-6	Remutaka tunnel ventilation (Post WMUP 6B scope)	Improve tunnel ventilation to reduce purge time between trains to allow higher frequency services through the tunnel.	●	●	●
WL-RS4-7	Maymorn second platform and loop (Post WMUP 6B scope)	The loop allows trains to pass each other and the platform allows turnback at Maymorn in case of an Remutaka Tunnel indicent during the peak.	●	●	●
WL-RS4-8	Upper Hutt Siding Lengthening (Post WMUP 6B scope)	To allow a freight train to stand offline from the mains at the boundary of the high frequency network to allow timetable adjustments.	●	●	●
WL-RS4-19	Upper Hutt - additional stabling	To allow a freight train to stand offline from the mains at the boundary of the high frequency network to allow timetable adjustments.	●	●	●
HVL-RS4.3-9	Manor Park - additional stabling (RS4.3)	Increase stabling by 48 cars for overnight stabling for HVL EMU trains			●
HVL-RS4.3-10	Manor Park Melling Link (RS4.3)	To provide an alternative route for the WL express service and provide a new service to 2 stations along the new route.			●
HVL-RS4.12-11	Taita - New at platform turnback (RS4.1 & RS4.2)	New track and plaform to allow inner tier trains to turnback at Taita	●	●	
HVL-RS4.2-12	Hutt Valley Line 3rd Main (RS4.2)	To allow the express to pass the all-stop service		●	
HVL-RS4-13	Melling Junction to WRS 3rd Main OR high-capacity ETCS (RS4.1 & RS4.2)	To allow a ten minute Melling Service to run alongside the WL service.	●	●	
ML-RS4-14	Melling Line - Complete Duplication (Km1+700 to Km3+000)	To increase the section of track trains can pass in by completing full duplication of the Melling Line	●	●	●
ML-RS4-15	Melling Junction - Duplicate Junction at grade	Complete dull duplication of the Melling line including the junction (at grade). Grade separation of the junction would be required for RS6.	●	●	●
WRS-RS4-16	WRS Precinct - New 5th (freight) main (allowing 50kph arrival / departure) (RS4.1 only)	To allow 50 kph arrival & departure from the freight yard	●		
WRS-RS4-17	WRS Precinct - 4th main (WRS to Dist Jcn) & Platorm 10	To construct a 4th Main between Distant Jucntion and Wellington Railway Station and construct a new Platofrm 10	●	●	●
WRS-RS4-21	WRS Precinct - Reconfigure flyover junction (Separation of KPL, HVL)	To separate the WL & HVLs	●	●	●
WRS-RS4-18	WRS EMU Depot expansion	To expand the existing EMU depot to accommodate increased EMU numbers at RS4	●	●	●
WRS-RS4-20	WRS Precinct - additional stabling	To increase stabling with in WRS precinct to accommodate increase in fleet size at RS4	●	●	●

Network wide upgrades & Resilience Projects

It is expected all of the following network wide upgrade and resilience project works will be completed prior to the implementation of RS4:

- Maintenance and Access Planning (Hi-rail vehicle on-tracking pads, crossovers for bi-directional running, specialised maintenance plant procurement as required)
- Level Crossing upgrades and grade separation works – Vehicles (one per year to minimise road network congestion) & Pedestrian (under / over passes)
- ETCS L2 in all inner tier areas (i.e., from WRS to Plimmerton (KPL) and Taita (HVL)) with some areas requiring 'Fully Optimised' ETCS L2[15].
- Inundation Risk (Major & Moderate flooding)
- Slope stability - work beyond the initial 15 slopes (not assessed during this study)
- NSJ Full Duplication (via single bore tunnel as a minimum)

[15] It is assumed the Wellington ETCS Project will deliver an Optimised ETCS L2 solution. To achieve sufficient capacity in some sections of the network, it will need to be detail designed to deliver the highest capacity possible i.e., 'Fully Optimised'.

RS6 – INFRASTRUCTURE CHANGES REQUIRED

GWRC forecast the need for a 6-minute timetable by 2040 on the KPL and 2045 on the HVL. RS6 operates a 6-minute service starting from both the outer tier termini (Waikanae and Upper Hutt) as well as the inner tier termini (Plimmerton and Taita or Manor Park). Two infrastructure options were considered:

1. Retaining a separate MEL branch line and providing a 12-minute service to/from Riverlink, with a 6-minute service starting from Upper Hutt, Taita, Waikanae and Plimmerton. Johnsonville Line is assumed to be upgraded to allow a 12-minute service, but this is optional as it remains segregated. LNIRIM is expected to be an 18-minute service. Overall, this imposes significant demand on NIMT and WL track capacity – 3 mains from Waikanae, 4 mains from Plimmerton, 3 mains from Upper Hutt, and 4 mains from Taita. There are multiple station upgrades required and Wellington station would have 8 main lines on approach (3 KPL, 4 HVL/MEL, JVL) and need 13 platforms. The corridor constraints on the Wellington approaches means this is very unlikely to be feasible.

2. As above, except the Manor Park to Melling Link (MPML) is built, integrating the Melling service into the Upper Hutt service. This reduces the required number of tracks on the HVL to 3 mains from Upper Hutt to Manor Park, and 3 mains from Melling Junction to Wellington, otherwise 2 mains. Wellington has 7 main lines on approach (3 KPL, 3 HVL, JVL), needs 12 platforms. Eliminating the MEL service pattern by building the Manor Park to Melling Link is probably critical for the viability of a 6-minute timetable, and **this is the only option considered further**.

Irrespective of the options above, the total infrastructure required to operate a 6-minute timetable is so significant, it could be reasonably assumed it is unlikely to be able to be implemented in line with GWRC's forecast programme.

As an interim step, the maximum could be extracted from the 10-minute timetable using long consists, using high-capacity rolling stock with more seats and more standing capacity, and with fully optimised ETCS Level 2 (and potentially Level 3) signalling to meet growing demand from 2040.

Fundamentally, the 6-minute timetable triggers the need for extra tracks for trains entering the metro area from the wider regional network, because there is no path for a freight train through a 6-minute slot (especially considering a standing start from behind Waikanae with a long freight train).

Similarly, LNIRIM trains needing a path south of Plimmerton / Taita would need to operate at 2-minute headways between inner and outer tier suburban services without extra tracks - outer tier trains at 6-minute intervals would mesh with inner tier trains at 6 minute intervals, so a train every 3 minutes except they would be offset 4 minutes / 2 minutes to create a path for LNIRIM so it would be a train every 2 minutes. This means there would be 30 tph on each track, which is not robust with mixed service types and stopping patterns[16]. Consequently, multiple tracks are required to support a robust 6-minute timetable.

The extra tracks also preserve the express service run time savings via an overtake, allow for fast LNIRIM journeys (30 minutes from Upper Hutt to Wellington, and 45 minutes from Waikanae to Wellington), and provide viable freight train paths during the peak periods.

There may be alternative forms of the timetable with a service level between 10 and 6 minutes, but this has not been explored in any detail and is beyond the scope of this relatively high-level study. In any case, this is still likely to require investment out of proportion to that required for a 10-minute timetable, which has been identified as a tipping point in terms of infrastructure demand. This spend, if contemplated, might be warrant being compared with investment to increasing the reach of the

[16] Also the Wellington Rail Network is not fully segregated. This is a ground level railway exposed to a variety of weather conditions and subject to "incidents" as opposed to an underground metro with repeatable adhesion.

network. Extension south and linking east-west somewhere north of its centre. This has not been explored as part of this study.

The discussion above suggests RS4.3 may represent the immediate practical limit for Wellington Network improvements.

A twin bore North – South Junction tunnel is required for RS6, adding to the existing track to triplicate this section. However, there may be an argument for building a single or twin bore tunnel to duplicate this section independent of RS6. This is a critical and highly vulnerable section of the Wellington and national rail network.

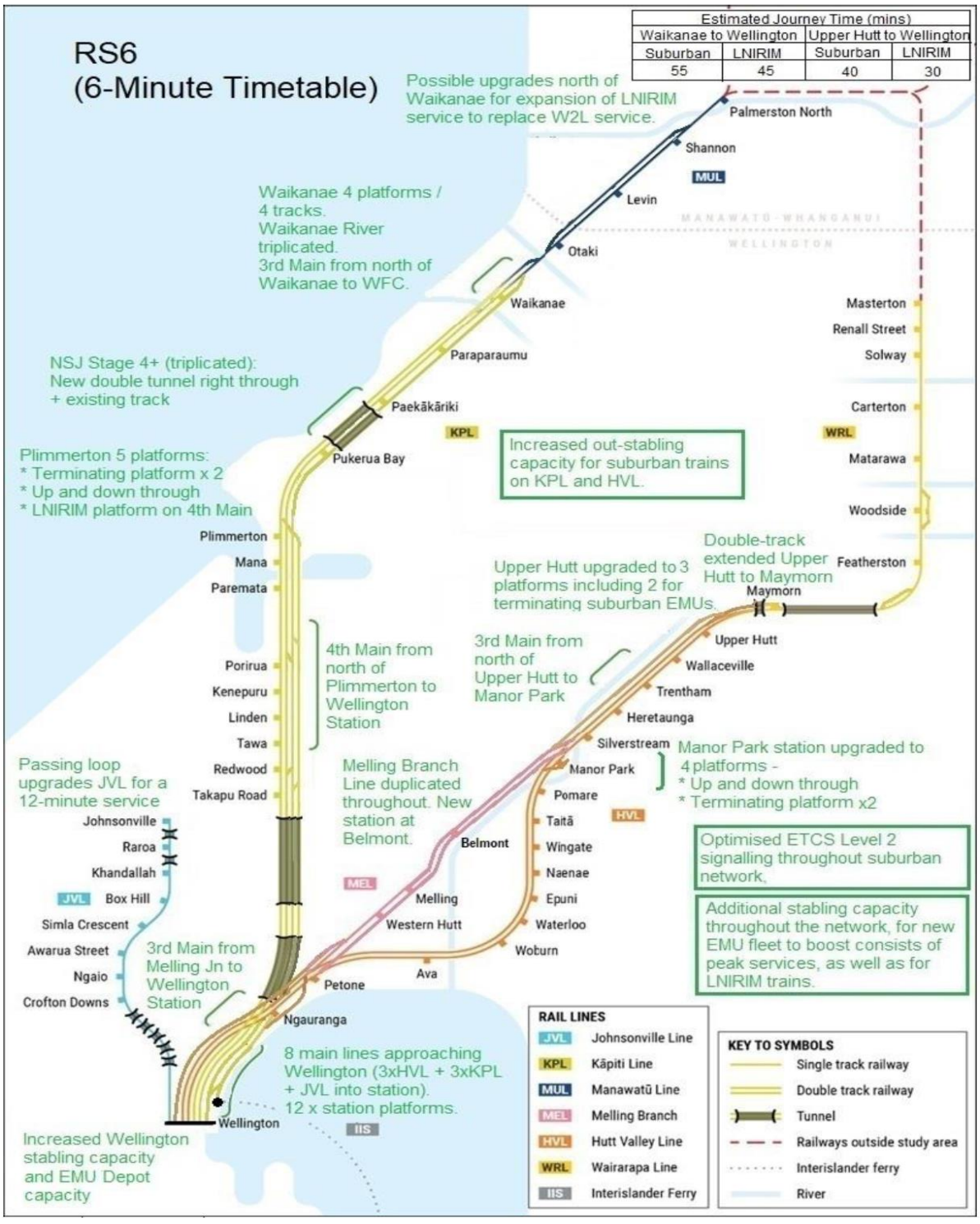


Figure 13 – Diagram of infrastructure changes required for RS6

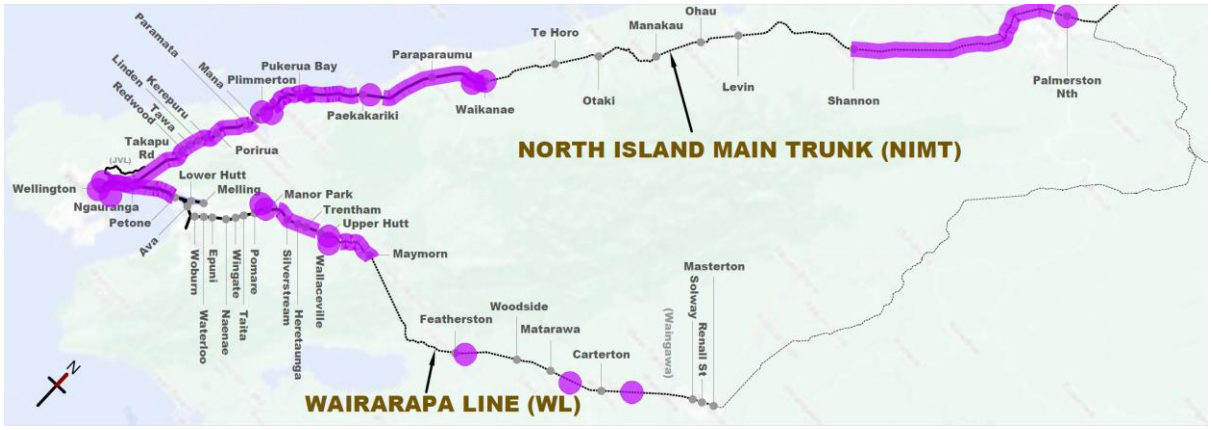


Figure 14 – Geographic extent of works required for RS6

Summary of infrastructure requirements:

North Island Main Trunk (NIMT) & Kapiti Line (KL)

NIMT-RS6-1	Palmerston North - Additional Stabling
NIMT-RS6-2	Shannon to PNth - Additional Duplication/Loop Extension (LNIRIM)
NIMT-RS6-3	Waikanae River Bridge Triplication
NIMT-RS6-4	Waikanae - 4 platforms & tracks
NIMT-RS6-5	Waikanae / Paekakariki - increase stabling
NIMT-RS6-6	Waikanae to WFC 3rd Main
NIMT-RS6-7	NSJ Fully Duplicated
NIMT-RS6-8	Pukerua Bay - shorten headway distances, eliminate tight curvature
NIMT-RS6-9	Plimmerton - 5 platforms (incl 2 terminating, 2 through and LNIRIM)
NIMT-RS6-10	Plimmerton to WRS 4th Main
KPL-RS6-11	Paremata / Plimmerton - Additional Stabling

Wairarapa Line (WL), Hutt Valley Line (HVL) & Melling Line (ML)

WL-RS6-12	Masterton to Upper Hutt - passing loop upgrades for LNIRIM
WL-RS6-13	Upper Hutt to Maymorn duplication
WL-RS6-14	Upper Hutt - 3 platforms (1 LNIRIM, 2 terminating)
WL-RS6-15	Upper Hutt - Additional Stabling
WL-RS6-16	Upper Hutt to Manor Park 3rd Main
HVL-RS6-17	Manor Park - 4 platforms (incl 2 terminating)
HVL-RS6-18	Manor Park - Additional Stabling
HVL-RS6-19	*MPML (if not delievered as part of RS4)*
ML-RS6-20	Melling Junction - Grade Separate Rail Junction
HVL-RS6-21	*Melling Junction to WRS 3rd Main (if not delivered as part of RS4)*

Wellington Railway Station Precinct (WRS)

WRS-RS6-22	Freight Link from HVL 3rd Main to KPL 3rd Main
WRS-RS6-23	WRS - 2 new station platorms - 11 & 12 (12 total)
WRS-RS6-24	WRS - increased stabling
WRS-RS6-25	WRS - Further EMU depot expansion

Johnsonville Line (JVL) – No further infrastructure changes required.

8. IMPLEMENTATION ROADMAP

The package of infrastructure required for each step forward in frequency must be designed, funded, delivered, and brought into service before the new timetable can be introduced. An initial programme has been developed to identify practical dependencies and potential implementation timeframes.

It is important to note that the implementation Roadmap given in this section assumes delivery to the Rail Plan aspirational timeframes and shows what would be required to meet them.

It is not presented as an achievable or recommended programme. Commentary around achievable delivery dates is given in later sections.

The Implementation Roadmap given in this section lays out an initial indicative overall programme of works, including all infrastructure packages required to implement each of the relevant RS timetables. It illustrates the quantum of work to be delivered to meet the Rail Plan's aspirational RS timetable delivery dates.

The first chart shows the works required to reach RS6. The second chart shows only the journey to RS4.

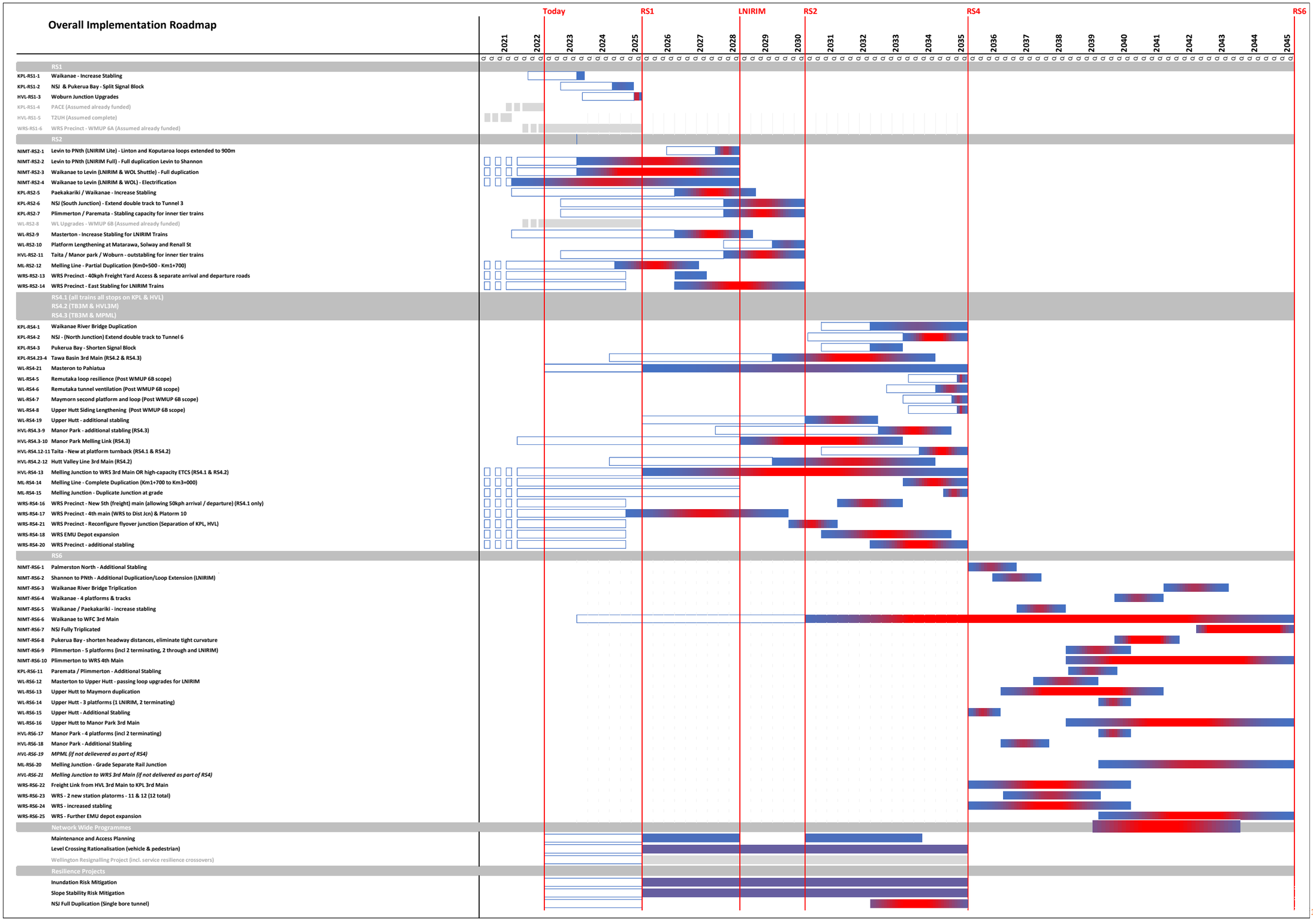
Each package has been programmed individually to meet the timetable aspirations whilst providing as 'smooth' a cashflow as possible. The cashflow in each package has been calculated using a normal distribution curve to crudely ascertain a spend profile that would be more appropriate for a construction project than a flat and equal distribution. A mobilisation timeframe has been programmed and is shown on the implementation roadmap as a clear bar preceding each project. The purpose of these bars are to indicate mobilisation dates for each project and as such have no cost allocated to them.[17]

Colour labelling has been used to provide a heatmap showing where monthly expenditure exceeds $10 million by highlighting those months in red. This provides comparative context to the potential forecast spend and informs the size and capacity of a central PMO required for the works programme.

Note that the several hundred million dollars required for the delivery of Wellington ETCS 2024 - 2030 is not included

[17] Costs associated with business case development are unlikely to be more than 5% of project costs so are not considered significant to show separately at this level of analysis. Land acquisition cost may fall in this period but until confirmed at the next stage of design, have been kept together with project costs in the main programme bar.

Overall Implementation Roadmap



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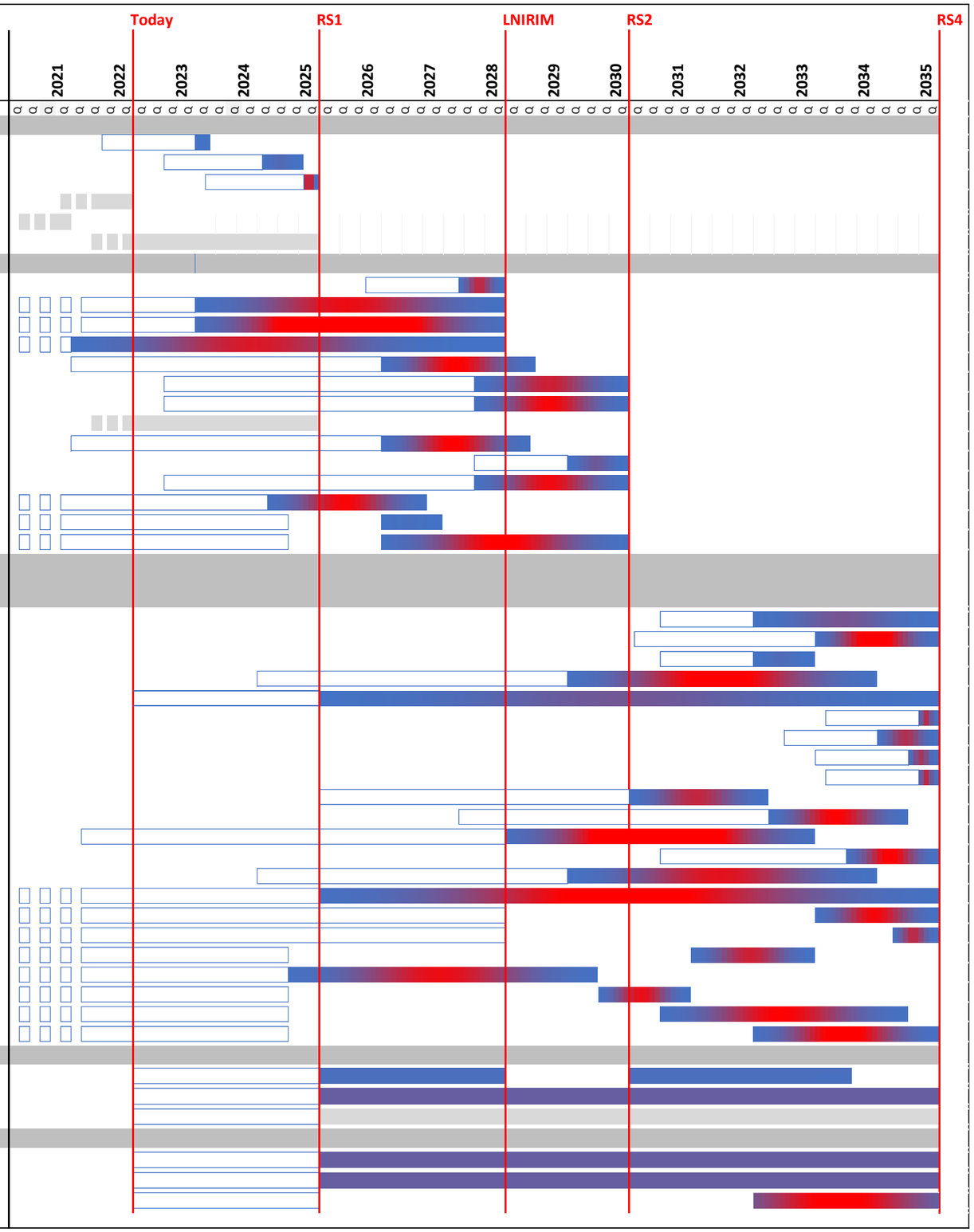
Overall Implementation Roadmap



	RS1
KPL-RS1-1	Waikanae - Increase Stabling
KPL-RS1-2	NSJ & Pukerua Bay - Split Signal Block
HVL-RS1-3	Woburn Junction Upgrades
KPL-RS1-4	PACE (Assumed already funded)
HVL-RS1-5	T2UH (Assumed complete)
WRS-RS1-6	WRS Precinct - WMUP 6A (Assumed already funded)
	RS2
NIMT-RS2-1	Levin to PNth (LNIRIM Lite) - Linton and Koputaroa loops extended to 900m
NIMT-RS2-2	Levin to PNth (LNIRIM Full) - Full duplication Levin to Shannon
NIMT-RS2-3	Waikanae to Levin (LNIRIM & WOL Shuttle) - Full duplication
NIMT-RS2-4	Waikanae to Levin (LNIRIM & WOL) - Electrification
KPL-RS2-5	Paekakariki / Waikanae - Increase Stabling
KPL-RS2-6	NSJ (South Junction) - Extend double track to Tunnel 3
KPL-RS2-7	Plimmerton / Paremata - Stabling capacity for inner tier trains
WL-RS2-8	WL Upgrades - WMUP 6B (Assumed already funded)
WL-RS2-9	Masterton - Increase Stabling for LNIRIM Trains
WL-RS2-10	Platform Lengthening at Matarawa, Solway and Renall St
HVL-RS2-11	Taita / Manor park / Woburn - outstabling for inner tier trains
ML-RS2-12	Melling Line - Partial Duplication (Km0+500 - Km1+700)
WRS-RS2-13	WRS Precinct - 40kph Freight Yard Access & separate arrival and departure roads
WRS-RS2-14	WRS Precinct - East Stabling for LNIRIM Trains
	RS4.1 (all trains all stops on KPL & HVL) **RS4.2 (TB3M & HVL3M)** **RS4.3 (TB3M & MPML)**
KPL-RS4-1	Waikanae River Bridge Duplication
KPL-RS4-2	NSJ - (North Junction) Extend double track to Tunnel 6
KPL-RS4-3	Pukerua Bay - Shorten Signal Block
KPL-RS4.23-4	Tawa Basin 3rd Main (RS4.2 & RS4.3)
WL-RS4-21	Masteron to Pahiatua
WL-RS4-5	Remutaka loop resilience (Post WMUP 6B scope)
WL-RS4-6	Remutaka tunnel ventilation (Post WMUP 6B scope)
WL-RS4-7	Maymorn second platform and loop (Post WMUP 6B scope)
WL-RS4-8	Upper Hutt Siding Lengthening (Post WMUP 6B scope)
WL-RS4-19	Upper Hutt - additional stabling
HVL-RS4.3-9	Manor Park - additional stabling (RS4.3)
HVL-RS4.3-10	Manor Park Melling Link (RS4.3)
HVL-RS4.12-11	Taita - New at platform turnback (RS4.1 & RS4.2)
HVL-RS4.2-12	Hutt Valley Line 3rd Main (RS4.2)
HVL-RS4-13	Melling Junction to WRS 3rd Main OR high-capacity ETCS (RS4.1 & RS4.2)
ML-RS4-14	Melling Line - Complete Duplication (Km1+700 to Km3+000)
ML-RS4-15	Melling Junction - Duplicate Junction at grade
WRS-RS4-16	WRS Precinct - New 5th (freight) main (allowing 50kph arrival / departure) (RS4.1 only)
WRS-RS4-17	WRS Precinct - 4th main (WRS to Dist Jcn) & Platorm 10
WRS-RS4-21	WRS Precinct - Reconfigure flyover junction (Separation of KPL, HVL)
WRS-RS4-18	WRS EMU Depot expansion
WRS-RS4-20	WRS Precinct - additional stabling
	Network Wide Programmes
	Maintenance and Access Planning
	Level Crossing Rationalisation (vehicle & pedestrian)
	Wellington Resignalling Project (incl. service resilience crossovers)
	Resilience Projects
	Inundation Risk Mitigation
	Slope Stability Risk Mitigation
	NSJ Full Duplication (Single bore tunnel)

SUMMARY OF INFRASTRUCTURE SOLUTION COSTS

The summary tables on the following pages list all infrastructure projects required to be delivered prior to the successive RS timetables and bring forward high-level programme and cost information from the detailed datasheets contained in Appendix 1. The data sheets themselves summarise the key findings of technical notes prepared by various consultants in support of this study.[19]

The cost estimates for infrastructure required to implement each successive Rail Scenario are summarised in the table below:

Rail Scenario		Cost Estimate ($M)
RS1	Approxiate 15-minute timetable	17
RS2	15-minute timetable	1,816
RS4.1	10-minute timetable (all trains all stops / no express)	1,983
RS4.2	10-minute timetable (3rd mains on both KPL & HVL)	2,419
RS4.3	10-minute timetable (3rd main on KPL, MPML bypass on HVL)	2,198
RS4.3 (NSJ Fully duplicated)	RS4.3 as above plus single bore tunnel duplicating NSJ for resilience	3,024
RS6	6-minute	10,217
Network Wide Upgrades	Maintenance & Access Planning Level Crossing Rationalisation	1,055
Resilience Projects	Inundation Risk Mitigation Slope Stability	1,160

Of the three options modelled that can deliver the RS4 timetable, RS4.3 has been selected as preferred for the purposes of presenting a consolidated view in the Implementation Roadmap.

[19] A bibliography of all technical notes and reports this study refers to is included at the end of this document.

RS1					
Line	Package Ref.	Description	Primary Purpose	Programme Estimate (months)	Rough order cost ($M)
KPL	KPL-RS1-1	Waikanae - Increase Stabling	Increasing stabling capacity from 12 to 20 cars	3	0
KPL	KPL-RS1-2	NSJ & Pukerua Bay - Split Signal Block	Split Up Main signal blocks to allow shorter headway between following passenger trains	8	3
HVL	HVL-RS1-3	Woburn Junction Upgrades	To minimise interference with the main line from train movements across Woburn Junction to and from the Gracefield Branch Line	3	14
			Total Rough Order Cost Estimate ($M)		17

RS2					
Line	Package Ref.	Description	Primary Purpose	Programme Estimate (months)	Rough order cost ($M)
NIMT	NIMT-RS2-1	Levin to PNth (LNIRIM Lite) - Linton and Koputaroa loops extended to 900m	Extension of passing loops at Linton and Koputaroa to let full length freights to clear the line and enable LNIRIM	9	25
NIMT	NIMT-RS2-2	Levin to PNth (LNIRIM Full) - Full duplication Levin to Shannon	Duplication between Levin and Shannon to avoid freights becoming stuck in passing loops between a more frequent LNIRIM service.	60	227
NIMT	NIMT-RS2-3	Waikanae to Levin (LNIRIM & WOL Shuttle) - Full duplication	Duplication of single track between Waikanae and Levin to prevent LNIRIM and WOL services holding up freight services and each other.	60	634
NIMT	NIMT-RS2-4	Waikanae to Levin (LNIRIM & WOL) - Electrification	Overhead line electrification between Waikanae and Levin to support an electrified WOL commuter shuttle service.	72	240
KPL	KPL-RS2-5	Paekakariki / Waikanae - Increase Stabling	Additional stabling for 50 cards for overnight storage (to cover RS2 & RS4 stabling requirements).	30	127
KPL	KPL-RS2-6	NSJ (South Junction) - Extend double track to Tunnel 3	Reduce length of North South Junction single track section by 400-500m	30	92
KPL	KPL-RS2-7	Plimmerton / Paremata - Stabling capacity for inner tier trains	New stabling in Paremata / Plimmerton area for inner tier trains (30 cars) to reduce conflicts in Wellington Station throat. (For RS2 & RS4)	30	121
WL	WL-RS2-9	Masterton - Increase Stabling for LNIRIM Trains	Increase stabling by 56 cars to be integrated with maintenance depot (for RS2 to RS6)	29	123
WL	WL-RS2-10	Platform Lengthening at Matarawa, Solway and Renall St	Platforms need lengthening to accommodate 8-car consists for LNIRIM peak to prevent ongoing use of operational workarounds.	12	11
HVL	HVL-RS2-11	Taita / Manor park / Woburn - outstabling for inner tier trains	New out-stabling for 48 cars to reduce conflicts in Wellington Station throat (for RS2 & RS4, not required for	30	116
ML	ML-RS2-12	Melling Line - Partial Duplication (Km0+500 - Km1+700)	New section of double track on the Melling Line where trains can cross allowing an increased frequency	31	126
WRS	WRS-RS2-13	WRS Precinct - 40kph Freight Yard Access & separate arrival and departure roads	Increase speed to 40kph and separate arrival and departure roads to minimise time freights block main line when entering freight yard.	12	1
WRS	WRS-RS2-14	WRS Precinct - East Stabling for LNIRIM Trains	Additional stabling for 42 cars for overnight storage and interpeak layover.	48	212
			Total Rough Order Cost Estimate ($M)	*	1,816

* This total does not include the cost of NIMT-RS2-4 which will not be required if battery powered trains are used.

RS4					RS41.	RS4.2	RS4,3
Line	Package Ref.	Description	Primary Purpose	Programme Estimate (months)	Rough order cost ($M)		
KPL	KPL-RS4-1	Waikanae River Bridge Duplication	Remove single track section to achieve full duplication south of Waikanae required to facilitate higher frequency timetables.	36	40	40	40
KPL	KPL-RS4-2	NSJ - (North Junction) Extend double track to Tunnel 6	Reduce length of North South Junction single track section to half what it is in 2022.	24	128	128	128
KPL	KPL-RS4-3	Pukerua Bay - Shorten Signal Block	Shorten signal block to allow closer following moves through North South Junction single track section	12	3	3	3
KPL	KPL-RS4.23-4	Tawa Basin 3rd Main (RS4.2 & RS4.3)	To allow the express to pass the all-stop service.	60		296	296
WL	WL-RS4-21	Masteron to Pahiatua	Reopening of section to provide freight route resilience between Masterton and Pahiatua	4	123	123	123
WL	WL-RS4-5	Remutaka loop resilience (Post WMUP 6B scope)	New resilience loop to allow trains to pass each other.	4	10	10	10
WL	WL-RS4-6	Remutaka tunnel ventilation (Post WMUP 6B scope)	Improve tunnel ventilation to reduce purge time between trains to allow higher frequency services through the tunnel.	12	29	29	29
WL	WL-RS4-7	Maymorn second platform and loop (Post WMUP 6B scope)	The loop allows trains to pass each other and the platform allows turnback at Maymorn in case of an Remutaka Tunnel indicent during the peak.	6	13	13	13
WL	WL-RS4-8	Upper Hutt Siding Lengthening (Post WMUP 6B scope)	To allow a freight train to stand offline from the mains at the boundary of the high frequency network to allow timetable adjustments.	4	11	11	11
WL	WL-RS4-19	Upper Hutt - additional stabling	To allow a freight train to stand offline from the mains at the boundary of the high frequency network to allow timetable adjustments.	27	76	76	76
HVL	HVL-RS4.3-9	Manor Park - additional stabling (RS4.3)	Increase stabling by 48 cars for overnight stabling for HVL EMU trains	27			112
HVL	HVL-RS4.3-10	Manor Park Melling Link (RS4.3)	To provide an alternative route for the WL express service and provide a new service to 2 stations along the new route.	60			566
HVL	HVL-RS4.12-11	Taita - New at platform turnback (RS4.1 & RS4.2)	New track and plaform to allow inner tier trains to turnback at Taita	18	78	78	
HVL	HVL-RS4.2-12	Hutt Valley Line 3rd Main (RS4.2)	To allow the express to pass the all-stop service	60		214	
HVL	HVL-RS4-13	Melling Junction to WRS 3rd Main OR high-capacity ETCS (RS4.1 & RS4.2)	To allow a ten minute Melling Service to run alongside the WL service.	120	607	607	
ML	ML-RS4-14	Melling Line - Complete Duplication (Km1+700 to Km3+000)	To increase the section of track trains can pass in by completing full duplication of the Melling Line	24	96	96	96
ML	ML-RS4-15	Melling Junction - Duplicate Junction at grade	Complete full duplication of the Melling line including the junction (at grade). Grade separation of the junction would be required for RS6.	9	25	25	25
WRS	WRS-RS4-16	WRS Precinct - New 5th (freight) main (allowing 50kph arrival / departure) (RS4.1 only)	To allow 50 kph arrival & departure from the freight yard	24	74		
WRS	WRS-RS4-17	WRS Precinct - 4th main (WRS to Dist Jcn) & Platorm 10	To construct a 4th Main between Distant Jucntion and Wellington Railway Station and construct a new Platofrm 10	60	226	226	226
WRS	WRS-RS4-21	WRS Precinct - Reconfigure flyover junction (Separation of KPL, HVL)	To separate the WL & HVLs	18	67	67	67
WRS	WRS-RS4-18	WRS EMU Depot expansion	To expand the existing EMU depot to accommodate increased EMU numbers at RS4	48	200	200	200
WRS	WRS-RS4-20	WRS Precinct - additional stabling	To increase stabling with in WRS precinct to accommodate increase in fleet size at RS4	36	178	178	178
			Total Rough Order Cost Estimate ($M)		1,983	2,419	2,198
			NSJ duplication via single bore tunnel				826
			Total Rough Order Cost Estimate ($M) - including NSJ full duplication				3,024

RS6			
Line	Package Ref.	Description	Rough order cost ($M)
NIMT	NIMT-RS6-1	Palmerston North - Additional Stabling	40
NIMT	NIMT-RS6-2	Shannon to PNth - Additional Duplication/Loop Extension (LNIRIM)	34
NIMT	NIMT-RS6-3	Waikanae River Bridge Triplication	56
NIMT	NIMT-RS6-4	Waikanae - 4 platforms & tracks	38
NIMT	NIMT-RS6-5	Waikanae / Paekakariki - increase stabling	47
NIMT	NIMT-RS6-6	Waikanae to WFC 3rd Main	3,219
NIMT	NIMT-RS6-7	NSJ Fully Triplicated	1,596
NIMT	NIMT-RS6-8	Pukerua Bay - shorten headway distances, eliminate tight curvature	250
NIMT	NIMT-RS6-9	Plimmerton - 5 platforms (incl 2 terminating, 2 through and LNIRIM)	70
NIMT	NIMT-RS6-10	Plimmerton to WRS 4th Main	1,597
KPL	KPL-RS6-11	Paremata / Plimmerton - Additional Stabling	42
WL	WL-RS6-12	Masterton to Upper Hutt - passing loop upgrades for LNIRIM	62
WL	WL-RS6-13	Upper Hutt to Maymorn duplication	685
WL	WL-RS6-14	Upper Hutt - 3 platforms (1 LNIRIM, 2 terminating)	33
WL	WL-RS6-15	Upper Hutt - Additional Stabling	34
WL	WL-RS6-16	Upper Hutt to Manor Park 3rd Main	463
HVL	HVL-RS6-17	Manor Park - 4 platforms (incl 2 terminating)	33
HVL	HVL-RS6-18	Manor Park - Additional Stabling	44
HVL	HVL-RS6-19	MPML (if not delievered as part of RS4)	-
ML	ML-RS6-20	Melling Junction - Grade Separate Rail Junction	225
HVL	HVL-RS6-21	Melling Junction to WRS 3rd Main (if not delivered as part of RS4)	607
WRS	WRS-RS6-22	Freight Link from HVL 3rd Main to KPL 3rd Main	272
WRS	WRS-RS6-23	WRS - 2 new station platorms - 11 & 12 (12 total)	96
WRS	WRS-RS6-24	WRS - increased stabling	276
WRS	WRS-RS6-25	WRS - Further EMU depot expansion	400
		Total Rough Order Cost Estimate ($M)	10,217

Network Wide Programmes	
Description	Rough order cost ($M)
Maintenance and Access Planning	100
Level Crossing Rationalisation (vehicle & pedestrian)	955
Wellington Resignalling Project (incl. service resilience crossovers)	*
Total Rough Order Cost Estimate ($M)	1,055

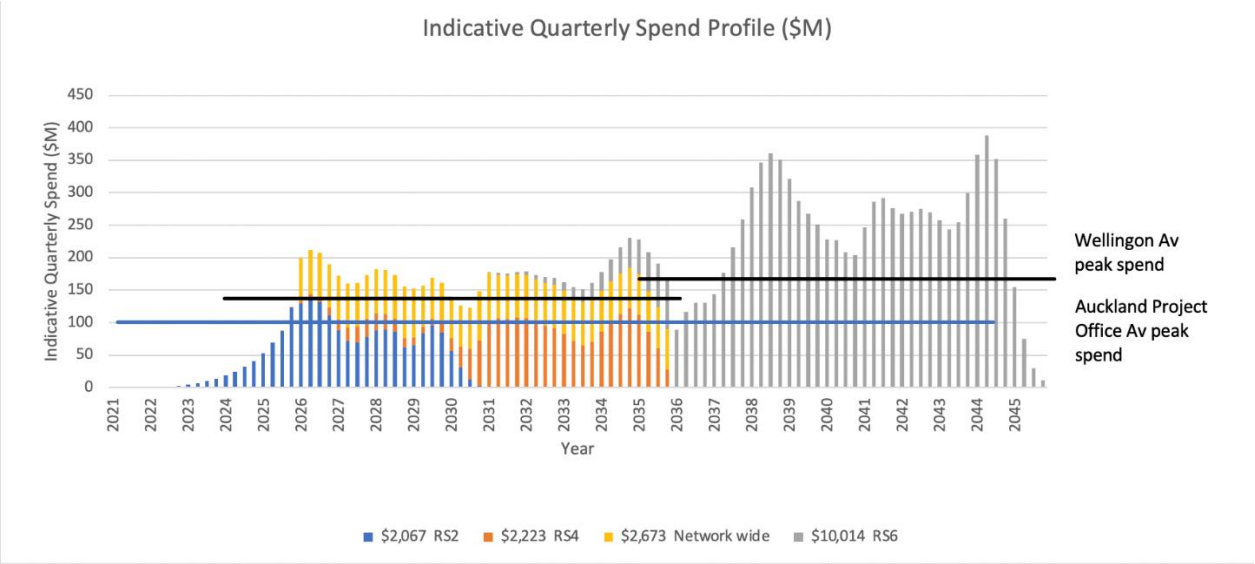
* Excluded here as separate funding being sought

Resilience Projects	
Description	Rough order cost ($M)
Inundation Risk Mitigation	950
Slope Stability Risk Mitigation	210
	1,160
NSJ Full Duplication (Single bore tunnel)	826
Total Rough Order Cost Estimate ($M)	1,986

CASHFLOW ANALYSIS

INITIAL PROGRAMME SPEND PROFILE

The resultant cashflow from the implementation roadmap is contained in the chart below:



The initial programme shows an average spend of $147M per quarter over 12 years is required to deliver the RS1, RS2, RS4 timetables and the Network Wide Upgrades. An average spend of $255M per quarter is required over the following 10 years to deliver RS6 infrastructure upgrades. This cashflow has been reasonably 'smoothed' to create a consistent monthly spend for ease of management and maintenance, though detailed linkages, dependencies, and interim benefits have not been assessed.

To indicate the achievability of this spend rate, a comparison can be made to the current spend on capital projects in Auckland of $100M per quarter at its current peak (2023).

Despite controversial complete blockades of sections of the network, the Auckland spend rate is considerably less than the indicative quarterly spend profile required to meet the Wellington Rail Plan's aspirational timetable implementation dates.

Further analysis needs to be undertaken to determine an appropriate level of spend for Wellington capital projects, but it is unlikely the initial programme given above is achievable, considering historic maximum capital project spend in the smaller Wellington network[20] has been in the vicinity of $25M per quarter (i.e., more in line with the Auckland Spend Profile @25% in the table below).

[20] Wellington lacks any equivalent to the very large CRL project, which is demanding very high spend on the rest of the network, so it is ready for the impact of CRL opening. There will be little opportunity to access the network for such major catch up or readiness works after CRL is opening, hence the accelerated spend.

ALTERNATIVE SPEND PROFILE SCENARIOS

The table below presents a rough assessment of timeframes based on four alternative spend profile scenarios.

Note: RS6 was also considered however, the revised completion dates were far beyond the 30-year planning period this study is focused on. If adopting the Auckland Spend Profile @25%, for example, RS6 would be delivered in the 22nd Century.

COMMERCIAL ANALYSIS	Total Spend	Av spend PQ	Prog. Duration (years)	Prog. Extension (years)	Revised Completion
BASELINE (from 2024)					
RS2, RS4 and Network Wide	7,072	147	12	0	**2035**
RS6	*10,217*	*255*	*10*	*0*	***2045***
AUCKLAND SPEND PROFILE - $100M PQ)					
RS2, RS4 and Network Wide		100	17	5	**2040**
AUCKLAND SPEND PROFILE @75%					
RS2, RS4 and Network Wide		75	23	11	**2046**
AUCKLAND SPEND PROFILE @50%					
RS2, RS4 and Network Wide		50	35	23	**2058**
AUCKLAND SPEND PROFILE @25%					
RS2, RS4 and Network Wide		25	69	57	**2092**

If the spend profile outlined in the initial program cannot be achieved, an alternative scenario will need to be adopted, with the corresponding extension to the program duration. This will deliver later implementation dates for higher frequency timetables.

The above spend profiles are based on the current $100m per quarter spend profile in Auckland. This was selected as a comparison point as the spend is being managed by KiwiRail in a New Zealand context with body of works not dissimilar to that being proposed as part of this Study.

This analysis has only considered spend profile, though there are several other key considerations in assessing the feasibility of delivering the overall programme of works such as resource constraints and network access.

Further work needs to be done to define the parameters for an achievable programme and understand how productivity could be maximised through additional resource, recruitment and training, efficient procurement, and contract administration models as well as investment in technology and access improvements recommend elsewhere in this report before a definitive conclusion can be reached. But it seems unlikely the Rail Plan's aspirational timeframes can be met.

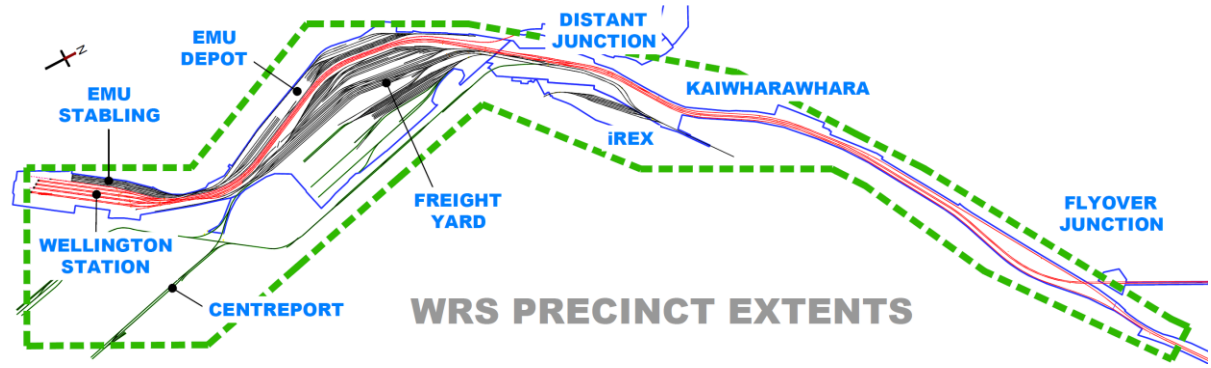
9. SOLUTIONS BY LOCATION

For additional reference, this section presents an overview of the upgrades proposed in previous sections grouped by key geographical / operational sections of the network.

WRS PRECINCT

The WRS Precinct is the most critical area of the Wellington rail network as it is currently configured.

All freight and passenger (metro & regional) services funnel into and out of this area, and any issues / incidents here significantly affect the entire network, for all KiwiRail and GWRC customers.



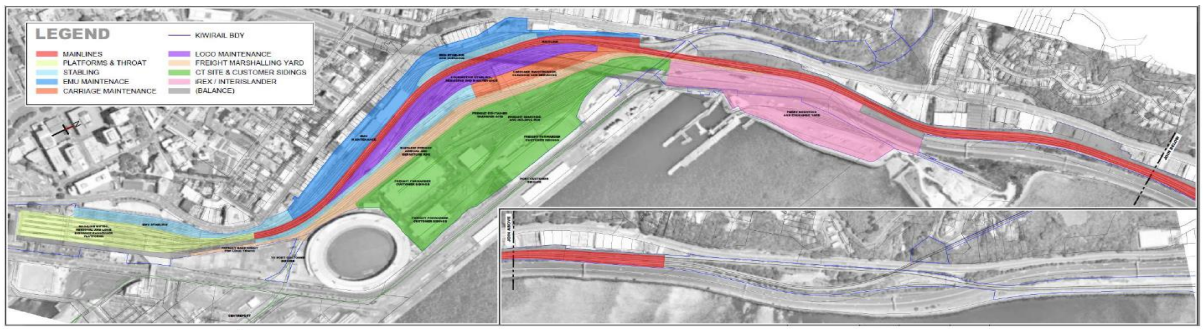
The forecast increased growth of both freight and passenger services will place considerable pressure on the operational reliability of the WRS precinct area and the ability to make infrastructure upgrades.

As infrastructure and services are added, constructability and maintenance access will be increasingly important to achieve that reliability.

Long term climate change mitigation and earthquake resilience is also a key consideration.

Analysis

Building on the 2021 Master Planning work, which investigated the options for implementing a 4th and 5th main, this study undertakes a higher-level analysis based on the land used by each 'function' and the anticipated growth of that area to respond to the increase in freight and passenger services.



Primary Function	Necessity for Function to be in WRS Area	Existing 2022		RS1 2025		RS2/RS2 Boosted 2025-2030		RS4/Variations 2030-2035		RS6 2040-2045		Expected Change
		Ratio	Area (ha)	Growth	Area (ha)	Growth	Area (ha)	Growth	Area (ha)	Growth	Area (ha)	
Mainlines	High	13%	5.3	0%	5.3	0%	5.3	33%	7.0	60%	11.3	Additional mainlines
Station Platforms & Throat	High	7%	2.8	0%	2.8	0%	2.8	10%	3.1	20%	3.7	Additional platforms
West Stabling (HVL & Wairarapa)	Low	3%	1.2	0%	1.2	0%	1.2	-5%	1.1	0%	1.1	Reduced capacity
North Stabling (JVL, HVL & Wairarapa)	Med	1%	0.6	0%	0.6	0%	0.6	0%	0.6	0%	0.6	Nil
East Stabling (KPL & Manawatu)	High	3%	1.2	0%	1.2	85%	2.2	0%	2.2	67%	3.7	Large area required
EMU Maintenance	Low	9%	3.8	0%	3.8	10%	4.2	45%	6.1	55%	9.4	Increase as fleet grows
LOCO Maintenance	Med	7%	2.7	0%	2.7	0%	2.7	0%	2.7	0%	2.7	Reduction in area
Carriage Maintenace	Low	3%	1.2	0%	1.2	-100%	0.0	0%	0.0	0%	0.0	Removed
Freight Marshalling Yard	High	7%	2.7	0%	2.7	20%	3.2	5%	3.4	5%	3.6	Increase with freight growth
iReX	High	15%	6.2	0%	6.2	0%	6.2	0%	6.2	0%	6.2	Nil
CT Site / Freight Customer Facilities	High	26%	10.9	0%	10.9	0%	10.9	0%	10.9	5%	11.4	Nil / Minor
Balance (P10 area / Ancillary Buildings)	n/a	7%	2.9	0%	2.9	0%	2.9	-10%	2.6	-10%	2.3	Reduction
TOTAL		100%	41.5		41.5		42.2		46.0		56.1	
ADDITIONAL LAND REQ EACH RS STEP					0.0		0.7		3.7		10.1	
					0%		2%		9%		22%	

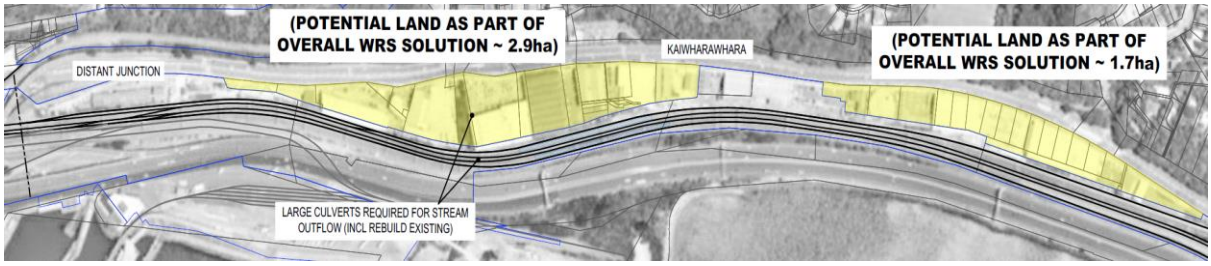
Key Findings

The existing rail designation area is effectively being used to capacity; therefore, growth will need to be accommodated via land acquisition, or optimisation/removal of functions from the WRS area.

- The approximate 'land required' over and above the **existing 56ha** is in the order of:
    - **1ha for RS2,**
    - **5ha for RS4, and**
    - **15ha for RS6.**
- Adding 1 to 5ha of land for RS2-4 will require careful decision making based on prioritisation of the necessity for the function to be in the WRS area.
- Adding 15ha of land for RS6 is not considered feasible, therefore will require substantial removal of functions from the WRS area.

The only practical large-scale land option within the WRS Precinct area is for the rail corridor to acquire all additional property bounded by the SH1 Motorway and Hutt Rd as indicated below. How realistic this is in terms of cost / benefit is yet to be assessed.

This represents a maximum of ~4.6ha and may be suitable for the RS4 works, noting there are multiple options for WRS reconfiguration to utilise these areas.



Key Conclusions

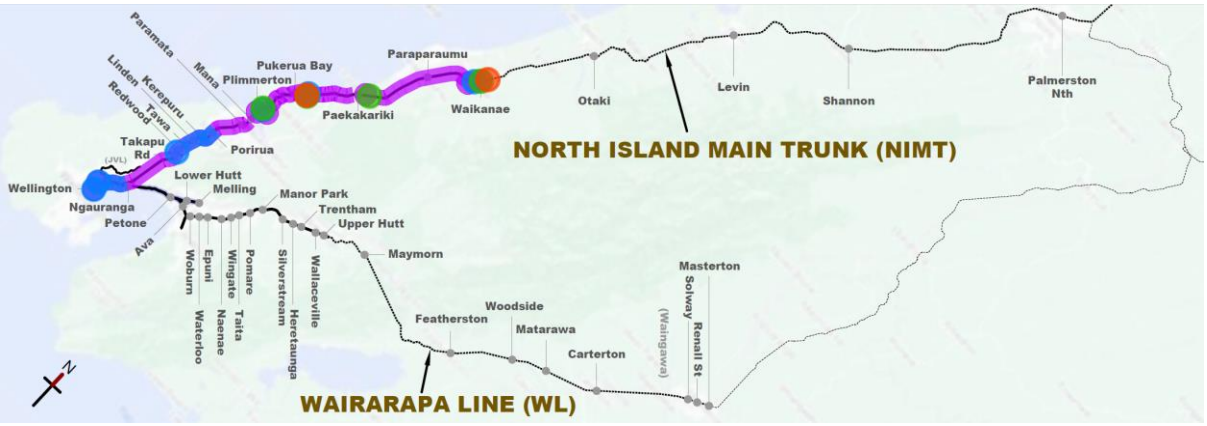
The existing rail designation area is effectively being used to capacity; therefore, growth will need to be accommodated via land acquisition, or optimisation/removal of functions from the WRS area.

- It is crucial that all proposed development with the WRS Precinct and its approaches are considered as a whole, and all material decisions made with strategic oversight. The digital model established for this purpose should be formalised and a formal change control process put in place, with Executive level monitoring.
- Coordinated development of the WRS Precinct Master Plan should be continued in 2023 to inform major strategic decisions (at minimum up to the RS4 scope). This needs to include:
  - Stabling, with a total network view
  - Train wash facilities
  - iREX
  - Mechanical facilities
  - Primary and back up port access
  - Safety upgrade of “Freddy’s Crossing”
  - Components of WMUP6A
  - Container transfer site and freight forwarders.
  - 40kph Freight Yard Access & separate arrival and departure roads
  - 4th main and flyover junction (Separation of KPL, HVL)
  - Platform 10
  - 5th freight main
  - EMU Depot expansion / additional or replacement facility elsewhere
  - Simplification of the WRS throat to remove special track structures
  - Maintenance access improvement / Enhanced separation between NIMT and WL including ‘maintenance mode’ operational timetables.
- Dependencies of staged construction will likely have a significant impact on overall implementation timeframes.
- Early robust decisions on master planning is likely required to give confidence to progress significant land acquisition.

The major strategic decision to be made is if the step from RS4 to RS6 is ever to be made. There are significant cost and/or layout compromises that will need to be made to allow space proofing within RS4 for RS6, so the decision needs to be made early.

NIMT (METRO)

The ‘Wellington Metro’ section of the NIMT, or Kapiti Line, covers between the Wellington Railway Station to Waikanae.



There are numerous projects identified within this area for most of its length, with long sections where suggested future timetables require additional works in the same areas as previous timetables. This creates major challenges with:

- Strategic decisions to combine the works, or futureproof (or not).
- Constructability and ongoing service disruption within the primary rail corridor.

The key locations along this section of line are:

TAWA BASIN

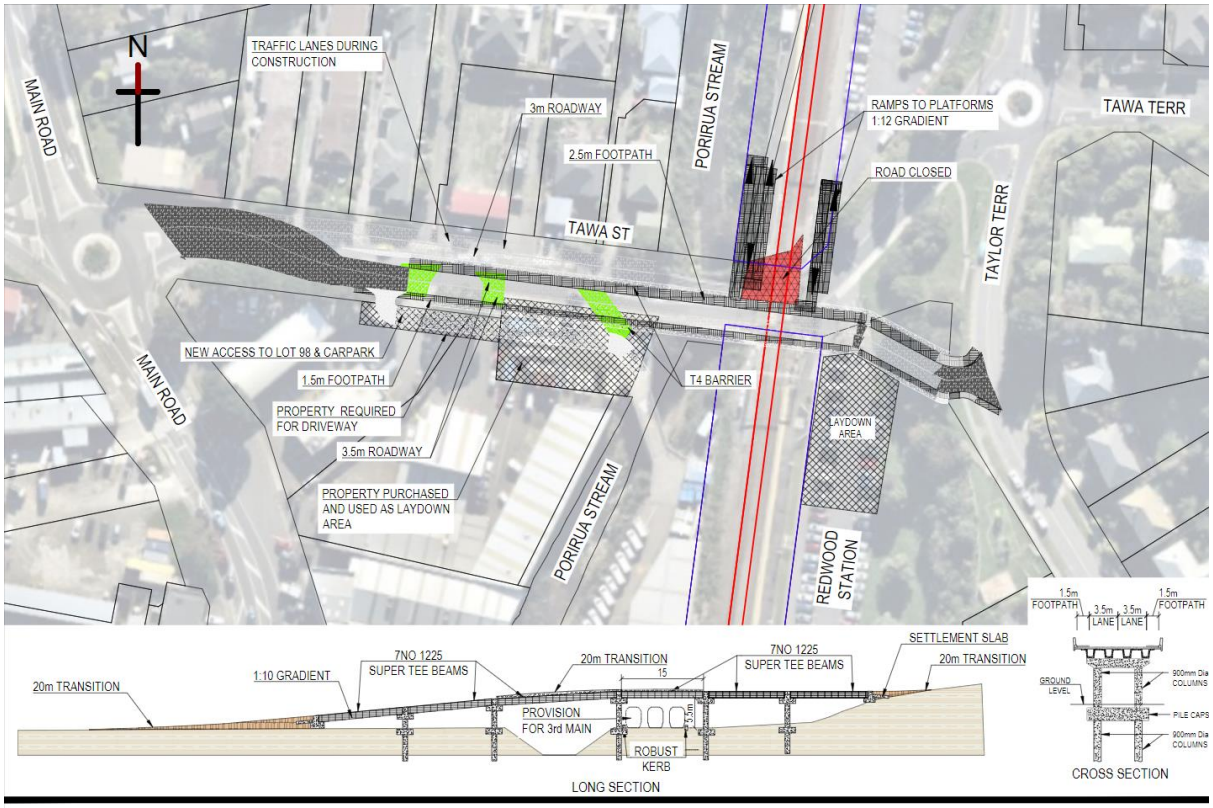
A third main through the Tawa basin area south of Redwood to north of Porirua is required to allow RS4 express trains to overtake the all-stop passenger service on the Kapiti Line.

There is potential to shut a station (Takapu Road or Redwood) to allow better delivery of the RS4 timetable, as the short distance between adjacent stations is detrimental to the timetable. This decision (incl which station) would need careful consideration and stakeholder buy in.

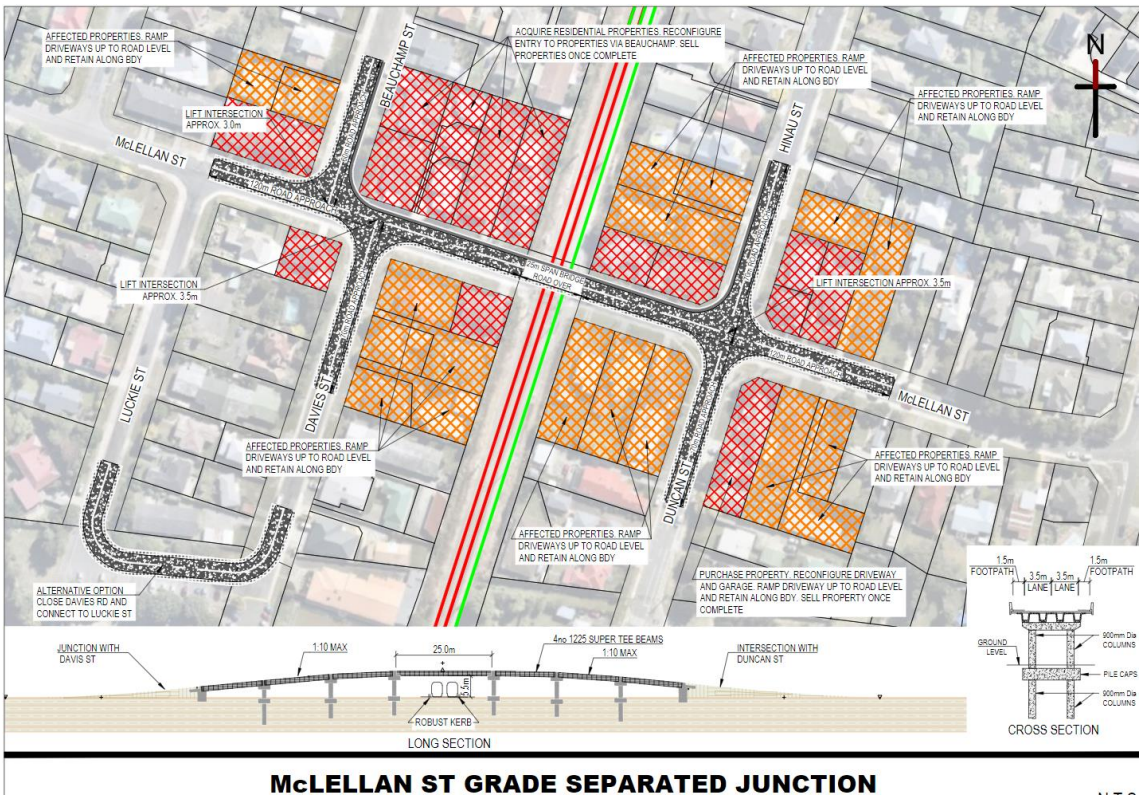
There will be significant civil engineering required through most of the 3rd main section including major retaining walls, potential elevated/cantilevered structures, and works within the stream environment.

The existing level crossings at Tawa St, McLellan St and Collins Ave need grade separation prior to the third main in this area being constructed, to reduce the risk of collision and traffic delays. These are significant projects in their own right, with substantial impacts on residential properties and local roads as indicated by the sketches below. The impact and cost of achieving these grade separations may be such that the project is better approached by WCC, PCC, KiwiRail and Waka Kotahi as a strategic rearrangement of arterial roads and cross connections over the entire Tawa Basin.

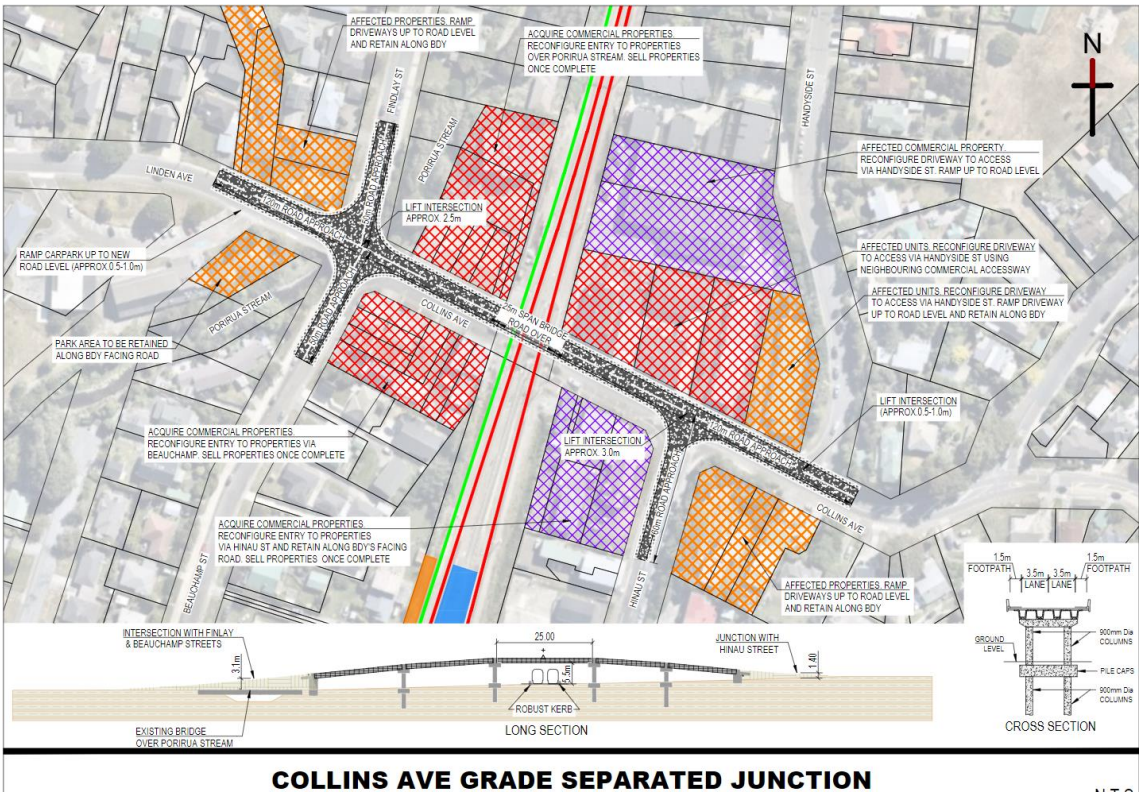
Elevating the entire Tawa rail route on a viaduct to solve all these issues (flood resilience, level crossing elimination and third main) was considered. This is the approach being taken to eliminate level crossings on the much busier network in the much larger Melbourne but is difficult to justify in Wellington on the basis of cost and impact.



TAWA ST GRADE SEPARATED JUNCTION



McLELLAN ST GRADE SEPARATED JUNCTION



COLLINS AVE GRADE SEPARATED JUNCTION

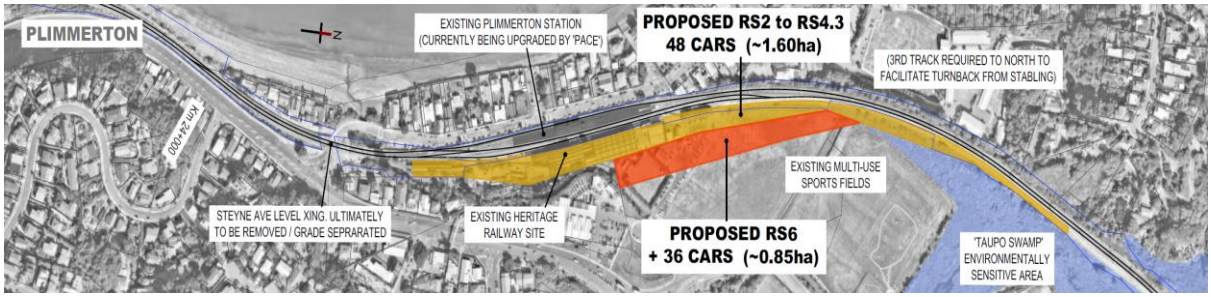
Futureproofing for, or construction of, a 4th main through this section as required to implement RS6 would be a significant step change increase in scope due in part to insufficient corridor width, requiring significant land acquisition.

PARAMATA - PLIMMERTON

Plimmerton is identified as the turnback location for the 'inner tier' of Kapiti metro services.

Although PACE is about to complete the first stage in providing an improved turnback operation with an additional platform, further major works at this location would be required for future timetables:

- Stabling capacity for RS2 onwards inner tier trains (assessed at Plimmerton, alternative Paremata or Mana)
- 5 RS6 platforms (including 2 terminating, 2 through and LNIRIM from 4th Main)
- RS6 Plimmerton to WRS 4th Main



The shape and geometry of the Plimmerton area does not lend itself easily to significant expansion.

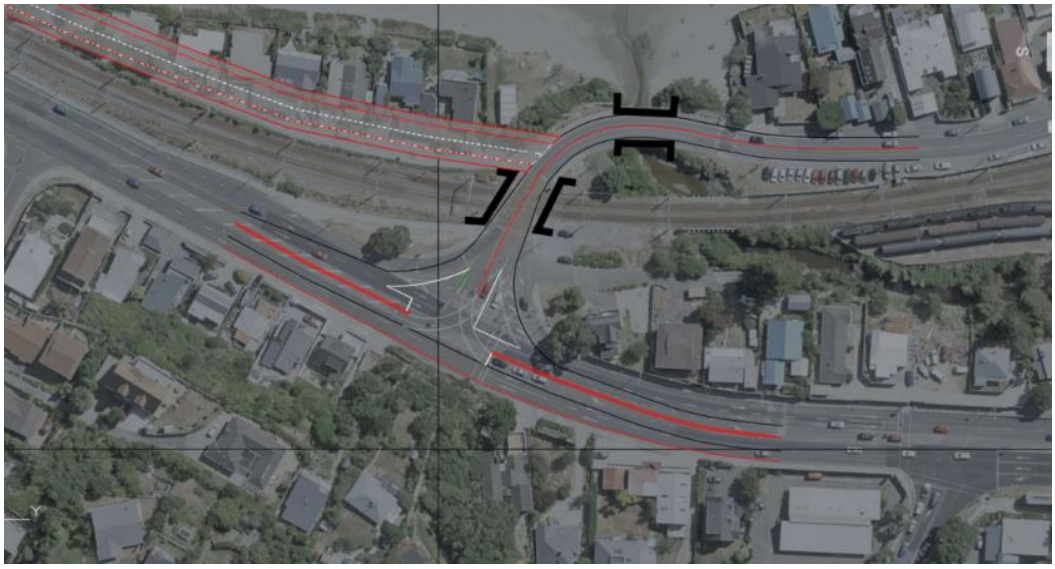
A master plan process will be required to incorporate mitigation for existing use as well as what appears unavoidable encroachment into the sensitive Taupo swamp area if development is focused on this site. In reality it may be that future generations would prefer to revert the poorly drained sports field to swamp and stabling around Mana may be a more desirable solution.

Grade Separation of the Steyne Ave level crossing will also need to be incorporated. Some options considered are shown below.

Option A: New road from Steyne Ave to St Andrews road along the coast

Option B: Coastal road extended to Pascoe Ave via Ngati Toa domain.

Option C: New road / bridge connecting Motuhara Rd to existing roundabout via Plimmerton Domain



Option D: Elevated intersection at Steyne Ave

Futureproofing for, or construction of, a 4th main through this section as required at RS6 would be a significant step change increase in scope. The Mainline Steam facility (Heritage Railway) will also need to be removed prior to RS6 implementation.

NORTH SOUTH JUNCTION

There are several projects that progressively unlock the North South Junction (NSJ) section of the network. These range from relatively lower cost track and signaling solutions to significant tunnelling and civil works to add mainlines. In order of magnitude and capacity impact:

- NSJ & Pukerua Bay - Split existing Up Signal Block for RS1 passenger trains to allow closer following distances.
- NSJ (South Junction) - Extend double track to Tunnel 3 for RS2

- Pukerua Bay - Shorten existing Signal Block for freights as well as passenger trains to further shorten following distances for RS4.
- NSJ (North Junction) - Extend double track to Tunnel 6 for RS4
- NSJ Fully Duplicated (single track long tunnel plus improved existing route)
- Pukerua Bay RS6 - shorten headway distances, eliminate tight curvature to lead into long tunnels.
- NSJ Fully Triplicated (twin bore long tunnel plus short NSJ) for RS6

Futureproofing for, or construction of, a 3rd main through this section as required at RS6 would be a significant step change increase in scope.

PAEKAKARIKI - WAIKANAE

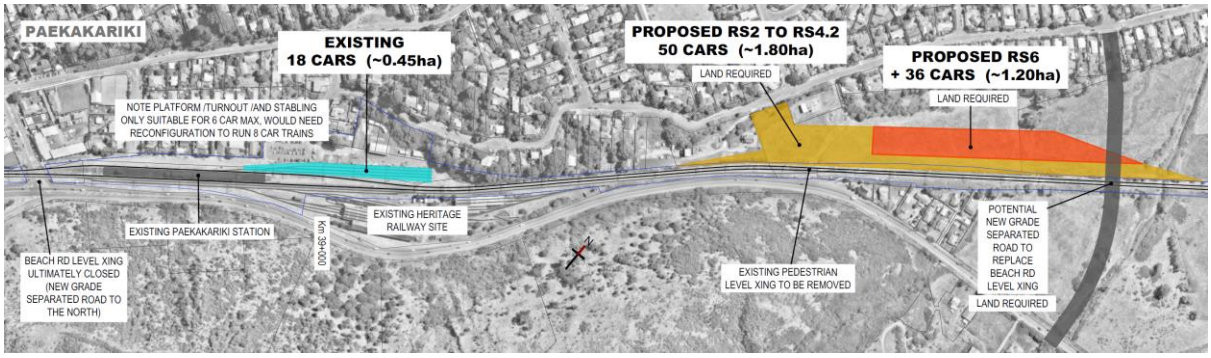
The two key locations in this section are at Paekakariki and Waikanae Station precincts.

Both areas would require a robust master planning process as they involve combining multiple infrastructure solutions and impact stakeholders outside the rail corridor.

Paekakariki

All other alternatives looking impractical, a combined solution for removal of Beach Rd level Xing by way of a grade separated connection to the north, with a relocated/new stabling facility is proposed. There appears a strong opportunity to create a positive combined outcome here.

Note that the existing stabling and former KiwiRail infrastructure depot adjacent to the station could potentially be made available for other activities with provision of replacement stabling to the north.



Waikanae

A reconfigured and expanded station precinct combining additional tracks and platforms, grade separation of Elizabeth St level crossing, and replacement for the station parking is proposed for this area.

These form part of the required project list to achieve the RS4 10-minute timetable, the most complex and difficult to achieve of these being a grade separated solution for Elizabeth St in the proximity (required prior to construction of a third main at this location):

- Waikanae & Paekakariki – Increased Stabling
- Waikanae River Bridge Duplication & Triplication
- Grade Separation of Elizabeth St

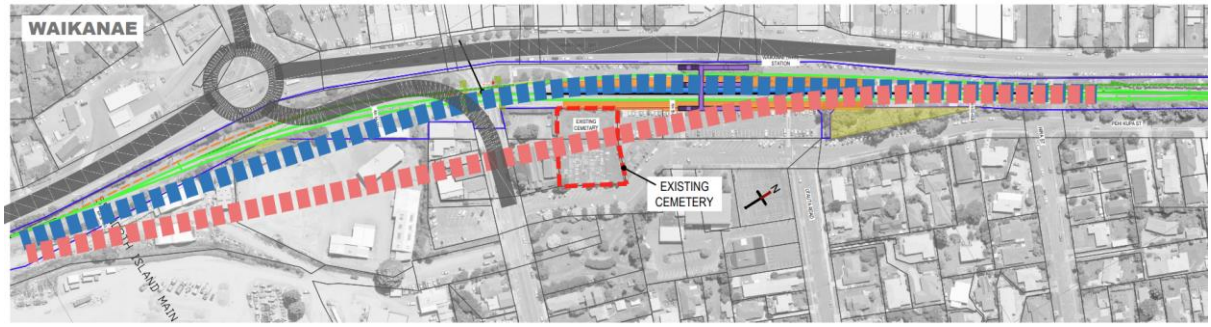
A number of options have been investigated for the grade separation of Elizabeth Street:

- Option A – Current location interchange with ramps on all legs to elevated roundabout at the current intersection.
- Options B – Anne St & Waikanae River Bridge
- Options C – Huia Street/Winara Ave & Main Road interchange

None of these options present a straight-forward solution and further work is required to resolve this. This work will need to be part of a more comprehensive investigation involving KCDC, KiwiRail and

Waka Kotahi. The major constraints such as the cemetery, major land required for the rail infrastructure, road realignment, and at least replacement carparking (likely increased / park and ride facilities), as well as grade separate pedestrian access across to the town centre suggest a KCDC led master plan for the redevelopment and rejuvenation of the entire Waikanae centre post SH1 revocation.

The sketch below is a rough example of the scale of impact of a master plan with the blue/pink dashed lines potential alternatives for rail realignments to allow road grade separation.



Note that futureproofing for, or construction of, a 4th platform to the station, expanded parking/station facilities, and an additional main from Waikanae to Wellington Station as required by the RS6 timetable would be a significant step change increase in scope:

- Waikanae – 4 platforms & tracks
- Waikanae – Further Increased Stabling
- 3rd Main all the way from Waikanae to Wellington Station
- Paekakariki – Further Increased Stabling

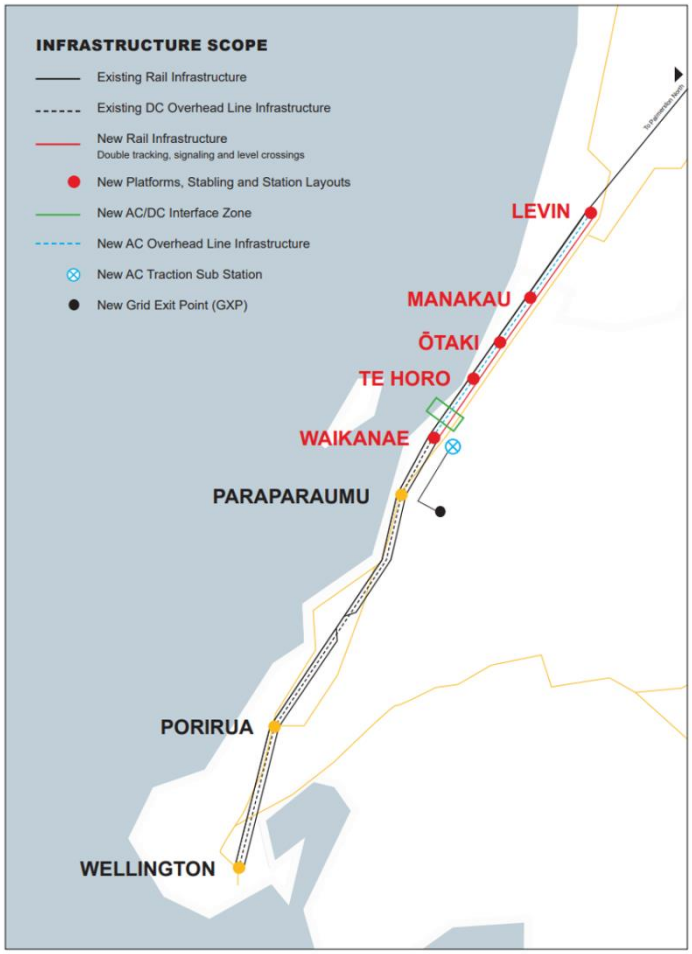
NIMT (NON-METRO)

The ‘Wellington Non-Metro’ section of the NIMT covers between Waikanae and Palmerston North and is served with LNIRIM and potential future WOL shuttle services.

There are several projects identified within this area for most of its length, however the majority is reasonably simple geography allowing a linear construction methodology which would be expected to be generally relatively straight forward, in part due to it being in a much lower frequency part of the network.

The key locations within this area are:

- Levin to Palmerston North (LNIRIM Lite) - Linton and Koputaroa loops extended to 900m and full duplication Waikanae to Shannon
- Waikanae to Levin (LNIRIM & WOL Shuttle) - Full duplication[21] and potential overhead line electrification
- Otaki to Levin & Shannon to Palmerston North - Additional Duplication/Loop Extension (if LNIRIM increases service)



Like most of the New Zealand rail network, the single-track section north of Waikanae is designed to accommodate freight with infrequent passenger services using crossing loops.

Operational modelling of the assumed WOL service (and LNIRIM service) has demonstrated the need for extended duplication (double track) to avoid uncompetitive passenger or freight service timings. Results of these modelling exercises in graphs can be found in the KSP operational modelling reports (see bibliography).

Overhead line electrification beyond Waikanae would require significant infrastructure spend as outlined in the adjacent diagram. There are non-infrastructure solutions that may be acceptable and preferrable, such as battery powered EMUs[22].

While adding resilience, expensive duplication of the two longest bridges at RS4 is not essential, as the relatively short section of single track remaining has minimal impact on timekeeping.

Modifications to Waikanae station are required to accommodate shuttle passengers changing between WOL and Metlink suburban services. Other modifications relate to proposals to provide a more intensive passenger service and LNIRIM and are covered in the Ministerial paper prepared by KR in Dec 2022.(**Error! Reference source not found.**)

Construction of new platforms, track layout changes and associated signalling works are required for WOL at Waikanae, Otaki, and Levin, as well as two proposed new intermediate stations (Te Horo and Manakau). Additional stabling is also required to accommodate the new fleet and timetable.

[21] Duplication is required for either WOL or LNIRM but once provided for one also supports the other.

[22] RS2 cost totals exclude the cost of electrification. Current KiwiRail locomotive decarbonisation plans envisage battery-electric locomotives for this route. It may be that consideration of freight, LNIRIM and inter-regional trains together warrants overhead line electrification of this medium density use route, but even this is not certain.

WAIRARAPA LINE / MELLING LINE (METRO)

The ‘Wellington Metro’ section of the WL covers between the Wellington Railway Station to Upper Hutt and includes the Melling Line.

There are multiple projects identified within this area for the entire length, with the majority being very complexand potentially disruptive to construct.

The key locations within this area are:

MELLING LINE

The Melling Line (ML) is a single-track spur off the Wairarapa Line (WL) Up Main. It is a relatively short line at approximately 3km length. It services Lower Hutt Station and Melling Station, which pick up important passenger catchments in Lower Hutt.

The number of trains that can run on this dead-end single track is very limited. The scope is split into two stages to reflect increases in service operations for the RS2 and RS4 timetables. The first stage (for RS2) duplicates from just past Melling junction to just north of Lower (Western) Hutt station, and the second stage (for RS4) duplicates the junction (at grade) along with the rest of the line through to Melling station.

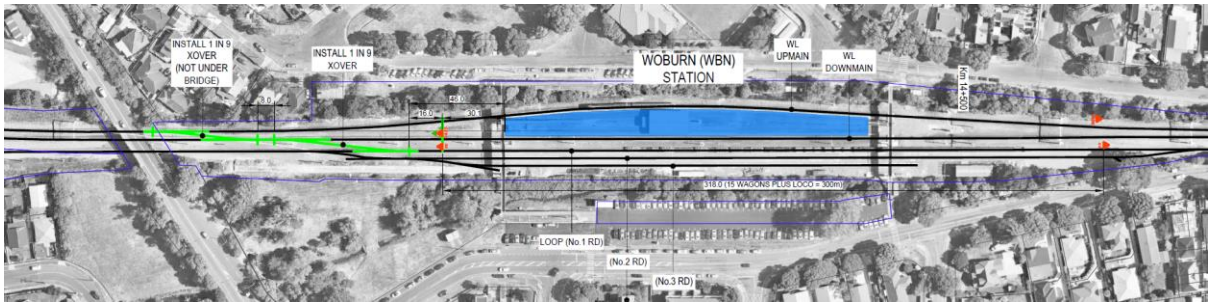
When the RS4 10-minute timetable is implemented on the main lines, the Melling Line will need to revert to a 20-minute service that meshes between ten-minute operations, or fully optimised ETCS L2 must be in place. To provide a more robust 10-minute service additional infrastructure would need to be constructed; either a third main from Melling Junction to WRS or a bypass route between Manor Park and Melling. As the Manor Park to Melling Link provides a route for WL express services (mitigating the need for a Hutt Valley Line third main) as well as providing the 10-minute Melling Line service, with the same trains, this is likely to be the preferred infrastructure solution.

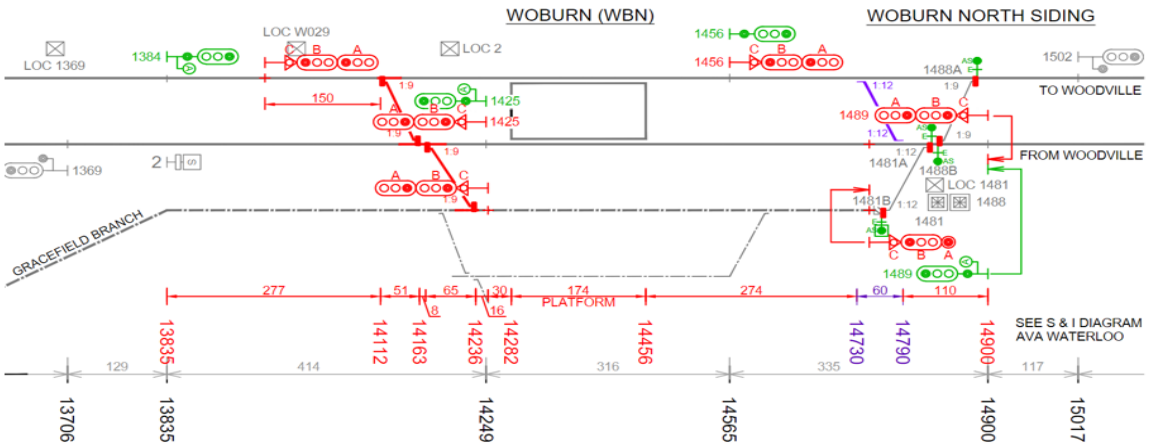
There is a significant interface with the Riverlink project around Melling Station and further north which needs to be considered. The Riverlink project needs to consider the futureproofing requirements of rail, especially for the Manor Park to Melling Link.

WOBURN JUNCTION

Installation of a new double crossover and signalling is required at Woburn Junction south of the station to allow entry to/from the south and limit the time freight trains block the mains while entering the Gracefield branch Line. An additional crossover north of the station is proposed to provide service resilience and bi-directional running capability to support maintenance and access planning.

This appears a highly beneficial project to improve the efficiency and safety of current operations.





WOBURN TO UPPER HUTT

This section includes many interlinked projects with the Manor Park to Melling link driving which ones are needed:

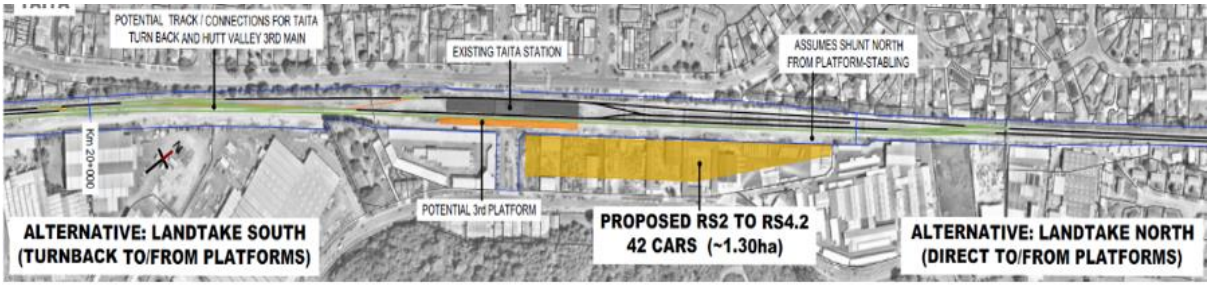
- Taita - New at platform turnback (RS4.1 & RS4.2)
- Hutt Valley Line 3rd Main (RS4.2)
- Manor Park - additional stabling (RS4.3)
- Manor Park - 4 platforms (including 2 terminating)
- Upper Hutt - 3 platforms (1 LNIRIM, 2 terminating)
- Upper Hutt to Manor Park 3rd Main

For example the additional out stabling in the Taita / Manor Park / Woburn area for inner tier trains could be combined with a redevelopment / reconfiguration of the station and bold investment in land acquisition to the north.

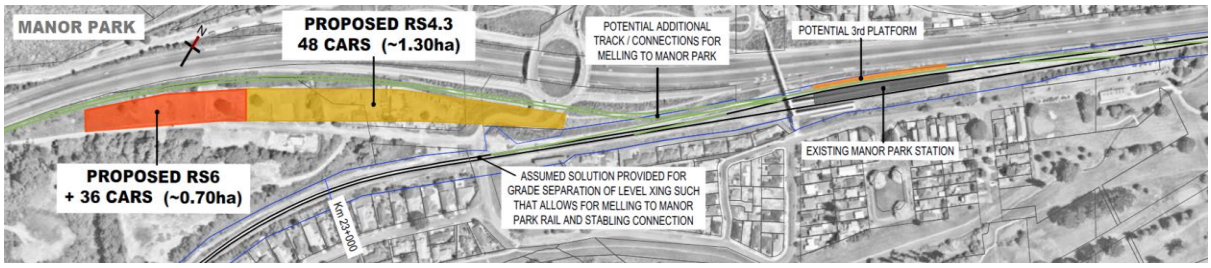
This section also includes four major vehicle level crossings at Manor Park, Sutherland Ave, Ward St and Blenheim St which require grade separation. As for the Tawa Basin, it would be advantageous for these to be considered as a package, with a strategic view taken of rail corridor crossing arterial road arrangements over the length of the section.

The indicative future layout requirements for Taita, Manor Park and Upper Hutt are given below:

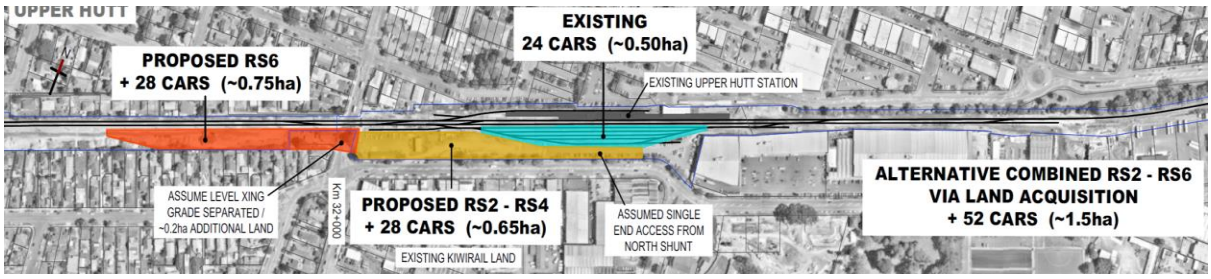
Taita:



Manor Park:



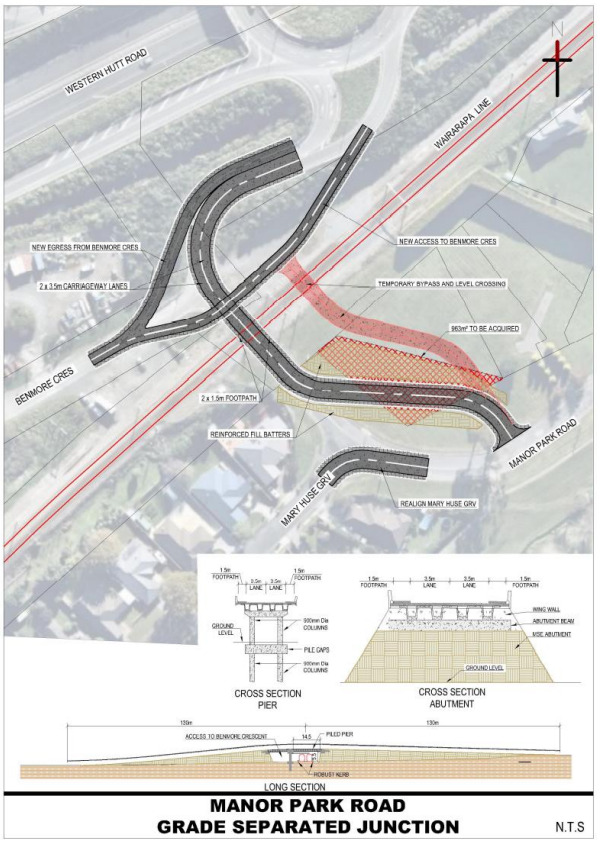
Upper Hutt:



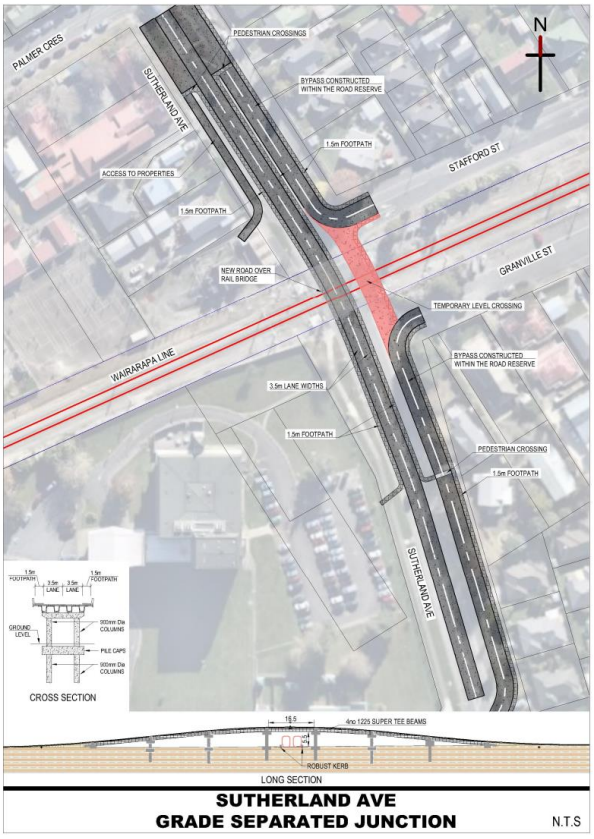
Care should be taken to consider the flexibility of design around some of the key stations where a master planning process should be employed such as Taita, Manor Park and Upper Hutt.

The four level crossing grade separations will require detailed planning to minimise disruption and will need to be in place prior to any additional mains in these locations (i.e., prior to RS4).

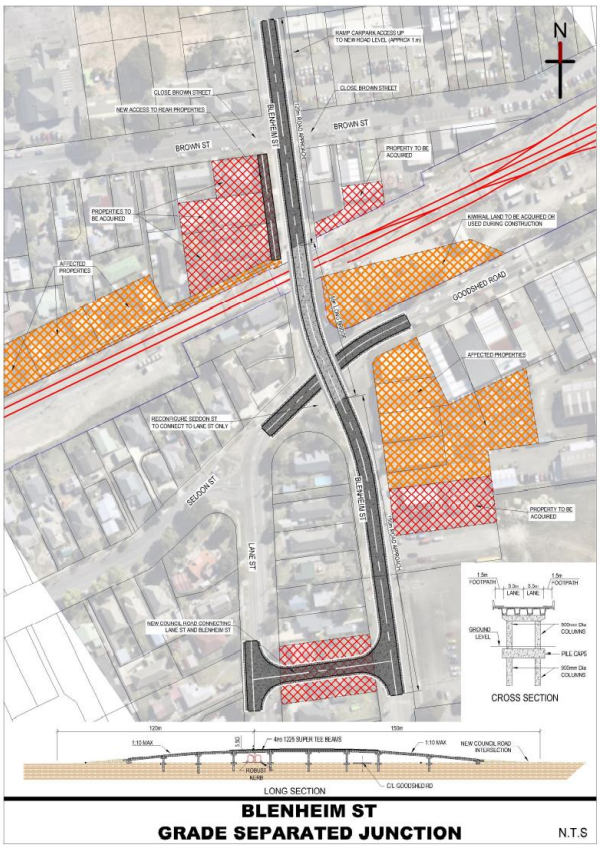
Indicative road layouts to achieve a grade separated crossing for each of the locations is given below with further detail available in the full Level Crossing Rationalisation tech memo.



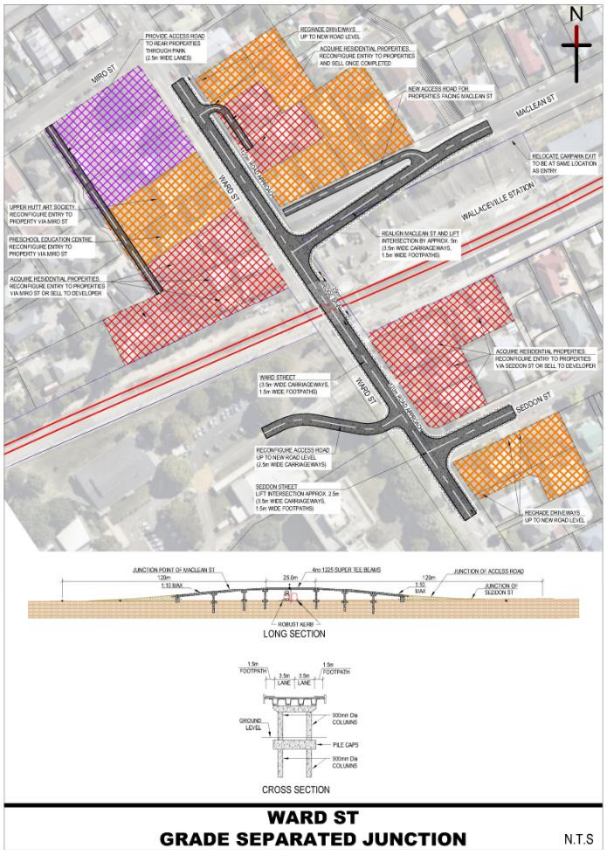
MANOR PARK ROAD
GRADE SEPARATED JUNCTION N.T.S



SUTHERLAND AVE
GRADE SEPARATED JUNCTION N.T.S



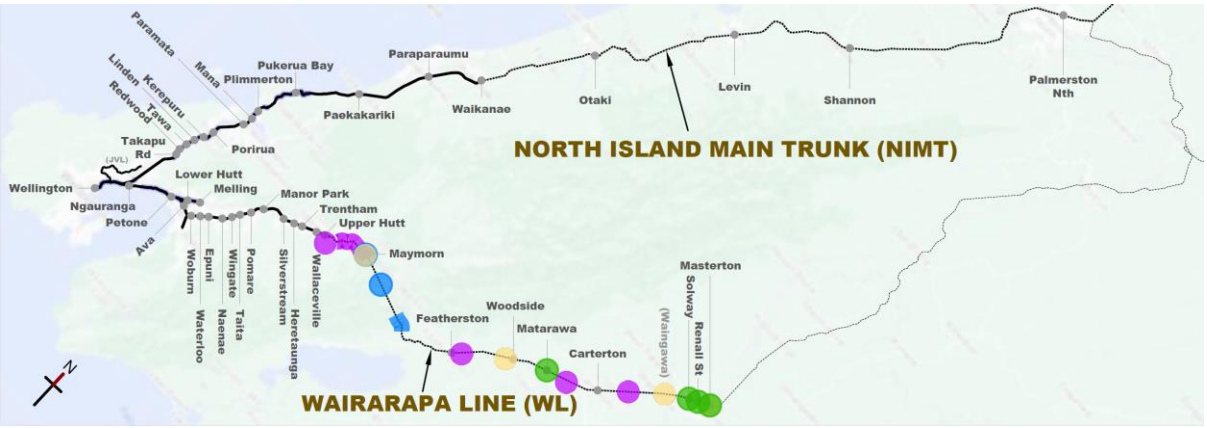
BLENHEIM ST
GRADE SEPARATED JUNCTION N.T.S



WARD ST
GRADE SEPARATED JUNCTION N.T.S

WAIRARAPA LINE (NON-METRO)

The 'Wellington Non-Metro' section of the WL covers between Upper Hutt and Masterton and served with LNIRIM services.



There are several post-WMUP6B projects identified at intervals along this section. Most could be constructed independently and in a logical sequence due to reasonably simple geography/access and lower train frequency, therefore project within this area would be expected to be relatively straightforward.

The key solutions identified for this area are:

- Upper Hutt Siding[23] Lengthening
- Maymorn second platform and loop
- Remutaka resilience and safety loop
- Remutaka tunnel ventilation to allow reduced headway between freight and passenger services through the tunnel
- Platform Lengthening at Matarawa, Solway and Renall St to accommodate 8-car consists
- Masterton to Upper Hutt - passing loop upgrades for LNIRIM @ 18 & 24 Mins
- Upper Hutt to Maymorn duplication (including Maoribank tunnel – T1WL) for RS6

It is expected that 4-car consists will operate throughout the day but 8-car consists will be used on the peak services. Lengthening of the platforms for 8-car operations at Matarawa, Solway and Renall St is not included in WMUP6B, but these upgrades are needed for service quality and to prevent ongoing use of operational workarounds i.e. selective door opening.

It's likely that 8-car consists will operate from LNIRIM start-up (GWRC's latest v4.0 TT), so ideally the platform lengthening should be implemented prior to 2028.

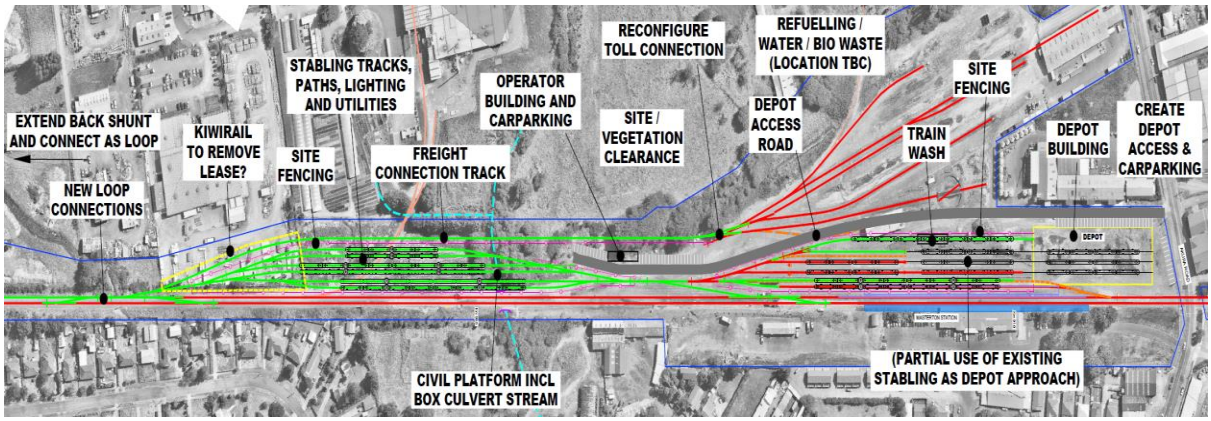
MASTERTON

Additional stabling and a maintenance depot has been identified for Masterton.

The LNIRIM services will be operated by independently powered multiple unit trains, providing a 15-minute service during the AM peak, and a 45-minute service during the PM peak. The start-up service is anticipated around the year 2028, with the full timetable in operation early 2030's.

[23] Allows longer freight trains to wait for their slot, clear of more intensive passenger operations.

The master planning of the Masterton Precinct needs to happen sooner rather than later (to also inform the 2023 design work of WMUP6B). Initial concept work shows the potential scale of the area is significant.



MASTERTON – PAHIATUA – PALMERSTON NORTH

An upgrade of the 64km of track between Masterton to Pahiatua is required to provide route resilience and reliability for freight[24] services, depending on the density of traffic forecasted for freight movements between Palmerston North and Wellington. This provides a crucial freight bypass option. First to improve “wheels free” BOL access to the Kapiti Route, plenty of which will be required to deliver RS2-RS6 and second, to allow some Napier freight to avoid the busy Kapiti Line.

JOHNSONVILLE LINE

The Johnsonville line is reasonably standalone from most of the works within this study. It remains segregated from the other lines and there is an assumption that there is no significant forecast growth.

Opportunities / issues historically identified are still relevant:

- Non infrastructure solutions to timekeeping (keep TSRs low Ngaio-Khandallah)
- Potential room for another train in the off-peak timetable.
- Increase to 6-car trains.
- Converting JVL to LRT (assuming offline from WRS to points south, increasing capacity at station for heavy rail, however, potentially reduces JVL capacity and requires additional passing loops)

The practicalities and benefits of converting the JVL rail corridor to bus operation have previously been comprehensively discounted each time the option is proposed and was not considered for this rail study.

The key opportunity identified as part of the WRS Precinct Master Planning is increasing the JVL line speed from the Wellington station platforms from 25kph to 40kph (as part of the 4th main reconfiguration). This makes a significant timesaving and adds to the resilience of the JVL services.

[24] And allow the future reintroduction of Wellington to Palmerston North via Woodville passenger services. Withdrawn July 1988.

NETWORK WIDE UPGRADES

INUNDATION RISK

An assessment has been made of the stormwater flooding (inundation) risk and the capital expenditure likely to be required to mitigate this risk progressively throughout the Study area. Stormwater flooding was assessed according to the 1 in 100-year (1% Annual Event Probability, 1% AEP) rainfall and tidal storm surge event models.

- The rainfall models identify areas where surface ponding and increased watercourse coverage during a 1% AEP rainfall event will cover areas of the rail network.
- The tidal storm surge event modelling identifies areas where areas of the rail network will be covered by waves and assumed 0.5m of sea level rise (SLR) for the predicted 50-year sea level increase due to climate change.

In areas where projects are proposed as part of this study it is expected the design of infrastructure improvements will take climate change into account and no additional allowance has been made over the scope contingency included in the rough order cost estimate for each project.

The rough order cost estimate allowed to mitigate general inundation risk across the network where no other infrastructure improvement projects are planned, reflects an arbitrary cost to raise the level of the rail throughout areas of inundation and equates to just under c.$1 billion across the network. These costs have been spread across the programme with the assumption that major risk areas (c.$810M) will be addressed first, followed by the moderate risk areas (c.$140M) to complete mitigation works before the RS4 timetable is implemented.

SLOPE STABILITY

No investigation work into slope stabilisation along the rail corridor has been undertaken as part of this capacity study. Slope stabilisation scope currently sits with the WMUP3 project and investigation and costing work is ongoing. An updated Risk Assessment Methodology (KSRL) is being developed but has not yet been officially approved or implemented within KiwiRail.

Although the list of high-risk slopes determined by the new tool has not been officially confirmed as accurate it has been used as a basis for developing a rough order cost for the purposes of this study.

Rough order costs to address slope stability over the coming decades has been estimated by taking the existing WMUP3 budget of approximately $10M (considered likely to be enough to remediate 4-5 locations based on the WMUP3 team's current understanding) and extrapolating it to cover all 52 slopes currently identified as higher risk. A 60% contingency has been allowed resulting in an overall rough order estimate of $210M.

It has been assumed slope stability works for these higher risk slopes is completed for the implementation of RS4.

EARTHQUAKES

No specific study of earthquake risk was carried out, aside from considerations of earthquake resilience in individual studies. However, the significant risk the entire WRS Precinct investment faces from earthquakes should be noted.

MAINTENANCE AND ACCESS PLANNING

To minimise the time and cost associated with generating rough order costs and programme for this study, the findings of the following access and maintenance studies conducted in Auckland have been utilised to approximate the overall access and maintenance planning strategy for Wellington[25]:

- Rail PBC Auckland Access, Maintenance & Renewals memo prepared by WSP/ RIC dated 17 October 2022; and
- Auckland Network Access Provision Philosophy paper prepared by Stephen Knight of RIC for the PSG – Technical Steering Committee dated 22 December 2021

This has been done with the understanding that the Wellington Metro environment is different to Auckland in scale and challenges. However, it has been assumed at this stage that some of the general philosophies developed for the Auckland Metro can be applied in Wellington, although further work will be required to validate these assumptions at the next stage of strategy development.

As a point of reference, the emerging themes from the 2022 Auckland Rail Programme Business Case (AR PBC) are worth considering with respect to their relevance on the Wellington Network, and how they dovetail with the intent of the Rail Plan:

- Decade 1: **Enhance resilience**
- Decade 2: Scale to meet demand and encourage mode shift
- Decade 3: Further enhance service & journey time benefits to accelerate mode shift

A key learning from the Auckland rail network is the need to invest in a solid and reliable network (at minimum in critical areas) before expanding services. There has been strong public backlash over disruption to the network while delivering catchup renewals and constructing CAPEX projects, and over reliability issues when new services / timetables come online.

As higher frequency timetables are implemented across the Wellington network, provision of adequate network access will be critical to maintain a network that is sufficiently robust and resilient to provide the service levels proposed.

The increased number of services operating will cause a step change in maintenance levels and a corresponding step change in access required and/or production efficiency utilising available access.

Any access regime proposed will need to create safe, efficient access to the corridor for rail and non-rail vehicles and plant.

[25] Development of the overall Wellington access and maintenance strategy is expected to be progressed as a future separate piece of work.

The AR PBC has developed a framework for access objectives. The overall objectives of the access strategy are to support a progression from the current to a future state:

- From a reactive maintenance to a predictive maintenance regime
- From a network managed in accordance with local standards to an international railway best practice standard for maintaining and renewing a railway network; whilst
- Meeting the challenges defined within the KiwiRail Strategic Asset Management Plan[26]

The specific objectives of the access regime are:

- To separate works from train operations (can mean running on one main while working on the other).
- To maximise the productive time available to the network as follows:
    - Maximise the length of the overall access windows
    - Maximise the utilisation of these windows by providing the ability to access the rail corridor efficiently to get people plant and equipment onto the corridor safely and quickly.
- To meet Level 3 of the Access and Maintenance scoring matrix as defined by the KRG Network Services team.[27]

Of the philosophies in the AR PBC paper the following are considered of value to the Wellington Network:

1. Take advantage of resilience crossovers to allow bi-directional running of trains[28] allowing clear and large access windows.
2. Installing Satellite depots at the mid points on lines to minimise travel time to any points lying on the extremities of the network.
3. Install access pads at regular locations to minimise the travel distance on site, increasing the utilisation of the Access Windows
4. Procuring modern plant and equipment to improve efficiencies of inspections and works.

Additionally, not identified in the AR PBC but considered of relevance to the Wellington network is:

5. Creating additional and efficient rail-bus transhipment hubs positioned to minimise length of rail replacement bus runs.

A rough estimate of $100million has been allowed in the overall roadmap costings for access pads (12 no.) and satellite yards and land acquisition (4 no.). Though required as part of the overall access and maintenance planning provision, the cost of resilience crossovers[29] set out in this study will be covered under the Wellington Resignalling Project and are not considered here.

[26] The KRG Strategic Asset Management Plan (SAMP) – developed in 2022 underpins the approach to Asset Management in the Auckland Metro and across the regional network. The SAMP focuses on the following KPI areas/Network Challenges below. The five identified rail network challenge areas are: 1. **Zero Harm**: reduce the safety and environment risks of our rail network, 2.Managing **Network Risk**: manage key reliability and resilience risks, 3.Delivering a **Valued Service**: deliver service levels agreed with our customers, 4.Delivering **Cost Efficiency**: improve our processes to ensure we deliver cost-effective services, 5.Developing **Capability**: ensure our operations are sustainable, and that we continually improve our AM capability.

[27] As part of the AR PBC work, the KRG Network Services team have developed a matrix to provide a scoring system that can be used to score the maintenance states and provide a framework for the different interventions for Access, Maintenance and Renewals.

[28] Noting that, unlike the AEA, currently the WEA has few crossovers placed for efficient wrong line running and nor does the signalling system support wrong line running once a train has crossed over. Running a train on the "wrong" main is authorised and kept safe by administrative (paperwork) controls.

[29] Note: There may be additional cost to procure specialist plant and equipment that has not been accounted for here and will need to be assessed by the Wellington maintenance and access planning team.

However, to refine and better inform this cost base and given the potential value of the works to the network it is important that strategic planning of access and the efficient utilisation of this access is a central theme in the overall planning for the implementation of all future timetables.

LEVEL CROSSING RATIONALISATION

An initial view has been formed of the potential treatment of level crossings within the Wellington Electrified Area (WEA) and the North Island Main Trunk Line (NIMT) between Waikanae and Palmerston North to enable operation of increased frequency passenger and freight services. Public road, standalone pedestrian, and private level crossings have been considered. Increased frequency services increase level crossing risk due to increasing the likelihood of collision. They also result in increased road congestion at higher frequencies, due to longer barrier down time.

It has been assumed that current physical protection measures using half arm barriers (public road) and automatic gates (pedestrian) will not be sufficient in the WEA at increased train frequencies and level crossings will therefore need to be closed, grade separated or bypassed[30]. The work involved in achieving this for the major crossings in built up areas in the WEA is daunting. These major crossings are discussed briefly in their geographical sections above and the costs to grade separate them are set out below. Major coordinated initiatives are required to each address of these and they would be best addressed as one overarching programme to co-ordinate road network disruption.

It has been assumed that all level crossings on the NIMT between Waikanae and Palmerston North will require maximum protection (half arm vehicle barriers & automatic pedestrian gates) but can remain at grade. Private Level crossings that cannot readily be closed have been assumed to be fitted with half-arm barriers. It is assumed that WMUP6B has delivered this work Upper Hutt to Masterton. Most of the WEA vehicle level crossings assessments have found a road over rail solution to be preferred, though it has been difficult to achieve standard approach gradients where the crossing is a primary feeder road, and it is likely departures will be needed to implement the proposed solutions.

Following review of existing pedestrian level crossing locations, it was decided to develop a generic cost estimate for installation of either an overbridge or underpass at each location with the optimum solution to be determined at a later design stage.

Costs to eliminate all vehicle and pedestrian level crossings within the WEA and to upgrade all level crossings to half arm barriers (vehicle) and automatic gates (pedestrian) between Waikanae and Palmerston North are likely to be in the region of $1bn as set out below:

Level Crossing group	Indicative cost ($M)
Vehicle level crossings (WEA)	778.4
Pedestrian Level Crossings (WEA)	132.0
NIMT Level Crossings (Waikanae to Palmerston North)	29.8
Private and KiwiRail Service Level Crossings	13.7
Total indicative capital cost	953.9

[30] Noting that this was the view taken during the 1946-1955 Hutt Valley deviation and duplication. No at grade road crossings were permitted in the main section of new works Petone to Silverstream, the works being carried out ahead of the housing development the railway was intended to support.

The most cost-effective way to deliver the protection upgrades to level crossings north of Waikanae, may be to incorporate them into a nationwide upgrade programme. This may be the time to progress a more highly standardised level crossing, with options for reduced installation complexity and cost, using the new HIMA solution with simplified cabling (using Wi-Fi) and applied on a production basis.

Grade separations in urban centres will have a significant impact on surrounding properties requiring substantial property acquisition and will cause significant disruption during construction. Stakeholder engagement will therefore be key to facilitate integrated solutions considering town planning aspirations to enhance areas around grade separated crossings.

It is assumed that the grade separations will be delivered as part of a co-ordinated programme aligned with other capacity projects where possible and limiting surrounding road congestion by undertaking no more than one per line at any one time. The assumption is that any crossing must be grade separated before a third main is introduced and that all crossings will be grade separated before the introduction of the RS4 timetable.

Given the magnitude of the investment required, particularly for vehicle level crossing grade separations, it is recommended that further consideration be made of the assumption that all level crossings within the WEA will need to be closed or grade separation in order to support future higher train frequencies. For example, it may be possible to provide acceptable levels of safety risk mitigation at crossings with low to moderate traffic volumes, through use of enhanced level crossing barriers and warning systems, such as the four-quadrant barriers with skirts and obstacle detection systems as used in the United Kingdom.

WELLINGTON RESIGNALLING PROJECT (INCLUDING SERVICE RESILIENCE CROSSOVERS)

The Wellington Resignalling Project will introduce ETCSL2 strategically across the network to enhance safety performance prior to, and coinciding with, the implementation of RS2 before a more comprehensive implementation is required for operations at RS4.

The use of ETCSL2 signalling to gain capacity benefit without further infrastructure investments will need to be carefully assessed during the Wellington Resignalling Project with the potential cost mitigation included as a benefit within its business case.

The Wellington Resignalling project costings will allow for installation of service resilience crossovers and the associated signalling to allow these to be used for bi-directional running to serve two main purposes:

1. to facilitate efficient transhipment of passengers following termination of rail services at stations (due to BOLs, unplanned service outage etc.), and

2. to facilitate provision of a rail service during planned maintenance single-line BOLs

The optimum installation programme for these crossovers has not yet been determined but will need to take into consideration not only the service resilience and steady state maintenance requirements above but whether there is benefit installing them early in the programme of works to enable the RS programme construction works to take advantage of them. Installation of these crossovers would be best aligned with the introduction of ETCS L2 rather than prior as this will provide the bi-directional signalling to take advantage of them.

Further work on the optimum crossover locations to provide the best service frequency will be carried out as part of the Wellington Resignalling Project but preliminary work has indicated that 4 additional

crossovers will be required to deliver a 30-minute passenger service using bi-directional running during a single-line BOL.

The table below details the crossovers deemed to be required for various levels of bi-directional running and their status.

Crossover location	Existing Crossovers	New crossovers / changes proposed
Tawa	Down to Up crossover at South end of station and Up to Down and North end	Remote control
Porirua	Up to Down and Down to Up facing crossovers at South end of station plus Down to Up crossover at North end	
Plimmerton	Up to Down facing crossover at South end of station plus facing and trailing crossovers installed as part of the PACE project	
Paekakariki	Up to Down and Down to Up facing crossovers at South end of station plus Down to Up crossover at North end	
Paraparaumu	Up to Down and Down to Up facing crossovers at South end of station	
Trentham	Up to Down and Down to Up facing crossovers at South end of station (These were retained as part of the T2UH duplication)	
South of Silverstream	Nothing existing[31]	Consider value of crossovers to provide operational options in response to relatively high number of incident related line closures north of Br30.
Taita	Up to Down and Down to Up facing crossovers at South end of station	
Waterloo	Nothing existing	Consider value of crossovers to better support the use of Waterloo, a purpose built bus-train interchange, for BOL bus-train transhipment.
Woburn	(Non-motorised) Down to Up crossover at North end of station. *Facing crossovers to assist with movement into and out of the Gracefield branch line are proposed to be installed prior to RS1.*	An additional facing crossover north of the station. (W2)
Petone	Down to Up crossover at South end of Station plus another Down to Up crossover at Melling Junction.	A new Up to Down crossover at the south end of Station to facilitate terminations of services from Wellington. (W1)
Johnsonville Line	Nothing existing.	Facing crossover JVL to NIMT Up main (J1)
Kaiwharawhara	All existing crossovers are at the South end of the station: ○ Up WL to Up NIMT; ○ Up to Down NIMT, and ○ Down NIMT to Down WL.	A means of terminating and setting back inbound services from Waikanae or Upper Hutt at Kaiwharawhara in the event of Kaiwharawhara to Wellington station section being shut or blocked (K1)

The rough order costs for installation of additional crossovers required is not included in the estimate for this study, instead these costs (J1, W1, W2, K1) have been included in the Wellington Resignalling costs[32]

Default scope parameters assumed for crossovers:

[31] Up to Down and Down to Up crossovers at north end of Manor Park station have been proposed as a replacement for Trentham Crossovers, so services from Wellington can be terminated at Manor Park in the event of the Silverstream rail overbridge being struck by an over height truck, but as Trentham crossovers have been retained through T2UH upgrades, these are no longer required.

[32] Four crossovers were allowed for in the Wellington Resignalling Indicative Business Case, July 2021

- It is assumed ETCS L2 is implemented i.e., provision for simplified or full bi-directional running is built into the computer signalling and these costs reflect only the hardware costs.
- 40kph Crossovers: Although identified as for bi-directional running, it would be prudent to assume these over the minimum 25kph cross overs (with 60kph being an over allowance). For reference the 40kph crossovers are ~70m long.
- Standard Martinus Crossover design at 4m track centres: Although potentially not feasible in some locations, this will likely be the default requirement.
- Given the variable existing track centres (generally 3.7-3.8m), scope allowance should be made for track slews on the approaches to the standard crossover design over a nominal 100m on each main on each approach.
- It is also assumed that a full formation rebuild is required under the new crossover (~70m for both mains).
- The crossover will require OLE and may require additional signalling (assume additional signal at each end at this stage).
- Operationally it will also require upgrading of systems and operating documentation / processes.

MULTIPLE UNIT STABLING

While included in costings in the preliminary issue a narrative will be added in Issue 1.

Analysis of Fleet in Service and Stabled [cars]

KZ139 - WNCCS

Version 3

			2022	2025	2025 to 2030	2025 to 2030	2030 to 2035		2040 to 2045
			Current TT	RS1	RS2	RS2 Boosted Consists	RS4.2 (no MPML)	RS4.3 (MNPL)	RS6
			15 to 20 minute TT	Approx. 15-minute	15-Minute	15-Minute	10-Minute		6-Minute
		Total Req Stabling Capacity per Site	(Existing)						
KPL & Manawatu	Overnight	Palmerston Nth	8	8	8	16	32	32	32	32
		Paekakariki / Waikanae	30	28	34	36	50	48	48	84
		Paremata / Plimmerton	0	0	0	30	40	48	48	84
		SUB-TOTAL WRS East	32	34	38	18	22	22	22	36
	Interpeak	Palmerston Nth	8	0	0	0	0	0	0	0
		Paekakariki / Waikanae	30	0	0	0	0	0	0	0
		Paremata / Plimmerton	0	0	0	0	0	0	0	0
		SUB-TOTAL WRS East	32	56	66	74	118	122	122	204
HVL & Wairarapa	Overnight	Masterton	22	24	24	56	56	56	56	56
		Upper Hutt	24	24	28	32	44	48	48	76
		Manor Park	0	0	0	0	0	0	48	84
		Woburn / Taita	0	0	0	30	40	42	0	0
		SUB-TOTAL WRS West/North	106	36	36	40	52	54	60	104
	Interpeak	Masterton	22	0	0	0	0	0	0	0
		Upper Hutt	24	0	0	0	0	0	0	0
		Manor Park	0	0	0	0	0	0	0	0
		Woburn / Taita	0	0	0	0	0	0	0	-
		SUB-TOTAL WRS West/North	106	68	70	106	116	110	116	196
		TOTAL WRS - Overnight	138	70	74	58	74	76	82	140
		TOTAL WRS - Interpeak	138	124	136	180	234	232	238	400

= Incl Loco Hauled Carriages

10. CONCLUSIONS AND NEXT STEPS

A comprehensive scheme for the infrastructure required to support staged increases in service frequency from the current schedule to six minutes and to extend reach has been developed.

The work required to deliver RS2 and RS4 within the timeframes being considered by GWRC would require a rate of spend significantly higher than that being spent by the Auckland Metro project office at its current peak. The even greater scale of the infrastructure investment required for the RS6 6-minute timetable and its impact on operations during construction will require careful balancing against the benefits. Stakeholder engagement is a key next step to understanding the impact of these findings.

FINDINGS AND DISCUSSION

There is scope to greatly improve the capacity and capability of the Wellington network but, as an existing and operating network in an established and geographically constrained built up area, each tranche of improvement becomes increasingly expensive and disruptive.

A comprehensive phased scheme for the infrastructure required to support staged increases in service frequency from the current schedule to six minutes, and to extend its reach, has been developed.

This knowledge will significantly inform planning for improved rail and transport services in Wellington. An informed decision on the realistic way to best meet future demands allows the intermediate stages to be planned and phased as logical steps towards this.

Aspirational Implementation Dates	2022	2025	2030	2035	2045
RS Timetable	**Current**	**RS1**	**RS2**	**RS4**	**RS6**
Nominal frequency	**15 to 20 min**	**Approx. 15 min**	**15 min**	**10 min**	**6 min**
Per stage rough order infrastructure cost ($billiion)	-	**0.02**	**2.0**	**5.2**	**10.2**
Cumulative rough order infrastructure cost ($billion)	-	**0.02**	**2.0**	**7.2**	**17.4**

TIMING

The RS2 – RS6 scheme is practical from an engineering perspective, but to meet the Rail Plan's aspirational timetable for RS2 & RS4 the Implementation Roadmap shows master planning, design, consenting and business case work should have already commenced for around 30% of the identified infrastructure projects required. Some projects should have already commenced construction.

Current timeframes for delivery of RS2 - RS4 appear optimistic. A prompt start to deciding exactly what is required, and by when, then a slower and steadier delivery is recommended.

The overall cash flow for these precursor infrastructure solutions is an average quarterly spend of circa. $147 (c.$600M / annum). To indicate the achievability of this spend rate, a comparison can be made to the current spend on capital projects in Auckland of $100M per quarter at its current peak (2023) – a busier and growing network. The relative importance of each network and the challenges faced delivering the Auckland works does suggest careful consideration of the value and the practicality of even higher spend rates in Wellington.

The step change in infrastructure required to allow delivery of the RS6 6-minute timetable would require increased spend of over $250M per quarter over 10 years (which is the equivalent of double the Auckland Project Office current peak spend), with the associated service disruption and increased maintenance requirements of a service more frequent than today.

GETTING THE JOB DONE - ACCESS FOR CONSTRUCTION

While there are considerations of funder cashflow, the most intractable constraint is the ability to deliver construction of this scope and at such a pace without prolonged and damaging disruption to passenger and freight services. The process of delivering the improvements could in itself choke off the demand driving them, if not staged and planned carefully to be at a sustainable rate.

Investments to improve the productivity of works when on track and to allow some level of customer operations during works should be a focus of any planning phase.

Based on assessment of spend rate alone, the aspirational delivery dates for 15-minute RS2 & 10-minute RS4 need to be carefully staged to avoid the perverse outcome delivery of works intended to deliver improvements damaging network performance and patronage and undermining the need for these improvements.

TEN-MINUTE FREQUENCY APPEARS TO BE AN OPTIMUM

The results show that the cost and disruption of frequency improvement work increases very rapidly with the reduction in times between services, suggesting a practical limit to the affordability and value[33] of a frequency-based service improvement.

The point of inflection comes when the two-track railway becomes insufficient for the increased frequency of trains, when either a third or fourth track or a relief route on another alignment becomes essential.

[33] To be demonstrated by BCR values calculated in future business cases.

This step change is triggered by any move to increase service frequency beyond ten minutes[34]. While this study makes no effort to determine the benefits of such an improvement and thus calculate cost-benefit, the size of the investment step strongly suggests that this is a limit for which it may be challenging to deliver equivalent benefits. This could also represent the point where increased capacity on each train begins to become the optimum approach.

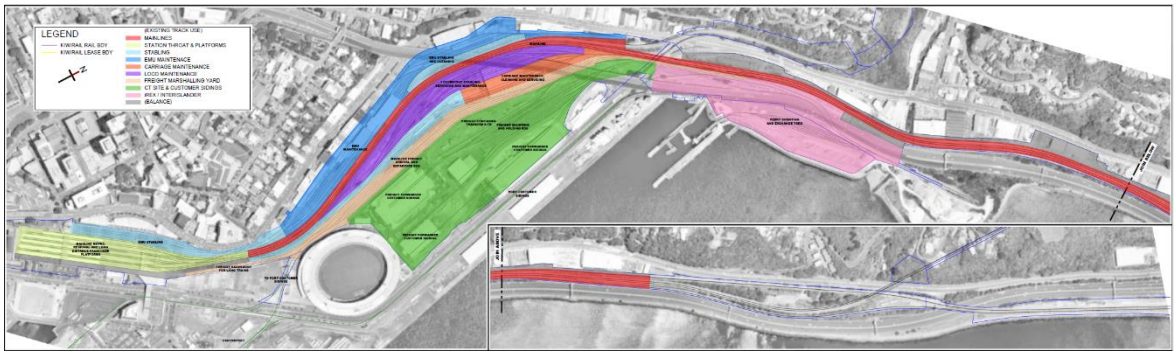
The need for duplicate and bypass tracks makes the cost of the step to a six-minute frequency 2.4 times the cost of getting to ten minutes[35]. The pattern of mingled express and inner all stops services provides good customer service but consumes significant track capacity due to the express services catching up the stopping trains as frequencies tighten.

NEED FOR AN EARLY CONSENSUS ON THE OBJECTIVE

There will likely need to be some bold early investment decisions (i.e., land) to secure options for future infrastructure. It will also be important to make a decision on whether the RS6 6-minute timetable is the eventual goal or not, prior to master planning being undertaken for RS4, as there will be instances where future proofing for RS6 will impact adversely on the quality of solution delivered for RS4, which is not desirable if this is to be the end state for the infrastructure.

A clear decision needs to be made if 6-minute RS6 is not to be the ultimate aspiration, as it highly influences the layout in several areas of the network (especially WRS Precinct) where space proofing or not-precluding RS6 has significant impact on land and track/facilities layout. The result can be an RS4 layout compromised to enable an RS6 that is never coming.

WELLINGTON RAILWAY STATION NORTHERN APPROACHES



A critical component of the Wellington network is the WRS Precinct area:

- Realising benefits from the billions of $ investment across the wider network (and NZ) could be significantly compromised if this area constrains flow and is at risk from earthquakes or inundation.

[34] Note that a “10 minute” frequency is one train every 5-10 minutes, comprising express trains and all stops trains, each on a ten minute headway. 12 trains per hour each way, plus freight and regional trains. Similarly, a “6 minute frequency” is a train every 3-6 minutes. 20 trains per hour, each way, plus the trains running beyond the WEA.

[35] Assuming the $826m single bore NSJ tunnel is provided at RS4.

- It is recommended early investment in robust infrastructure, futureproofing for expansion, maintenance access for reliability, and climate change mitigation is considered as a priority.
- A macro assessment has been done on the functions within the area, and the implications on required land driven by the growth of each function. As expected, given the available land has currently been used to its maximum, additional land and/or relocation of some functions away from the WRS area is required.

Wellington Railway Station precinct is crucial to the successful delivery of RS2 – RS4 – RS6 and it cannot accommodate all its current functions at the higher growth scenarios.

USE OF ETCS TO MAXIMISE CAPACITY

In view of the cost of and potential for disruption caused by the required infrastructure improvements, maximum advantage should be taken of the potential for ETCS Level 2 or beyond to maximise the capacity of the Wellington network. In addition, the Wellington ETCS project should build in maximum operational flexibility to enable efficient construction with reduced service disruption.

CHANGING PATTERNS OF TRAVEL NOT CONSIDERED

Although this study specifically addresses the constraints to implementing successive RS timetables on the existing Wellington Network, it does not address what changes may be required to service changing travel patterns in future, aside from consideration of linking centres north of Waikanae to the Wellington network.

The additional capacity created by the infrastructure solutions set out in this study will benefit development in centres outside Wellington City that have proximity to the rail network, and the addition of shuttle/frequent services north of Waikanae will give additional commuters better access to the Wellington Rail Network, but potential network layout changes to cater to changing travel patterns and development beyond the proximity of the current rail corridor have not been considered. Specifically extending the reach of the network south of Wellington Railway Station or linking the Kapiti and Hutt routes closer to their centres have not been studied.

LINKING OTAKI AND LEVIN INTO THE NETWORK

Beyond the Greater Wellington LNIRM business case, KiwiRail Memo Waikanae – Otaki – Levin Service summary paper(22) reports on the infrastructure required to extend frequent passenger services to Otaki and Levin. Full double-tracking through this area is necessary to ensure a reliable 30-minute shuttle service.

NORTH – SOUTH JUNCTION SECTION

A twin bore North – South Junction tunnel is required for RS6, adding to the existing track to triplicate this section. However, if RS4 represents the immediate practical limit for Wellington Network

improvements there may be a resilience argument for building a single[36] or twin bore tunnel to duplicate this section independent of RS6. This single-track section placed on a vulnerable hillside is a critical and highly vulnerable section of the Wellington and national rail network. The version of RS4 including this as an option is presented in the summary table.

CLIMATE CHANGE AND NATURAL DISASTERS

Due to limits on time and budget this study has not attempted to fully address the future impacts of climate change and design mitigation for this at a network-wide level.

Further work needs to be done to understand how to build in resilience against climate change and other natural disasters to the overall strategy for developing Wellington's railway network especially within key areas such as the Wellington Railway Station Precinct, as many of the investments proposed in this study could be undermined by future inundation and / or other natural disasters such as earthquakes. This point applies not just to rail but also to transport and other infrastructure generally.

This climate change resilience workstream could significantly influence the strategy for the infrastructure and operations of the rail network and should be addressed prior to funding release for any of the infrastructure projects proposed in this study. Other Wellington infrastructure and land use planning streams should apply the same scrutiny – this should not just be limited to rail.

[36] Under modern tunnelling practice, a double track tunnel would be two single bores in any case, so one can be built without precluding the second being added later.

CONCLUSIONS

A comprehensive scheme for the infrastructure required to support staged increases in service frequency from the current schedule to six minutes has been developed.

The volume of work required is such that the current Rail Plan assumptions for the introduction of RS2 and RS4 may be difficult to achieve. Practical dates for these enhancements need to be determined.

Capacity may be able to be increased during this longer delivery period through optimised ETCS signalling, compromise timetables and higher capacity trains.

Given the step change in infrastructure required following RS4, RS6 may not be the preferable ultimate aspiration for the Wellington Network. If this finding is confirmed, available options are:

- To invest in a robust network to eventually provide a highly reliable 10-minute timetable. This assumes customers will be more attracted to a reliable 10-minute service than a less reliable 6-minute one.
- To increase passenger capacity via higher capacity consists.

Regardless of the decision on RS6, a prolonged programme of work has potential to continuously disrupt services over several decades if not carefully delivered. Careful planning is required to not have the improvement investment negate the very reason for making it.

NEXT STEPS

STAKEHOLDER ENGAGEMENT

Stakeholder engagement is a key next step to understanding the impact of the findings of this study.

Key stakeholders will be asked to review and provide feedback on this document to make sure the proposals it suggests are aligned with plans being developed in other forums and that the challenges it identifies around timing and cost are considered.

To engage effectively KiwiRail will need to undertake further work to understand at a high-level:

- if the market has sufficient capacity to deliver the programme of work based on spend profile and type of activity.
- how available network access compares to that required to deliver the infrastructure solutions set out in this study.
- how feasible the delivery of the programme is with respect to maintenance requirements, customer impact and forecast freight and passenger demand.

FURTHER ACTIONS

Continuation of key studies is recommended to ensure an appropriate level of momentum (to avoid 'put it down, pick it up' inefficiencies) and should include.

- Coming to a decision on the practical timing of the RS steps, how far these go and the strategy for increasing capacity beyond RS4.
- Making an early decision on at least the RS2 and RS4 (RS4.3) steps
- Progressing delivery of highly optimised Wellington ETCS
- Make the ability to carry out works on the network while maintaining a level of rail service one of the priorities of the Wellington ETCS project.
- Creation of a small KiwiRail organisation to coordinate and progress activities on planning and preparing RS2 and beyond.
- Fund the early development of RS2 and RS4 (RS4.3) detailed plans and designs to allow acceleration of Design, Planning, Consents and Business Case processes to avoid delays to construction commencing and further delays to RS2 and RS4 realistic dates.
- Early focus on more providing for cost effective and less disruptive network access in the face of significant coming investment, preferably in time to benefit current projects like the A-Box replacement.
- Firm commitment to the Master Plan process for the WRS Precinct by all Wellington programmes.
- Begin Development of Master Plans for other key areas:
    - Network Stabling strategy
    - Melling Line and Melling junction upgrades and Riverlink interface
    - Waikanae town centre redevelopment
    - Plimmerton grade separation project
    - Tawa Basin grade separation project
    - Hutt Valley Line options for RS4 (Bypass or third Mains)

    - NSJ area including Muri Curve options
- Use Master Plan outputs to inform land acquisition requirements and potentially mobilise a land acquisition function to formulate a plan for, and then manage, the Notice of Requirement (NOR) process across entire network.
- Engaging with Riverlink Project to make sure the ability to extend Melling line through to Manor Park is preserved and assess in relation to Hutt Valley Line third main as a solution for RS4
- Consideration of providing increased capacity per service as one of the ways of meeting demand in the face of longer delivery of infrastructure required to increase the number of services.
- A serious study of the implications of climate change and resilience on this investment.
- Addressing the potential change in usage of the railway away from the basic historic tidal flow to/from Wellington CBD, which may be worth consideration as part of a separate study.

STANDARD PROJECT NEXT STEPS

If / when the individual projects are to be progressed, there are several standard next steps that should be specifically considered at the start of the mobilisation period. These are set out in Appendix A along with the Data Sheets for each individual infrastructure solution.

BIBLIOGRAPHY

Doc Ref.	Report Title	Consultant	Date of Issue	Version
1	Preliminary Wellington Timetable Evolution and Infrastructure Roadmap	KSP Consultants Ltd	1st August 2022	01
2	KZ 139-01 W2L paper	KSP Consultants Ltd		V3
2	KZ 139-02 Wellington Timetable Evolution and Infrastructure Roadmap	KSP Consultants Ltd	22nd December 2022	02
3	KZ 139-02 Appendix 2: Train Graphs	KSP Consultants Ltd	22nd December 2022	02
4	KZ 139-03 Woburn Junction Modelling Report	KSP Consultants Ltd		01
5	KZ 139-05 LNIRIM on NIMT	KSP Consultants Ltd		Draft 02
6	KZ 139-06 LNIRIM Lite on NIMT	KSP Consultants Ltd		-
7	KZ 139-07 Waikanae to Levin Evolution Table	KSP Consultants Ltd		Draft 04
8	KZ 139-08 Resilience Crossovers Modelling Report	KSP Consultants Ltd		-
9	KZ 139-09 Identifying Curve Easing Opportunities	KSP Consultants Ltd		Draft 01
10	KZ 139-10 Stabling Evolution Excel File	KSP Consultants Ltd		V1
11	KZ 139-11 NSJ Line Speed Modelling for Stage 2 Upgrade	KSP Consultants Ltd		-
12	Operational Modelling Peer Review	R Donaldson Rail Ltd		-

Doc Ref.	Report Title	Consultant	Date of Issue	Version	Infrastructure Solution Reference	Project Name
13	Waikanae to Otaki Feasibility Study	Vitruvius	9 November 2022	2.0	KPL-RS1-1	Waikanae – Increase Stabling
14	NSJ & Pukerua Bay Signalling Changes	RIC	23 November 2022	2.1	KPL-RS1-2	NSJ & Pukerua Bay Split Signal Blocks
15	Woburn Junction Upgrades	RIC	November 2022	2.1	KPL-RS1-3	Woburn Junction Upgrades
16	V-1130 NIMT Future Upgrades – LNIRIM Lite	Vitruvius	28 October 2022	1	NIMT-RS2-1	Levin to PNth - LNIRIM Lite - Linton and Koputaroa loops extended to 900m.
17	Wellington Metro Future Upgrades Otaki to Levin to Shannon Feasibility Study	Vitruvius	9 November 2022	2	NIMT-RS2-2	Levin to PNth - LNIRIM Full - Full duplication Levin to Shannon
18	WMUP Feasibility Study – NIMT – Waikanae to Palmerston North – Level Crossing Upgrades memo	Vitruvius	12 October 2022	1	NIMT-RS2-2	Levin to PNth - LNIRIM Full - Full duplication Levin to Shannon
19	Technical Note | WNCCS – NIMT Signalling Changes Waikanae North	RIC	November 2022	2	NIMT-RS2-2	Levin to PNth - LNIRIM Full - Full duplication Levin to Shannon
20	Waikanae to Levin Evolution	KSP	November 2022	3	NIMT-RS2-2	Levin to PNth - LNIRIM Full - Full duplication Levin to Shannon
21	NIMT Waikanae to Palmerston North Level Crossing Upgrades Memo	Vitruvius	12 October 2022	-	NIMT-RS2-2	Levin to PNth - LNIRIM Full - Full duplication Levin to Shannon
22	KiwiRail Memo Waikanae – Otaki – Levin Service summary paper	KiwiRail	9 December 2022	Final Draft	NIMT-RS2-3	Waikanae to Levin - LNIRIM & WOL Shuttle - Full duplication
23	Wellington Metro Future Upgrades Otaki to Levin & Levin to Shannon	Vitruvius	9 November 2022	2	NIMT-RS2-3	Waikanae to Levin - LNIRIM & WOL Shuttle - Full duplication

Doc Ref.	Report Title	Consultant	Date of Issue	Version	Infrastructure Solution Reference	Project Name
	Feasibility Study Report					
24	Wellington Metro Future Upgrades Waikanae to Otaki Feasibility Study Report	Vitruvius	9 November 2022	2	NIMT-RS2-3	Waikanae to Levin - LNIRIM & WOL Shuttle - Full duplication
25	Technical Note | WNCCS – NIMT Signalling Changes Waikanae North	RIC	21st November 2022	2	NIMT-RS2-3	Levin to PNth - LNIRIM Full - Full duplication Levin to Shannon
26	Waikanae to Levin Evolution	KSP	November 2022	3	NIMT-RS2-3	Levin to PNth - LNIRIM Full - Full duplication Levin to Shannon
27	NIMT Waikanae to Palmerston North Level Crossing Upgrades Memo	Vitruvius	12 October 2022	-	NIMT-RS2-3	Levin to PNth - LNIRIM Full - Full duplication Levin to Shannon
28	KiwiRail Memo Waikanae – Otaki – Levin Service summary paper	KiwiRail	9 December 2022	Final Draft	NIMT-RS2-4	Waikanae to Levin (LNIRIM & WOL) Electrification
29	Wellington network capacity constraints study, OHLE Extension Waikanae – Otaki – Levin technical note	RIC	November 2022	2	NIMT-RS2-4	Waikanae to Levin (LNIRIM & WOL) Electrification
30	W20 and W2L Traction Supply Options Study	Beca and Systra	6 December 2022	-	NIMT-RS2-4	Waikanae to Levin (LNIRIM & WOL) Electrification
31	Preliminary Technical Requirements for AC/DC Traction System Interfaces	EXP	19 October 2022	-	NIMT-RS2-4	Waikanae to Levin (LNIRIM & WOL) Electrification
32	Network Stabling	RIC	November 2022	3	NIMT-RS2-5	Paekariki/ Waikanae Increase Stabling

Doc Ref.	Report Title	Consultant	Date of Issue	Version	Infrastructure Solution Reference	Project Name
33	NSJ and Pukerua Bay – Signaling Changes	RIC	31 January 2023	2	NIMT-RS2-6	NSJ (SJ) Extend Double Track to Tunnel 3
34	Wellington Future Rail Concepts	Aurecon	12 December 2022	2	NIMT-RS2-6	NSJ (SJ) Extend Double Track to Tunnel 3
35	Network Stabling	RIC	November 2022	3	KPL-RS2-7	Plimmerton/ Paremata Increase stabling
36	Network Stabling	RIC	November 2022	3	WL-WS2-9	Masterton – increase stabling
37	Wairarapa Line Post WMUP6B resilience upgrades	RIC	December 2022	2	WL-RS2-10	Platform Lengthening at Matarawa, Solway, and Renall Street
38	Network Stabling	RIC	November 2022	3	HVL-RS2-11	Taita/ Manor Park, Woburn
39	Melling Line Duplication @ Grade Separation	RIC	December 2022	2	ML-RS2-12	Melling Line – Partial Duplication
40	WRS Precinct master Plan	RIC	November 2022	2	KPL-RS2-13	WRS Precinct – 40 KPH
41	WRS Precinct master Plan	RIC	November 2022	2	WRS-RS2-14	WRS Precinct - Stabling
42	Waikanae Bridge Duplication Costing Spreadsheet	RIC	January 2023	1	KPL-RS4-1	Waikanae River Bridge Duplication
43	Wellington Future Rail Concepts	Aurecon	12 December 2022	2	KPL-RS4-2	NSJ (NJ) Extend Double Track to Tunnel 6
44	NSJ and Pukerua Bay – Signaling Changes	RIC	31 January 2023	2	KPL-RS4-3	Pukerua bay – Shorten Signal Block for Freights
45	Tawa Basin Third Main	RIC	December 2022	2	KPL-RS4.23-4	Tawa Basin 3rd Main
46	Wairarapa Line Post WMUP6B resilience upgrades Technical Note	RIC	December 2022	2	WL-RS4-5	Remutaka Loop Resilience
47	Remutaka Tunnel Ventilation	WSP	5 July 2022	3	WL-RS4-6	Remutaka Tunnel Ventilation

Doc Ref.	Report Title	Consultant	Date of Issue	Version	Infrastructure Solution Reference	Project Name
48	Wairarapa Line Post WMUP6B resilience upgrades Technical Note	RIC	December 2022	2	KPL-RS4-7	Maymorn Second Platform
49	Wairarapa Line Post WMUP6B resilience upgrades Technical Note	RIC	December 2022	2	WL-RS4-8	Upper Hutt Siding Lengthening
50	Wairarapa Line Post WMUP6B resilience upgrades Technical Note	RIC	December 2022	2	WL-RS4-21	Masterton to Pahiatua Upgrades
51	Network Stabling	RIC	November 2022	3	HVL-RS4-19	Upper Hutt Additional Stabling
52	Network Stabling	RIC	November 2022	3	WL-RS4.3-9	Manor Park Station - Stabling
53	Manor Park to Melling Link	RIC	December 2022	2	HVL-RS4.3-10	Manor Park to Melling Link (RS4.3)
54	Cost Summary	RIC			HVL-RS4.12-11	Taita – New Platform turn backs
55	HV Line 3rd Main	RIC	November 2022	2	HVL-RS4.2-12	Hutt Valley Line 3rd main
56	WRS to Melling Junction 3rd Main	RIC	December 2022	2	HVL-RS4-13	Melling Junction to WRS 3rd Main
57	Hutt Valley Line 3rd Main	RIC	November 2022	2	ML-RS4-14	Melling Line Comp Duplication
58	Hutt Valley Line 3rd Main	RIC	November 2022	2	ML-RS4-15	Melling Line Duplication at Grade
59	WRS Precinct master Plan	RIC	November 2022	2	WRS-RS4-16	WRS Precinct 5th Main
60	WRS Precinct master Plan	RIC	November 2022	2	WRS-RS4-17	WRS Precinct 4th Main
61	WRS Precinct master Plan	RIC	November 2022	2	WRS-RS4-21	WRS Precinct – reconfigure flyover
62	WRS Precinct master Plan	RIC	November 2022	2	WRS-RS4-18	EMU Depot Expansion

Doc Ref.	Report Title	Consultant	Date of Issue	Version	Infrastructure Solution Reference	Project Name
63	Network Stabling	RIC	November 2022	3	WRS-RS4-20	Additional Stabling
64	Inundation Risk	RIC	January 2022	2		Network Wide Upgrades
65	Level Crossing Rationalisation	RIC	December 2022	2		Network Wide Upgrades
66	NSJ Options for double tracking NIMT	WSP	20th December 2022	2		NSJ Full duplication (via single bore tunnel)

GLOSSARY OF TERMS

Acronym / Name	Definition / Description
AEA	Auckland Electrified Area
AEP	Annual Event Probability (rainfall event severity)
AR PBC	Auckland Rail Programme Business Case
BCR	Benefit Cost Ratio
BOL	Block of Line
CBD	Central Business Disctrict
DMU	Diesel Multiple Unit
EMU	Electric Multiple Unit
GW(RC)	Greater Wellington (Regional Council)
HIMA	Specialist in automated safety solutions including rail signalling solutions
HVL(3M)	Hutt Valley Line (3rd Main)
IBC	Indicative Business Case
iReX	Inter-Island Resilient Connection Project
JVL	Johnsonville Line
KCDC	Kapiti Coast District Council
KPL	Kapiti Line
KSP	KSP Consultants Ltd
KRG	KiwiRail Group Ltd
LNIRIM	Lower North Island Rail Integrated Mobility
MEL	Melling Line
MPML	Manor Park to Melling Link
MSP	Mode Shift Plan
NIMT	North Island Main Trunk rail line
NOR	Notice of Requirements – part of land acquisition process to secure land designation for railway use
NSJ	North South Junction – refers to the length of single track between north and south junctions
NZ	New Zealand
OLE	Overhead Line Electrification
PACE	Porirua Area Capacity Enhancements
PBC	Programme Business Case
PDC	Porirua District Council
PMO	Project Management Office
PQ	Per quarter
PSG	Project Steering Group
Rail Plan	The Wellington Regional Rail Plan Programme Business Case - a Greater Wellington Regional Council (GWRC) initiative to set out the long-term direction of investment in the rail network. This investment is a cornerstone of the draft Regional Land Transport Plan (RLTP), draft Regional Public Transport Plan (RPTP), and draft Regional Mode Shift Plan (MSP), and it will help enable the outcomes sought by the preferred direction of the Wellington Regional Growth Framework (RGF). The Rail Plan has a 30-year timeframe for investment and is expected to be updated throughout this period.
RIC	Rail Infrastructure Consultants Ltd

RGF	Regional Growth Framework
RLTP	Regional Land Transport Plan
RPTP	Regional Public Transport Plan
RS	Rail Scenario – relate to increasing frequency timetables: RS1 = 14-16-14 minute, RS2 = 15-minute, RS4 = 10-minute, and RS6 = 6-minute RS3 & RS5 are not considered as separate scenarios in this study as infrastructure required for RS3 allows an RS4 timetable, similarly RS5 infrastructure allows an RS6 timetable.
S&I diagram	Signalling and Interlocking diagram
SEU	Signalling Equivalent Unit
SH1	State Highway 1
SLR	Sea Level Rise (due to climate change)
T2UH	Trentham to Upper Hutt
T7	Tunnel 7
TB3M	Tawa Basin 3rd Main
TT	Timetable
W2O	Waikanae to Otaki
WEA	Wellington Electrified Area
WFC	Wellington Freight Centre
WL	Wairarapa Line
WOL	Waikanae-Otaki-Levin – refers to a new proposed commuter shuttle servicing these areas
WNCCS	Wellington Network Capacity Constraints Study
WMUP	Wellington Metro Upgrade Programme – specific parts referred to in this study: WMUP III – A programme of track renewals to improve track condition and performance. WMUP6A – Safety and capacity improvements and upgrades of Wellington Station northern approaches, including renewal of the legacy 'A' Box signal system. WMUP6B – Infrastructure programme to support higher frequency regional passenger services from the Wairarapa and Palmerston North.
WRS	Wellington Railway Station

APPENDIX A – DATA SHEETS

[See separate document: Appendix A – Data Sheets]

APPENDIX B – IMPLEMENTATION ROADMAP

APPENDIX C – COST BREAKDOWN

Attached is detailed break-down of all costs associated with the body of work. **[Placeholder table below]**

	Infrastrucure Solutions	Rough order cost
	RS1	-
KPL-RS1-1	Waikanae - Increase Stabling	0.1
KPL-RS1-2	NSJ & Pukerua Bay - Split Signal Block	2.1
HVL-RS1-3	Woburn Junction Upgrades	15.5
KPL-RS1-4	PACE (Assumed already funded)	-
HVL-RS1-5	T2UH (Assumed complete)	-
WRS-RS1-6	WRS Precinct - WMUP 6A (Assumed already funded)	-
	RS2	-
NIMT-RS2-1	Levin to PNth - LNIRIM Lite - Linton and Koputaroa loops extended to 900m	14.1
NIMT-RS2-2	Levin to PNth - LNIRIM Full - Full duplication Levin to Shannon	244.7
NIMT-RS2-3	Waikanae to Levin - LNIRIM & WOL Shuttle - Full duplication	633.9
NIMT-RS2-4	Waikanae to Levin - LNIRIM & WOL - Electrification	239.9
KPL-RS2-5	Paekakariki / Waikanae - Increase Stabling	101.5
KPL-RS2-6	NSJ - South Junction - Extend double track to Tunnel 3	35.4
KPL-RS2-7	Plimmerton / Paremata - Stabling capacity for inner tier trains	96.1
WL-RS2-8	WL Upgrades - WMUP 6B (Assumed already funded)	-
WL-RS2-9	Masterton - Increase Stabling for LNIRIM Trains	101.3
WL-RS2-10	Platform Lengthening at Matarawa, Solway and Renall St	10.0
HVL-RS2-11	Taita / Manor park / Woburn - outstabling for inner tier trains	98.0
ML-RS2-12	Melling Line - Partial Duplication (Km0+000 - Km1+700)	102.6
WRS-RS2-13	WRS Precinct - 40kph Freight Yard Access & separate arrival and departure roads	28.4
WRS-RS2-14	WRS Precinct - East Stabling for LNIRIM Trains	161.3
	RS4.1 (all trains all stops on KPL & HVL) RS4.2 (TB3M & HVL3M) RS4.3 (TB3M & MPML)	-
KPL-RS4-1	Waikanae River Bridge Duplication	33.0
KPL-RS4-2	NSJ - Duplicate Nth from Tunnel 6	58.1
KPL-RS4-3	Pukerua Bay - Shorten Signal Block	5.0
KPL-RS4.23-4	Tawa Basin 3rd Main (RS4.2 & RS4.3)	214.1
WL-RS4-5	Remutaka loop resilience (Post WMUP 6B scope)	6.8
WL-RS4-6	Remutaka tunnel ventilation (Post WMUP 6B scope)	21.0
WL-RS4-7	Maymorn second platform and loop (Post WMUP 6B scope)	9.5
WL-RS4-8	Upper Hutt Siding Lengthening (Post WMUP 6B scope)	4.9
HVL-RS4.3-9	Manor Park - additional stabling (RS4.3)	92.4
HVL-RS4.3-10	Manor Park Melling Link (RS4.3)	231.7
HVL-RS4.12-11	Taita - New at platform turnback (RS4.1 & RS4.2)	48.8
HVL-RS4.2-12	Hutt Valley Line 3rd Main (RS4.2)	151.5
HVL-RS4-13	Melling Junction to WRS 3rd Main OR high-capacity ETCS (RS4.1 & RS4.2)	497.0
ML-RS4-14	Melling Line - Complete Duplication (Km1+700 to Stn approach)	9.5
ML-RS4-15	Melling Junction - Duplicate Junction at grade	23.9
WRS-RS4-16	WRS Precinct - 5th freight main (allowing 50kph arrival / departure)	36.7
WRS-RS4-17	WRS Precinct - 4th main and flyover junction (Separation of KPL, HVL & P10)	47.9
WRS-RS4-18	WRS - EMU Depot expansion	50.0
	Network Wide Programmes	-
	Inundation Risk Mitigation	819.7
	Maintenance and Access Planning	100.0
	Service Resilience Crossovers	15.0
	Metro Area Level Crossing Grade Separations (vehicle)	1,635.4
	Metro Area Level Crossing Grade Separations (Pedestrian)	179.9
	Total Rough Order Cost 2023 - 2035 (excl RS6 infrastructure)	6,176.7

KiwiRail