Appendix 7

PROJECT
IRON BOOMERANG
east west line parks limited

Calibre Operations Pty Ltd

East West Line Parks Limited

Additional Simulations and Capacity Assessment – Supplementary Report

CARP11069-REP-Z-005

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0	Issued for use	J. Morton	G. Williams	D. McKell	P. Costello	August 2012
B	Issued for Client Review	J. Morton	G. Williams	D. McKell		July 2012
A	Issued for Internal Review	J. Morton				July 2012
Rev	**Description**	**Author**	**Checked**	**Approved**	**Authorised**	**Date**

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1.0 BACKGROUND

Calibre has previously developed a report to assist with demonstrating to stakeholders, including the QLD Government, the efficiency merits of the East West Line Parks Ltd (EWLP) solution for the Galilee Basin. EWLP has subsequently engaged Calibre to undertake a further analysis of an altered (Eastern) alignment, including above rail parameters such as fuel burn across 26.5 tonne axle load (tal), 32.5tal and 40tal, and the below rail characteristics of the proposed network at 240mtpa and 120mtpa.

Calibre has also been asked to undertake an assessment of an alternative standard gauge (SG) 32.5tal alignment and an alternative 26.5tal proposed alignment and connection to the QR National (QRN) network to compare with the EWLP corridor.

Calibre understands the information is required to inform an efficiency study and report (to be prepared by others) in order to demonstrate a superior logistics solution to stakeholders.

2.0 EXECUTIVE SUMMARY

This report builds on work previously completed in the EWLP Additional Simulations and Capacity Assessment CARP11069-REP-Z-002. During the initial study, Calibre settled on an efficiency measure that consolidates track distance, tonnages hauled, and fuel consumption into a single understandable measure to compare systems.

The EWLP alignment routes the haulage task along a further distance than either of the two alternative alignments, and in order to offset the additional distance penalty, uses 40tal limits rather than 26.5tal and 32.5tal. To demonstrate the fuel efficiency of the 40tal wagons, the EWLP alignment was simulated with 26.5tal, 32.5tal, and then 40tal wagons.

Initial simulations used a 30 Tonne Tare mass wagon for the 40tal trains, and the simulation runs reflected a higher fuel burn in the empty direction due to the heavier wagons. Calibre then ran additional simulations at 26 Tonne Tare following discussions with EWLP and Everything Infrastructure, and applied a shorter (270 wagon) reference train to more closely match locomotive power to trailing load over the alignment.

The resulting fuel burns compare quite favourably with all the simulation runs at 32.5tal, 26.5tal, and 30t tare 40tal wagons. When coupled with aerodynamic wagon covers, and a shorter reference train (270 wagons) which requires fewer locomotives, the EWLP solution burns 25,440,000 less litres of fuel over a 12 month period at 240mtpa than for the equivalent tonnages over the alternative SG 32.5tal corridor.

The results suggest pursuit of a light tare 40tal coal wagon is a goal worth striving for, with a number of alternative concepts beyond conventional design possible. A shorter, squatter wagon with a suitably low centre of gravity may produce significant efficiencies and set new benchmarks for rail innovation.

The results confirmed that a 270 wagon reference train using 3 locomotives is a more efficient solution than the 300 wagons train using 4 locomotives. The shorter trains need a total of 14 fewer locomotives in the fleet, and 90 fewer wagons. An advantage that 270 wagon train offers, is it is easily divisible by 3 – the optimum wagon set. 3-wagon sets need only 1 ECP control unit to control the brakes on the 3 wagons. Maintenance rake sizes drive the maintenance facility workflow, and are easily established by factors of 3 – 30, 45, 60, 75, or 90.

Results for a lighter tare 40tal wagon are favourable when compared to the 32.5tal due to the payload and empty journey mass advantages.

The fitting of wagon covers is estimated to offer 9% fuel efficiency over a non-covered wagon. The benefits of covers extend to significant reductions in fugitive coal dust emissions. Coal dust contaminated ballast and substructures, weakening track support and can lead to higher maintenance costs, track degrading and derailments.

Table 1 shows the full comparison of fuel usage across the EWLP Eastern Alignment utilising various axle loads and incorporating the use of covered wagons and the proposed reference trains of the alternative alignments.

Table 1: Fuel Usage Comparison

	Train Type	Total Fuel Litres	Litre per Tonne	Fuel consumption per '000 GTK
EWLP Eastern Alignment	Uncovered Train 270 (26t Tare)	41,229	1.17	1.43
	Covered Train 270 (26t Tare)	37,518	1.06	1.30
	Uncovered Train 300 (26t Tare)	49,470	1.26	1.54
	Covered Train 300 (26t Tare)	45,018	1.15	1.40
	Uncovered Train 300 (30t Tare)	50,868	1.34	1.55
	Covered Train 300 (30t Tare)	46,290	1.22	1.41
	Uncovered 300 Wagons 26.5tal	35,927	1.42	1.59
	Uncovered 300 Wagons 32.5tal	39,359	1.23	1.49
Alternative Standard Gauge 32.5 TAL	Uncovered Train 240 Wagons 32.5tal	29,787	1.16	1.61
Alternative Narrow Gauge 26.5 TAL	Uncovered Train 120 wagons 26.5tal	16,805	1.66	2.49

3.0 PROJECT SCOPE

The scope of this project encompasses a multi-faceted approach to assess the capabilities and outputs of the EWLP Eastern Alignment primarily. The scope also includes an assessment of an alternative 32.5tal SG alignment and an alternative 26.5tal narrow gauge alignment connecting into the QR National Network.

3.1 Phase 1

1: Simulations to provide EWLP with a comparison for 26.5tal and 32.5tal variations for the HA199VA01 (Western GIC Alignment) and Eastern GIC Alignment using 300 wagon reference train.

- Speed Graphs for 26.5tal and 32.5 tal empty and loaded
- Transit times for 26.5tal and 32.5tal empty and loaded
- Fuel Burn for 26.5tal and 32.5tal empty and loaded
- Comparison of 26.5tal and 32.5tal to original 40tal using the fuel per '000 GTK measure.

2: Compare simulations runs for reference train using 9%[1] reduction in fuel consumption over the total cycle with reference to the EcoFab NASA aerodynamic paper in relation to covered wagons.

3: Assess infrastructure requirements Eastern GIC Alignment for a 240mtpa (reducing to 220 mtpa from QRN connection point) and a 120 mtpa scenario.

3.2 Phase 2

Provide a high level assessment of a proposed narrow gauge 26.5tal alternative alignment with connection to the QRN Network through to Abbot Point. This is to include the metrics of:

- Above rail requirements
- Below rail requirements
- Cycle times
- Fuel consumption.

Assumption for assessment:

- Newlands trunk capacity of 110mtpa
- 60mtpa from Carmichael mine area
- 40mtpa to Abbot Point
- 20mtpa to Dudgeon Point (not included in this assessment beyond QRN connection point)
- 30mtpa from Mac Mines.

[1] Fuel reduction factor and supporting report supplied by EWLP

3.3 Phase 3

Provide a high level assessment of a proposed standard gauge 32.5tal alignment to Abbot Point. This is to include the metrics of:

- Above rail requirements
- Below rail requirements
- Cycle times
- Fuel consumption.

Assumption for assessment:

- Trunk capacity of 150 mtpa
- Mine connection points, alignment geography for simulations, and relevant tonnages to be supplied by EWLP.

3.4 Phase 4

Collate and submit all information as a supplementary report to CARP11069-REP-Z-002: Additional Simulation and Capacity Assessment

4.0 ASSUMPTIONS

Table 2 outlines the rollingstock assumptions for this assessment.

Table 2: Rollingstock Assumptions

Vehicle	Tare (t)	Length (m)	Axle Load	Pay Load (t)	Gross Weight (t)
ES44Ac Locomotive	196	22	32.5 t	N/A	N/A
GT42Ac Locomotive	120	22	20 t	N/A	N/A
Coal Wagon (26.5 tal)	22	15.7	26.5 t	84	106
Coal Wagon (32.5 tal)	22	16.2	32.5 t	106	130
Coal Wagon (40 tal)	30	19.3	40 t	126	160
Coal Wagon (40 tal)	26	19.3	40 t	130	160

Calibre has used a maximum payload accuracy estimate of 97% of theoretical capacity for each wagon. This figure represents the assumed level of target accuracy in order to ensure at a minimum, certainty of tonnage system throughput with the capital applied to the task, and enables the Operators to ensure that there is sufficient buffer to protect from overload condition.

For fuel consumption and to measure transit time, this simulation study applied a “start to finish” analysis of the train as it travelled the alignment. Excluded in the fuel consumption figures for the comparison between networks, was fuel used during loading, unloading and other non-productive dwell times.

Calibre uses OpenTrack simulation tool to measure the energy expended in overcoming resistance to train movement, expressed in Mega Joules (MJ). The formula for converting MJ to litres is as follows;

Formula; $litres = \frac{MJ * 222}{3600 * 0.843}$

Where;

MJ = Output of OpenTrack (is the energy calculated by OpenTrack to move the train over the alignment)

g/kWh = the assumed locomotive efficiency (222g/kWh)

Density of Diesel Fuel (*0.843*t/m^3)

No of seconds in an hour = *3600*

5.0 EWLP WESTERN GIC TRAIN COMPARISON – 26.5TAL, 32.5TAL AND 40TAL

5.1 Assessment parameters

Trains across all three axle loads in the simulations were initially based on a 300 wagon reference train, with an appropriate number of locomotives to haul the trailing load. A loaded and unloaded train simulation was completed to provide the transit time and energy expended in Mega Joules (MJ) during the simulated trip. This data has been used to calculate the estimated fuel consumption in litres of diesel per train trip for an empty and loaded train on the GIC (western) alignment.

The following initial train configurations were used in the different simulations to produce the required data for a comparison between the different alignment options.

Train composition:

- 26.5tal - 4 x GT42Ac[2] Locos and 300 26.5tal wagons (22t tare)
- 32.5tal - 3 x ES44Ac Locos and 300 32.5tal wagons (22t tare)
- 40.0tal - 4 x ES44Ac Locos and 300 40.0tal wagons (30t tare).

5.2 Results of the comparison

Table 3 provides the consolidated results for each of the nominated axle loads. To allow for comparison between the options, two calculations have been utilised in the assessment. These are litres of fuel per tonne and fuel consumption per ‘000 GTK’s. Both of these measures are referenced in Section 2.2.4 of CARP11069-REP-Z-002 Additional Simulations and Capacity Assessment. This comparison was carried out on the Western Alignment.

The results demonstrated that the potential for the 40tal train lies in utilising the locomotive power to its maximum potential, making some allowance for contingency, and striving for as lighter tare as possible. The heavier payload advantages that 40tal offers, along with the potential to make better use of the tractive efforts available with modern locomotives, demonstrates that a 40tal solution is an economically superior solution than 32.5tal.

[2] GT42Ac equivalent to 4100 class QR narrow-gauge locomotive

The approach of using a 300 wagon reference train across each axle load scenario found that it is difficult to identify the economic 'sweet spot' in terms of above rail asset utilisation. Using the tractive effort potential of the locomotives to determine the reference train by axle load was found to be a more effective way to find the efficiency advantages.

Table 3: Fuel Consumption – Western GIC Alignment

Train Type	Pay Load (Tonnes)	Total Transit Time (Hrs:Mins)	Total Fuel Litres	Litre per Tonne	Fuel consumption per '000 GTK
26.5 tal	25,200	21:46	41,239	1.63	1.67
32.5 tal	31,800	21:35	45,247	1.42	1.57
40.0 tal	37,800	20:54	58,003	1.53	1.62

5.3 Reduction of Fuel for Covered Wagons

EWLP have identified an opportunity to improve on the efficiency of their proposed 40tal coal railway. Fitting the wagons with an aerodynamic wagon cover will eliminate the contamination of adjoining properties during the journey, ensure consistent designed moisture level and product quality, and prevent coal dust from contaminating the track substructure. Coal dust degrades the effectiveness of ballast, and can lead to track substructure failure and subsequent derailment and maintenance costs.

A more tangible economic benefit of wagon covers is the decrease in air resistance and drag experienced with empty train trips. Ecofab, a global manufacturer of wagon covers commissioned a study by Monash University, and a NASA test using wind tunnels, which demonstrated a potential for fuel consumption savings, particularly for empty trips.

Ecofab's results demonstrate an average saving of 9% in total trip fuel consumption using covered wagons. Wagons designed to offer additional aerodynamic benefits may offer additional savings when coupled with wagon covers.

Calibre undertook a fuel consumption analysis by using the base data provided by OpenTrack™ of the GIC 40tal (30t tare) 300 wagon reference train and reduced the total fuel consumption by 9%.

A reduction of 5,221 litres of fuel from the original estimated fuel consumption was identified using a 9% efficiency gain equating to a reduction of 0.14 litres per tonne.

The results have been displayed in Table 4.

Table 4: Fuel Consumption with Covered Wagons – Western Alignment

Train Type	Total Fuel Litres	Litre per Tonne	Fuel consumption per '000 GTK
Uncovered Train	58,003	1.53	1.62
Covered Train	52,782	1.39	1.47

When further analysed across the EWLP Eastern alignment (see section 6), and using 26t Tare wagons with covers, when compared to the alternative 32.5tal SG solution uncovered wagon fuel burn results, the covers and 40tal efficiencies together represent a 25,440,000 litres of fuel burn saving over 12 months of operation @ 240mtpa. When compared with the 26.5tal wagon of the Narrow Gauge/QRN alignment results, the benefits of covered, light tare, aerodynamic wagons hauling greater payloads are significant.

5.4 Infrastructure Requirements for 240 mtpa

Calibre has conducted an assessment of the infrastructure requirements for the Western GIC Alignment with trunk capacity at 240mtpa and 120mtpa.

Calibre has identified that the 240mtpa profile will require duplication of the main trunk from the 431km location (Mac Mines Connection) to the 0 km point at the maintenance yard. Separation of loaded trains in one direction (known as headway) will need to be 55 minutes to provide the required capacity. 11 crossover locations are required to facilitate this tonnage throughput and provide operational flexibility and surety. Crossover locations have been selected to accommodate the 55 minute headway and will need assessment against engineering requirements to ensure placement suitability.

Table 5: Crossover Locations 240mtpa – Western Alignment

Crossover Number	Location on Network
1	431.0 km
2	399.0 km
3	333.3 km
4	290.2 km
5	259.1 km
6	224.8 km
7	199.7 km
8	163.6 km
9	109.4 km
10	61.4 km
11	17.1 km

The remaining 196 kilometres of network can be single line section, with 8 passing sidings to provide sufficient capacity for the crossing and staging of trains onto the network.

Calibre has nominated the crossing locations in accordance with operational sensibilities to facilitate the throughput task. Where possible, the crossing locations are matched to the mine junction locations. Further assessment should be undertaken to provide confidence that these locations satisfy both operational and engineering needs for the design of the network.

Table 6 outlines the crossing locations for the 240mtpa network. The sections shown in red in the table are duplicated sections.

Table 6: Crossing Locations 240mtpa – Western Alignment

Station From	Station To	Location Point	Required Tonnes
China Coal	Alpha Coal GVK	626.5km	30,000,000
Alpha Coal GVK	Kevin's Corner GVK	606.0km	75,000,000
Kevin's Corner GVK	Alpha North	601.0km	105,000,000
Alpha North	Degulla	577.5km	135,000,000
Degulla	Siding 1	542.0km	150,000,000
Siding 1	Carmichael Coal	508.5km	150,000,000
Carmichael Coal	Siding 2	475.0km	210,000,000
Siding 2	Mac South	453.0km	210,000,000
Mac South	**Bowen**	**431.0km**	**240,000,000**
Bowen	**Maintenance Yard**	**219.3km**	**220,000,000**

5.5 Infrastructure requirements for120mtpa

Calibres assessment of the network against the 120mtpa scenario, demonstrates that a single line section network with 13 passing sidings will be sufficient. Table 7 outlines the crossing locations that have been identified to meet the operational requirements of the network. As with previous iterations, these sidings will need further investigation to ensure that design requirements balance with operational needs.

Table 7: Crossing Locations 120mtpa – Western Alignment

Station From	Station To	Location Point	Required Tonnes
China Coal	Alpha North	626.5km	30,000,000
Alpha North	Degulla	577.5km	70,000,000
Degulla	Siding 1	542.0km	90,000,000
Siding 1	Mac South	508.5km	90,000,000
Mac South	Siding 2	431.0km	120,000,000
Siding 2	Siding 3	383.1km	120,000,000
Siding 3	Siding 4	335.2km	120,000,000
Siding 4	Siding 5	287.3km	120,000,000
Siding 5	Siding 6	239.4km	120,000,000
Siding 6	Siding 7	191.6km	120,000,000
Siding 7	Siding 8	143.7km	120,000,000
Siding 8	Siding 9	95.8km	120,000,000

Station From	Station To	Location Point	Required Tonnes
Siding 9	Maintenance Yard	47.9km	120,000,000

5.6 Rollingstock Requirements

The rollingstock requirements for 240mtpa are listed in Table 8.

Table 8: Rollingstock Requirements

Mine	Trains	Train Sets	Locomotives	Wagons
Mac Mines Project South	2.89	3	12	900
Carmichael	6.15	6	24	1,800
Degulla	1.63	2	8	600
Alpha North	3.34	3	12	900
Kevin's Corner	3.47	3	12	900
Alpha West	1.76	2	8	600
Alpha	3.5	4	16	1,200
China First	3.57	4	16	1,200
Spare			**13**	**320**
Total		27	121	8,420

It is intended that all train consists will be pooled and dispatched to meet the overall demands of the network. This process would be managed through the use of Master and Daily Train Planning and also through the resource allocation tools.

Included in the above totals, a pool of spares has been estimated to support operations. This may consist of:

- 13 locomotives (1 spare loco for every 2 consists)
- 3 spare swing rakes of 100 wagons each (1 swing rake for every 10 trains) plus 20 spare wagons.

Swing rakes allow for the employment of a bulk maintenance strategy where as one entire block of wagons is removed from service and replaced with a swing rake to allow for scheduled maintenance to occur.

6.0 EWLP EASTERN GIC TRAIN COMPARISON VER 2 (26.5TAL, 32.5TAL AND 40TAL)

6.1 Assessment parameters

As with the assessment of the Western Alignment, trains in the initial simulations are based on a 300 wagon reference train. A loaded and unloaded train simulation was completed to provide the transit time and energy expended in MJ during the simulated trip. This data has been used to inform the fuel consumption in litres of diesel per train trip on the Eastern GIC alignment.

The following train Metrics were used in this assessment.

Train composition:

- 26.5tal - 4 x GT42Ac Locos and 300 26.5tal wagons (22t tare)
- 32.5tal - 3 x ES44Ac Locos and 300 32.5tal wagons (22t tare)
- 40.0tal - 4 x ES44Ac Locos and 300 40.0tal wagons (30t tare).

The analysis identifies that using 300 wagon reference trains across the three different axle load scenarios, did not provide comparable result for the purposes of efficiency analysis, however it provided a good foundation to determine the approach for further efficiency simulations analysis.

6.2 Results of the comparison

Table 9 provides the consolidated results for comparison of each of the trains. The two calculations utilised in the assessment were, litres of fuel per tonne and fuel consumption per '000 GTK's. Both of these measures are referenced in Section 2.2.4 of CARP11069-REP-Z-002 Additional Simulations and Capacity Assessment.

Similar to the western alignment simulations, the analysis shows that the 40tal reference train is overpowered in comparison to the 32.5tal reference train. In addition, the 30 Tonne tare of the 40tal train wagons is contributing to higher return trip fuel consumption.

Although a difference of 0.11 litres of fuel per tonne was recorded in favour of the 32.5tal train when compared to the 40tal train, the analysis also shows a distinct advantage to the 40tal train over the 26.5tal train when both measures are compared.

Table 9: Fuel Consumption – Eastern GIC Alignment

Train Type	Pay Load (tonnes)	Total Transit Time (Hrs:Mins)	Total Fuel Litres	Litre per Tonne	Fuel consumption per '000 GTK
26.5 tal	25,200	18:21	35,927	1.42	1.59
32.5 tal	31,800	18:14	39,359	1.23	1.49
40.0 tal	37,800	17:44	50,868	1.34	1.55

6.3 Reduction of Fuel for Covered Wagons

Using the data provided by OpenTrack™ a reduction of 4,578 litres of fuel from the original estimated fuel consumption was identified using the 9% reduction with the consumption of fuel reducing by 0.12 litres per tonne.

The fuel consumption per '000 GTK was also reduced and a difference of 0.14 was recorded. The results have been displayed in Table 10.

Table 10: Fuel Comparison – Eastern Alignment

Train Type	Total Fuel Litres	Litre per Tonne	Fuel consumption per '000 GTK
Uncovered Train	50,868	1.34	1.55
Covered Train	46,290	1.22	1.41

6.4 Infrastructure Requirements for 240 mtpa

Duplication is required for the main trunk from the 398 km location (Mac Mines Connection) to the maintenance yard. Separation of loaded trains will be 55 minutes to provide the required capacity on the duplicated sections. Eight crossover locations are required to ensure operational flexibility and surety. These locations are listed in Table 11. The placement of the crossover locations is dictated by the need to have 55 minutes separation between loaded trains. Further analysis is required to ensure the engineering suitability of these locations.

Table 11: Crossover Locations – Eastern Alignment

Crossover Number	Location on Network
1	398 km
2	336 km
3	289 km
4	255 km
5	220 km
6	168 km
7	114 km
8	60 km

Beyond the duplication, the remaining 196 kilometres of network will be single line section. Seven passing sidings are required on this portion of the network to provide sufficient capacity. Where possible, Calibre has placed the passing sidings at the junction of mine spur lines.

As with the location of the crossovers in the duplicated section, further studies should be undertaken to provide confidence that the passing siding locations are suitable from an engineering perspective. The sections marked in red in Table 12 are fully duplicated sections, the crossovers for which are listed in Table 11 above.

Table 12: 240mtpa Network Capacity Assessment

(Stations named after nearby mine deposits)

Station From	Station To	Location Point	Required Tonnes
China Coal	Alpha	573 km	30,000,000
Alpha	Kevin's Corner	552 km	60,000,000
Kevin's Corner	Alpha North	547 km	90,000,000
Alpha North	Degulla	530 km	130,000,000
Degulla	Siding 1	497 km	150,000,000
Siding 1	Carmichael	458 km	150,000,000
Carmichael	Mac South	420 km	210,000,000

Mac South	**Bowen**	**398 km**	**240,000,000**
Bowen	**Maintenance Yard**	**220 km**	**220,000,000**

6.5 Infrastructure requirements for120mtpa

To provide sufficient capacity for 120mtpa scenario, Calibre recommends a single line section network with 12 passing sidings at the following locations. As with previous iterations, the sidings will provide for passing and staging of trains to and from the mainline.

Table 13: 120mtpa Network Capacity Assessment

Station From	Station To	Location Point	Required Tonnes
China Coal	Alpha	573km	30,000,000
Alpha	Degulla	530 km	70,000,000
Degulla	Siding 1	497 km	90,000,000
Siding 1	Mac Mines	447 km	90,000,000
Mac Mines	Siding 2	398 km	120,000,000
Siding 2	Siding 3	348 km	120,000,000
Siding 3	Siding 4	298 km	120,000,000
Siding 4	Siding 5	248 km	120,000,000
Siding 5	Siding 6	199 km	120,000,000
Siding 6	Siding 7	149 km	120,000,000
Siding 7	Siding 8	99 km	120,000,000
Siding 8	Maintenance Yard	49 km	120,000,000

6.6 Rollingstock Requirements

The rollingstock requirements for 240mtpa are listed in Table 14.

Table 14: Rollingstock Requirements (required for each potential customer)

Mine	Trains	Train Sets	Locomotives	Wagons
Mac Mines South	1.99	2	8	600
Carmichael	4.02	4	16	1,200
Degulla	1.43	2	8	600
Alpha North	3.08	3	12	900
Kevin's Corner	2.41	3	12	900
Alpha	2.81	3	12	900
China First	3.26	4	16	1,200

Spare			**10**	**220**
Total		21	94	6,520

It is intended that all train consists will be pooled and dispatched to meet the overall demands of the network. This process would be managed through the use of Master and Daily Train Planning and also through the resource allocation tools.

Included in the above totals, a pool of spares has been estimated to support operations. This consists of:

- 10 locomotives (1 spare loco for every 2 consists)
- 2 spare swing rakes of 100 wagons each (1 swing rake for every 10 trains) plus 20 spare wagons.

Swing rakes allow for the employment of a bulk maintenance strategy where as one entire block of wagons is removed from service and replaced with a swing rake to allow for scheduled maintenance to occur.

7.0 NARROW GAUGE 26.5TAL ALTERNATIVE ALIGNMENT

7.1 Assessment parameters

Calibre has used OpenTrack™ to undertake a simulation of the narrow gauge alternative alignment which is assumed to connect into the QR Network. Calibre has utilised the QR National metrics for this assessment, with trains for the Greenfield also restricted to the known Brownfield metrics:

- Narrow Gauge - 4 x GT42Ac Locos and 120 X 26.5tal wagons.

A loaded and unloaded train simulation was completed to provide the transit time and energy expended in MJ during the simulated trip. This data has been used to calculate the estimated fuel consumption in litres of diesel per train trip for an empty and loaded train on the Narrow Gauge/QR National Alignment.

Table 15: Fuel Consumption Adani/QR National Alignment

Mine	Pay Load (Tonnes)	Total Transit Time (Hrs:Mins)	Total Fuel Litres	Litre per Tonne	Fuel consumption per '000 GTK
Carmichael	10,080	11:48	16,264	1.61	2.49
Mac Mines South	10,080	12:17	17,346	1.72	2.49

7.2 Infrastructure Requirements for 110 mtpa

Due to the tonnage profile from Carmichael and Mac Mines, 60mtpa and 30mtpa respectively, duplication is required for the entire network. Separation of trains in the loaded direction is 30 minutes to provide the required capacity. 20 crossover locations are required to provide operational flexibility and surety.

Calibre has used the existing crossing loop locations on the QR National Network as the location for crossovers once the system is duplicated. Crossover locations on the Greenfield component of the narrow gauge network have been selected to accommodate train separation of 30 minutes. Engineering validation will be required to confirm these locations as suitable.

Table 16: Crossovers

Network	Number of Crossovers
NG greenfield	5
QR Network (Newlands)	15 (Existing Passing Sidings)

Table 17 outlines the train consist and train pathing requirements for the Alternative Narrow Gauge26.5tal alignment for both Carmichael and Mac Mines.

Table 17: Rollingstock Requirements

Mine	Transit Time (Hrs:Mins)	Cycle Time (Hrs:Mins)	Distance in km	No. of Trains	Train Paths Required
Carmichael	12:17	20:65	413.000	8	9.8
Mac Mines South	11:48	21.42	439.000	16	18

8.0 ALTERNATIVE STANDARD GAUGE 32.5TAL ALIGNMENT

8.1 Assessment parameters

Calibre has used OpenTrack™ to undertake a simulation of the Alternative Standard Gauge Alignment. A loaded and unloaded train simulation was completed to provide the transit time and energy expended in MJ during the simulated trip. This data has been used to calculate the estimated fuel consumption in litres of diesel per train trip for an empty and loaded train.

The following train configurations were used in the different simulations to offer the required data for the comparison. Data for simulations was provided by EWLP.

Train composition:

- 32.5tal – 3 x ES44Ac Locos and 240 32.5tal wagons.

As Calibre has not been supplied the horizontal and vertical alignments for each mine spur connection to the main line for this study, an average fuel consumption rate of 9.88 litres per km per loco has been utilised for each. This figure is based upon OpenTrack™ outputs on other sections of this network, and is added to the OpenTrack™ outputs for the rest of the loaded and unloaded run.

Table 18: Fuel Consumption Alternative 32.5tal SG Alignment

Mine	Pay Load (Tonnes)	Total Transit Time (Hrs:Mins)	Total Fuel Litres	Litre per Tonne	Fuel consumption per '000 GTK
Alpha	25,440	14:61	30,063	1.18	1.60
China First	25,440	15:27	31,150	1.22	1.58
Kevin's Corner	25,440	14:28	29,727	1.16	1.61
Alpha North	25,440	14:42	29,983	1.17	1.61

Degulla	25,440	13:30	28,014	1.10	1.64

8.2 Infrastructure Requirements for 150 mtpa

Duplication is required across the 487 km of the network, with the remaining 20 km to Alpha Mine being a single line section. Separation of trains in the loaded direction will be 60 minutes to provide the required capacity. Eight crossover locations are required to afford operational flexibility and surety and have been placed in this assessment to support the 60 minute train separation. As the single line section will service Alpha only, passing of trains along the 20 km length will not be required; however the mine balloon loop will be able to accommodate two trains to perform a crossing move if necessary.

As with the previous assessments, further studies should be undertaken to provide confidence that the locations are best suited to the engineering requirements of the alignment, as well as the operational sensibilities.

Table 19: Infrastructure Siding and Crossovers

Passing Sidings	Number of Crossovers
0	8

Table 20 shows the ramp of tonnages across the alignment, and where the mines are expected to join this proposed network. Mine tie-in data has been supplied by EWLP.

Table 20: 150 mtpa Mine Tie-in and Capacity Assessment

Station From	Station To	Location Point	Required Tonnes
Alpha	China First	507 km	30,000,000
China First	Kevin's Corner	487 km	60,000,000
Kevin's Corner	Alpha North	480 km	90,000,000
Alpha North	Degulla	476 km	130,000,000
Degulla	Maintenance Yard	425 km	150,000,000

Table 21 outlines the train consist and train pathing requirements for the Alternative SG 32.5tal alignment for all identified stakeholders.

Table 21: 150 Mtpa Rollingstock Requirements

Mine	Transit Time (Hrs:Mins)	Cycle Time (Hrs:Mins)	Distance in km	No. of Trains	Train Paths Required
Alpha	14.61	27.07	507	4	3.5
China First	15.27	27.80	529	4	3.5
Kevin's Corner	14.28	26.71	498	4	3.6
Alpha North	14.42	26.86	501	5	4.7
Degulla	13.30	25.63	460	3	2.8

9.0 26T TARE 40 TONNE AXLE LOAD 270 WAGON REFERENCE TRAIN SIMULATION (EASTERN ALIGNMENT)

Calibre has undertaken an assessment of the 40tal Eastern Alignment using an assumed 26t tare wagons to identify the efficiencies of the higher payload wagons on fuel consumption. Table 22 outlines the rollingstock metrics that forms the basis of this assessment. The previous 40tal simulations at 30 Tonne tare, showed that for the system to provide the benefits of heavier payloads, the wagon tare is an important metric to control to as low as possible.

Table 22: Rollingstock Metrics 270 Wagon Train

Loco Length (m)	Loco Tare (t)	Wagon Length (m)	Train Length (m)
22	196	19.3	5,277

An opportunity exists for EWLP to work with rollingstock manufacturers to develop an innovative approach to the wagon design. As this proposed railway does not have the inherent legacy issues of existing railways such as structure gauge, shorter and wider wagons may be possible. This style of design may have a positive influence on factors such as 'in-train forces', reducing the long term maintenance on rollingstock. It may allow for faster loading and unloading times, reducing the cycle time and therefore fuel consumption. Savings may also be realised through a reduction in capital expenditure on items such as crossing loops and balloon loop lengths.

This analysis also introduces subsequent simulations of trains more matched to locomotive tractive effort potential. 270 x 40tal wagons is a more efficient match for three GE ES44Ac locomotives than 300 x 40tal. With a closer match of locomotive power to trailing load, a more efficient fuel burn is evident.

Table 23 shows the fuel consumption outputs of the study. This has been displayed in litres per tonne and consumption per '000 GTK and includes the 30t tare wagon as a comparison.

Table 23: Fuel Usage Comparison

Train Type	Pay Load (Tonnes)	Total Transit Time (Hrs:Mins)	Total Fuel Litres	Litre per Tonne	Fuel consumption per '000 GTK
270 Wagons 26t Tare	35,100	19:02	41,229	1.17	1.43
300 Wagons 26t Tare	39,000	17:16	49,470	1.26	1.54
300 Wagons 30t Tare	37,800	17:44	50,868	1.34	1.55

It is evident from the analysis that matching the trailing load to locomotive potential significantly improves the fuel consumption results. Transit times are slower; a result of the heavier trailing load per locomotive, and the locomotives spend more time in higher power settings, however the result is a more efficient use of available power.

Calibre has also provided an assessment of the impact of covered wagons on fuel consumption. This can be seen in Table 24. For reference, the 30t tare wagons have been included in this table. The lighter tare wagons compare favourably with the 30t tare wagons reference train.

Table 24: Covered/Uncovered Fuel Comparison

Train Type	Total Fuel Litres	Litre per Tonne	Fuel consumption per '000 GTK
Uncovered Train 270 (26t Tare)	41,229	1.17	1.43
Covered Train 270 (26t Tare)	37,518	1.06	1.30
Uncovered Train 300 (26t Tare)	49,470	1.26	1.54
Covered Train 300 (26t Tare)	45,018	1.15	1.40
Uncovered Train 300 (30t Tare)	50,868	1.34	1.55
Covered Train 300 (30t Tare)	46,290	1.22	1.41

9.1 270 Wagon Train Impact on Infrastructure (240mtpa)

With a heavier trailing load per locomotive and lower payload train than the 300 wagon reference train, a review of the infrastructure was required to compare with earlier findings. A slower transit time, and lower payload means that more trains are required in the system. Separation of loaded trains will need to be 50 minutes to provide the required capacity on the duplicated sections. Calibre have identified that 10 Crossovers are required to service this tonnage profile and enable the shorter headways required.

Beyond the duplication, the remaining network will be single line section. Seven passing sidings are required on this portion of the network to provide sufficient capacity. Where possible, Calibre has placed the passing sidings at the junction of mine spur lines.

As with the location of the crossovers in the duplicated section, further studies should be undertaken to provide confidence that the passing siding locations are suitable from an engineering perspective.

Table 25: Infrastructure Comparison – 26t Tare 270 Wagon Reference Train

Ref Train	Passing Loops	Crossovers	Duplication	Train Numbers
270 Wagon 26t Tare	7	10	398 km	23
300 Wagon 30t Tare	7	8	398 km	21

9.2 Rollingstock Requirements

The rollingstock requirements for 240mtpa are listed in Table 26.

Table 26: Rollingstock Requirements

Mine	Trains	Train Sets	Locomotives	Wagons
Mac Mines Project South	2.17	2	6	540
Carmichael	4.37	5	15	1,350
Degulla	1.56	2	6	540
Alpha North	3.36	4	12	1,080
Kevin's Corner	2.64	3	9	810
Alpha	3.12	3	9	810
China First	3.66	4	12	1,080
Spare			**11**	**200**
Total		23	80	6,410

It is intended that all train consists will be pooled and dispatched to meet the overall demands of the network. This process would be managed through the use of Master and Daily Train Planning and also through the resource allocation tools.

Included in the above totals, a pool of spares has been estimated to support operations. This consists of:

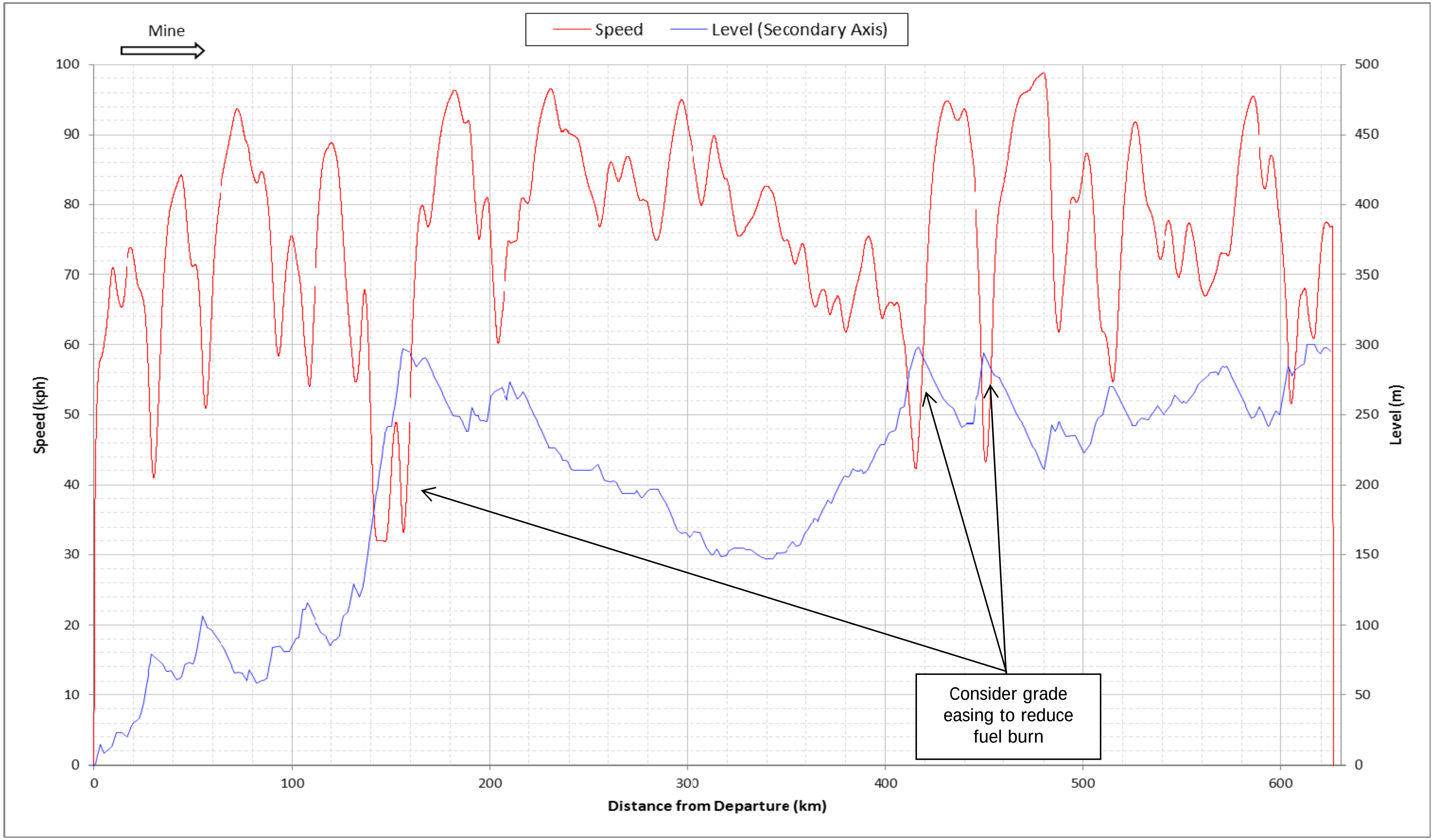
- 11 locomotives (1 spare loco for every 2 consists)
- 2 spare swing rakes of 90 wagons each plus 20 spare wagons.

Swing rakes allow for the employment of a bulk maintenance strategy where as one entire block of wagons is removed from service and replaced with a swing rake to allow for scheduled maintenance to occur.

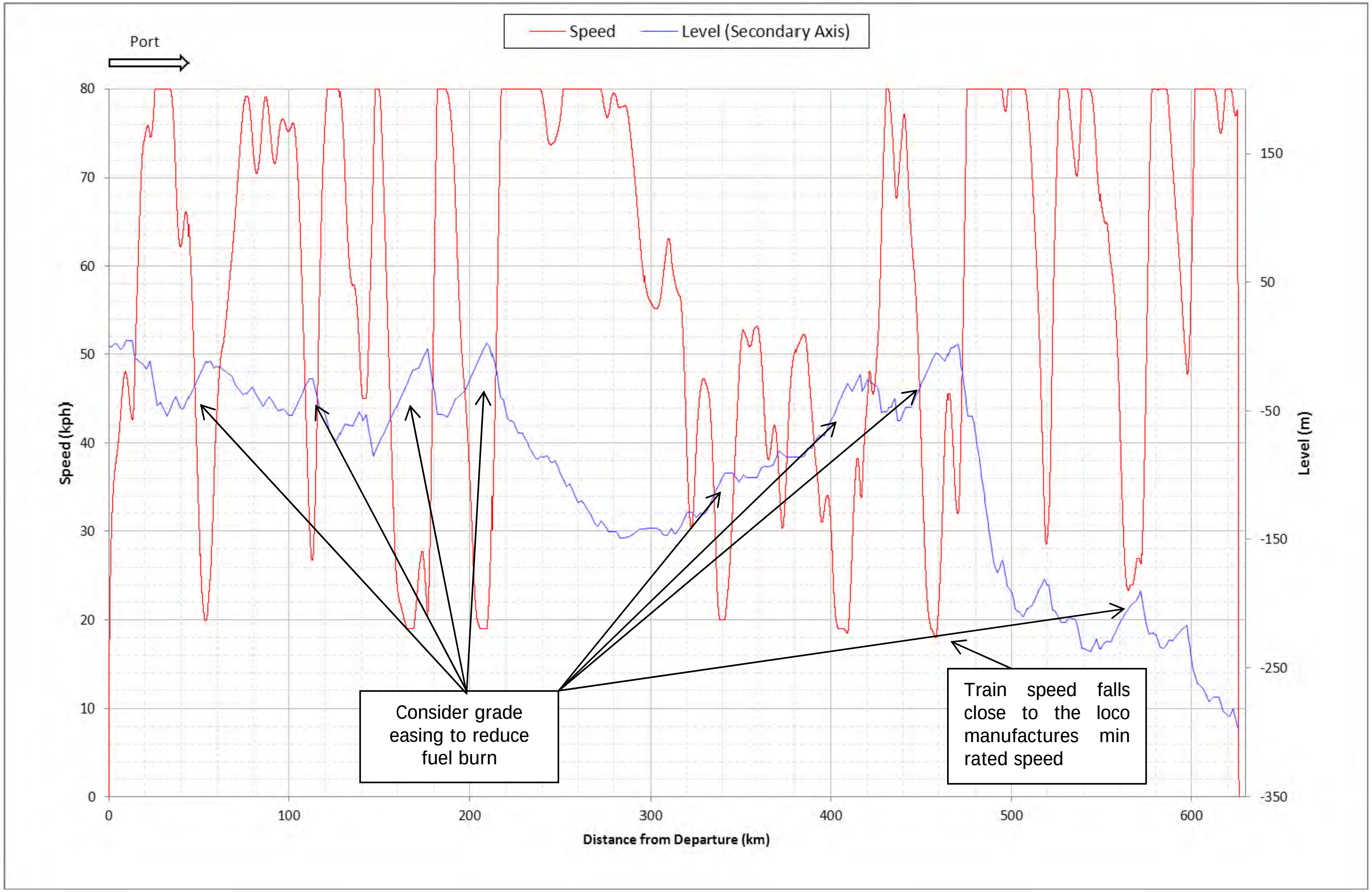
What the 270 wagon analysis demonstrates is despite the slower cycle time, and although a larger number of trains are needed, it results in fewer wagons, and fewer locomotives that the 300 wagon reference train case.

270 wagon train offers an easily managed wagon set maintenance strategy. Easily divisible by 3, 3 – pack wagon sets are multipliable by 5 (15), 6 (18), 9 (27), 10 (30), 15 (45), 18 (54), 20 (60), 30 (90), 40 (120). The resulting rake sizes can be flexibly adapted to a shunt plan and maintenance strategy. Intuitively, 60, 90 or 120 wagon sets are logical for planned maintenance. Calibre has assumed wagon sets of 90 apply for this analysis. Each wagon requires annual inspection, and can be scheduled with an asset management tool that interacts with the activity scheduling for the maintenance and provisioning dwells.

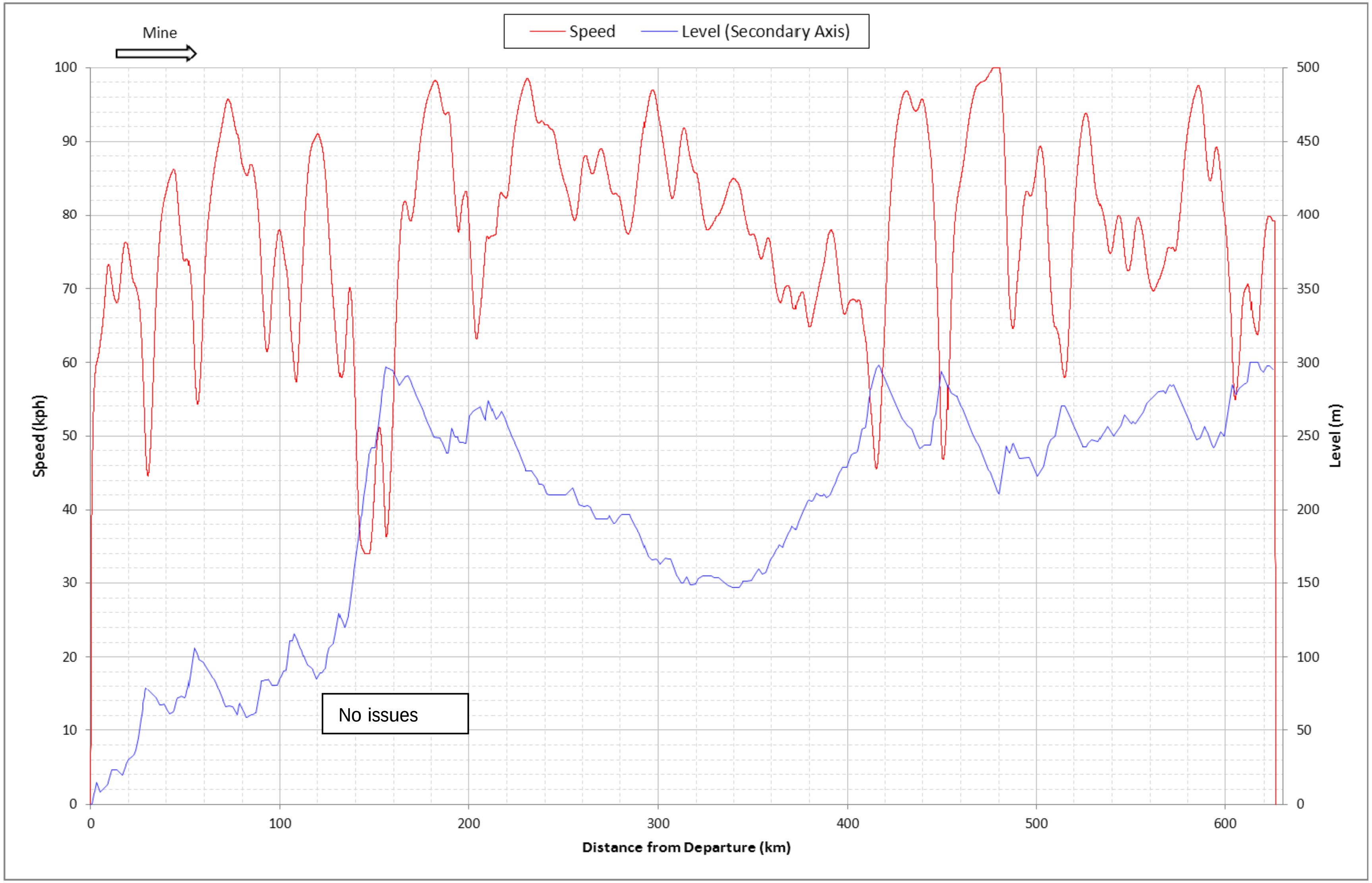
Speed Graph EWLP HA199-VA01 26.5tal Empty Train


Mine
Speed
Level (Secondary Axis)
Speed (kph)
Level (m)
Distance from Departure (km)
Consider grade easing to reduce fuel burn
100
90
80
70
60
50
40
30
20
10
0
500
450
400
350
300
250
200
150
100
50
0
0
100
200
300
400
500
600

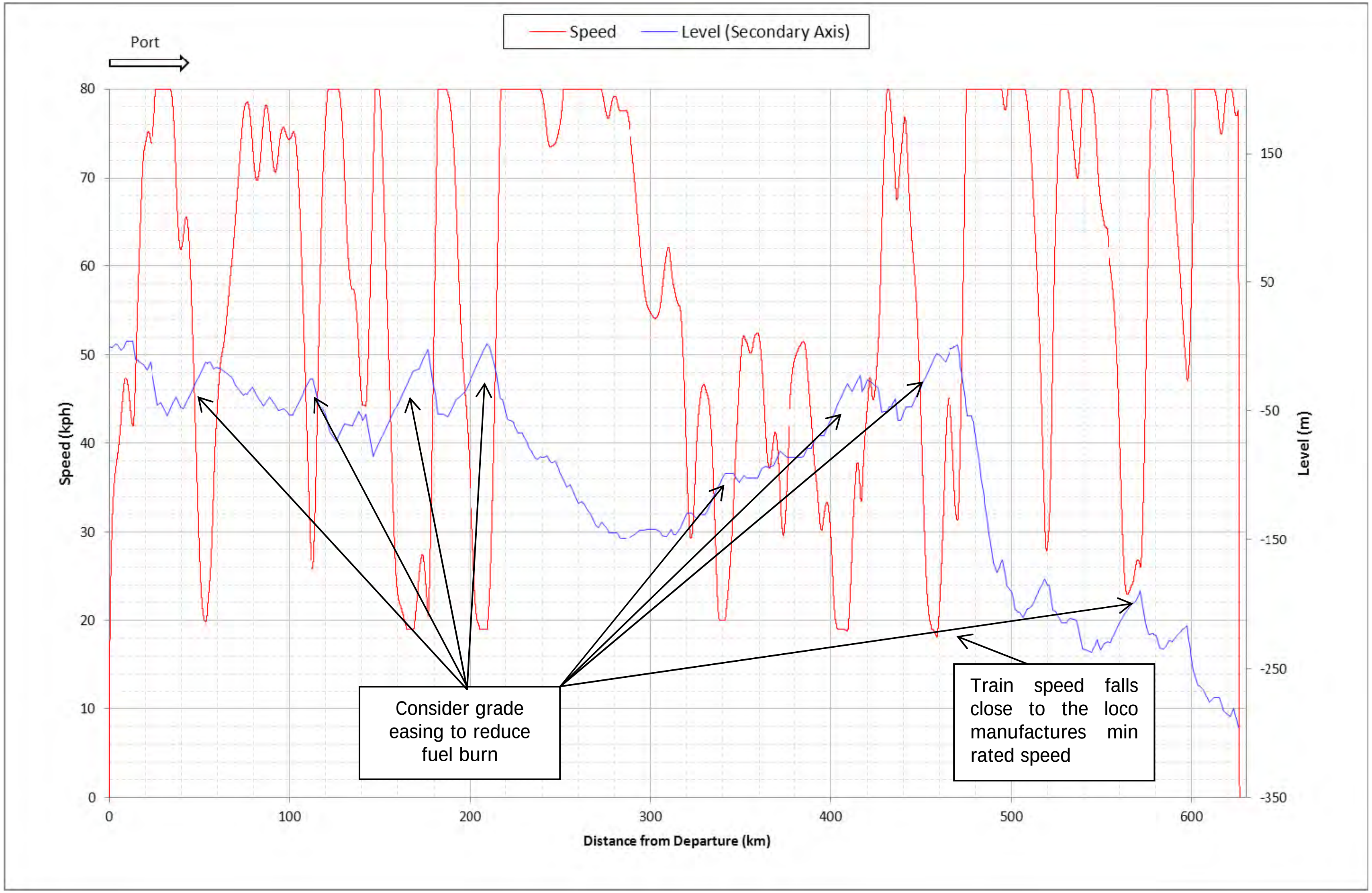
Speed Graph EWLP HA199-VA01 26.5tal Loaded Train



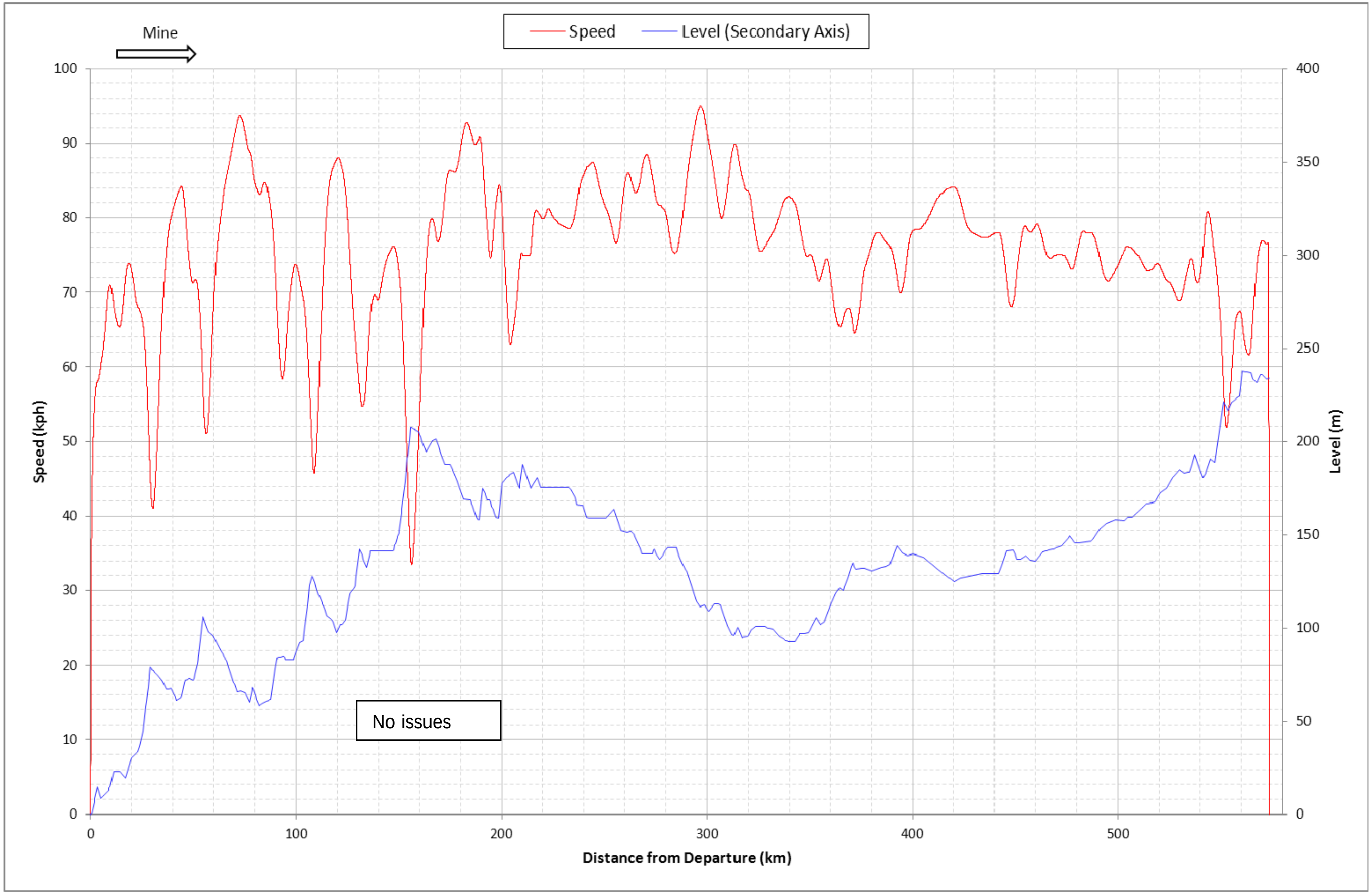
Speed Graph EWLP HA199-VA01 32.5tal Empty Train



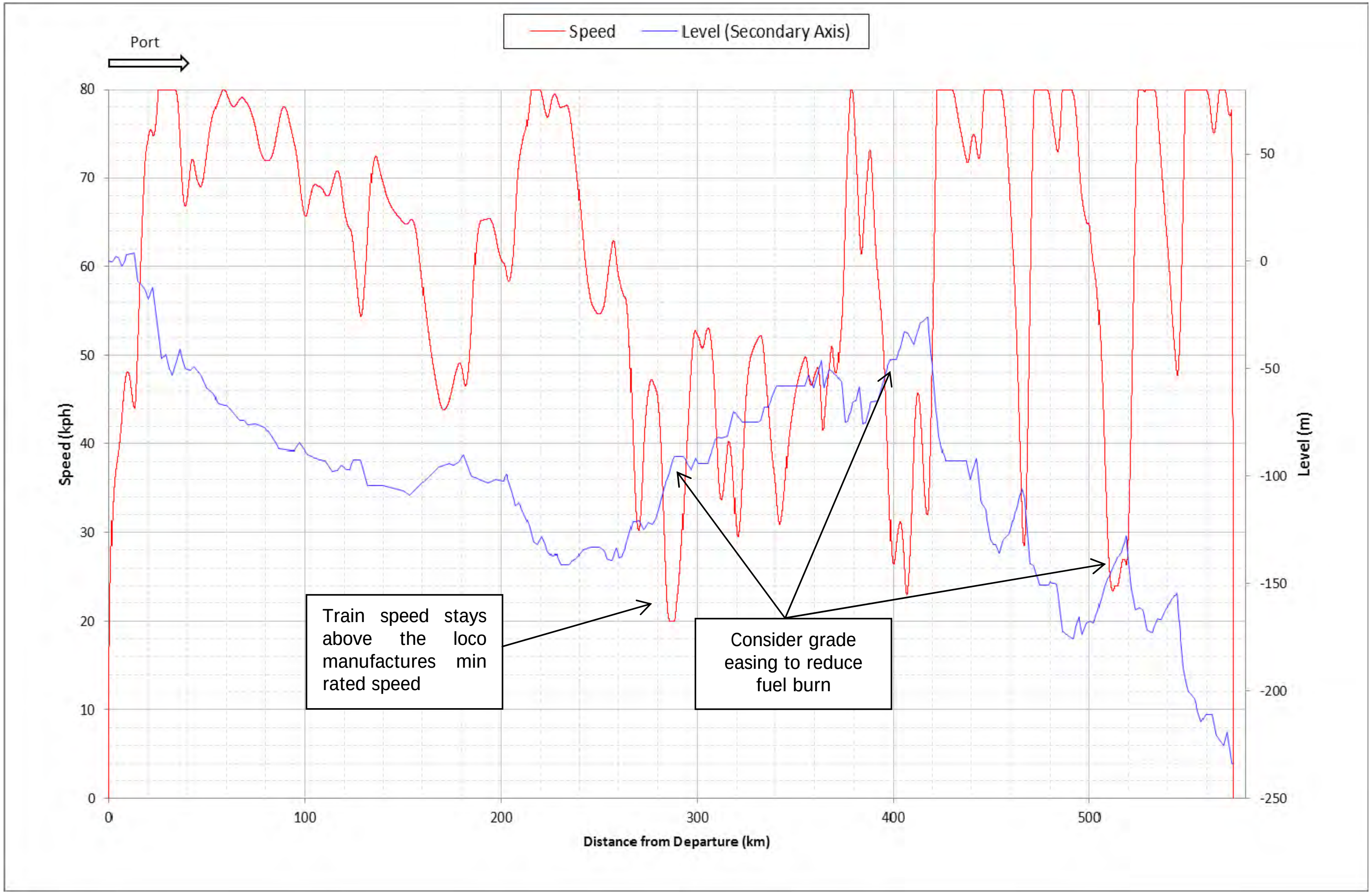
Speed Graph EWLP HA199-VA01 32.5tal Loaded Train


Speed
Level (Secondary Axis)
Port
80
70
60
50
40
30
20
10
0
Speed (kph)
150
50
-50
-150
-250
-350
Level (m)
0
100
200
300
400
500
600
Distance from Departure (km)
Consider grade easing to reduce fuel burn
Train speed falls close to the loco manufactures min rated speed

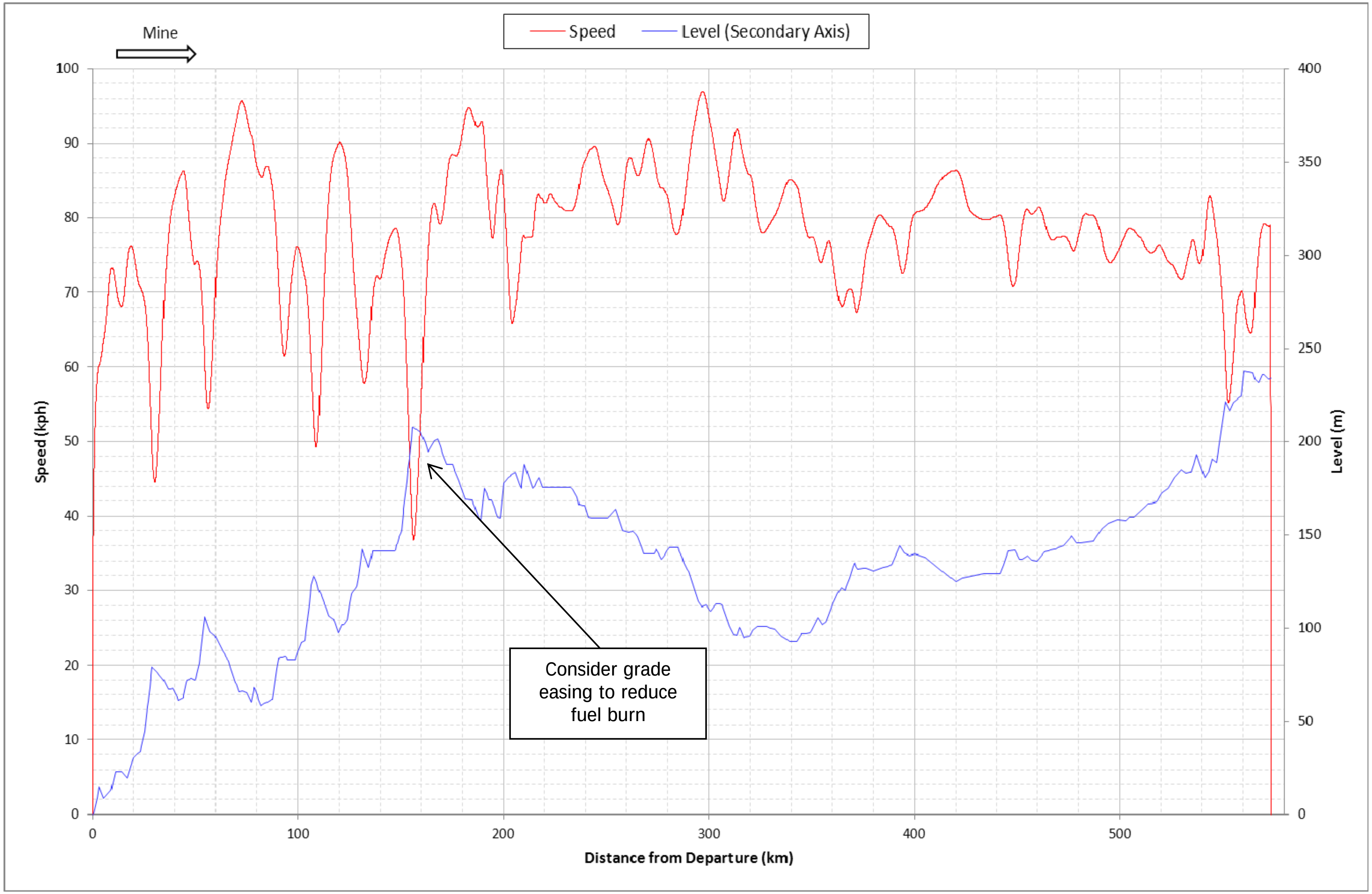
Speed Graph EWLP Eastern GIC 26.5tal Empty Train


Mine
Speed
Level (Secondary Axis)
No issues
Speed (kph)
Level (m)
Distance from Departure (km)
0
10
20
30
40
50
60
70
80
90
100
0
50
100
150
200
250
300
350
400
0
100
200
300
400
500

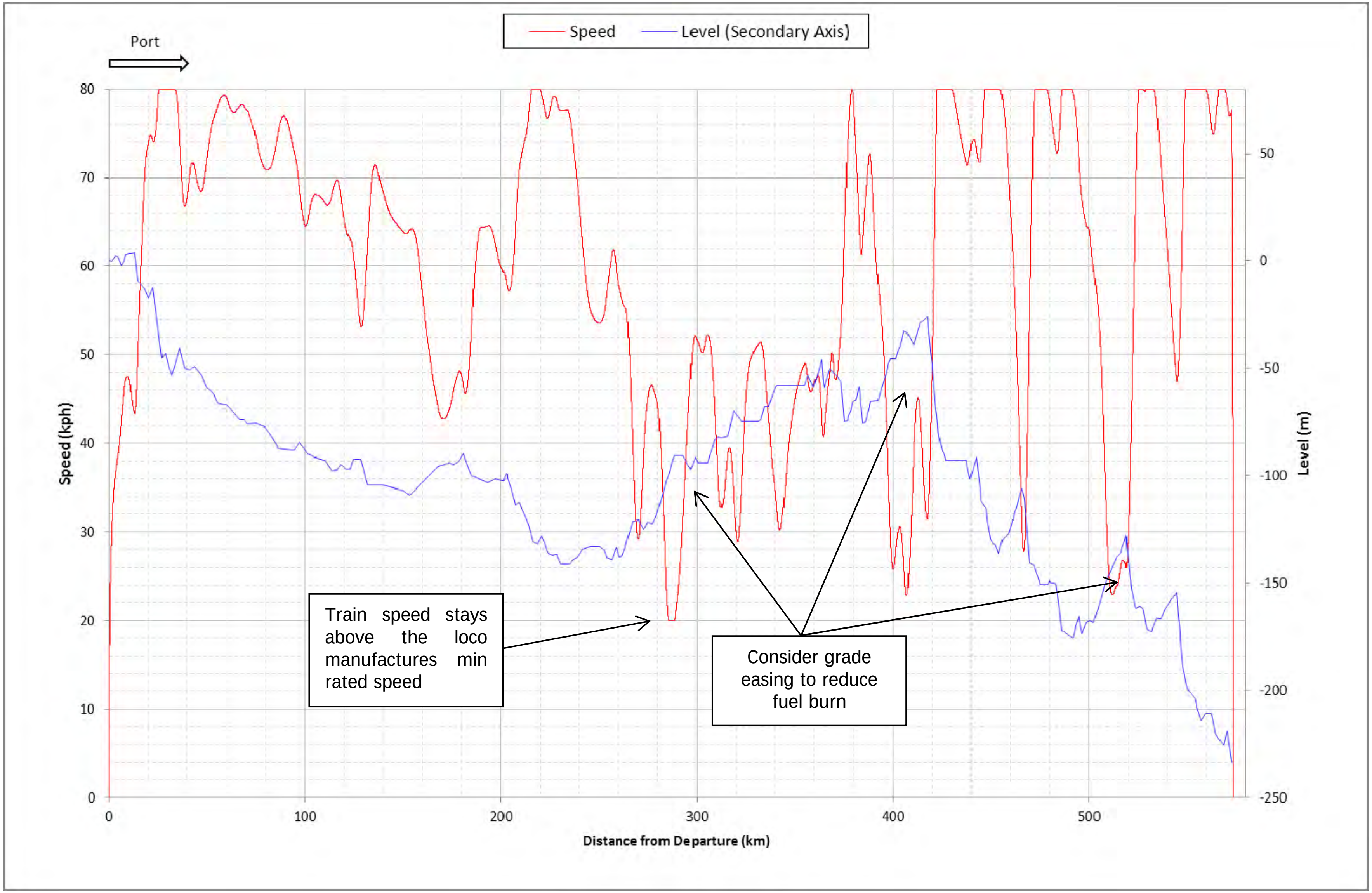
Speed Graph EWLP Eastern GIC 26.5tal Loaded Train


Speed
Level (Secondary Axis)
Port
80
70
60
50
40
30
20
10
0
Speed (kph)
0
100
200
300
400
500
Distance from Departure (km)
50
0
-50
-100
-150
-200
-250
Level (m)
Train speed stays above the loco manufactures min rated speed
Consider grade easing to reduce fuel burn

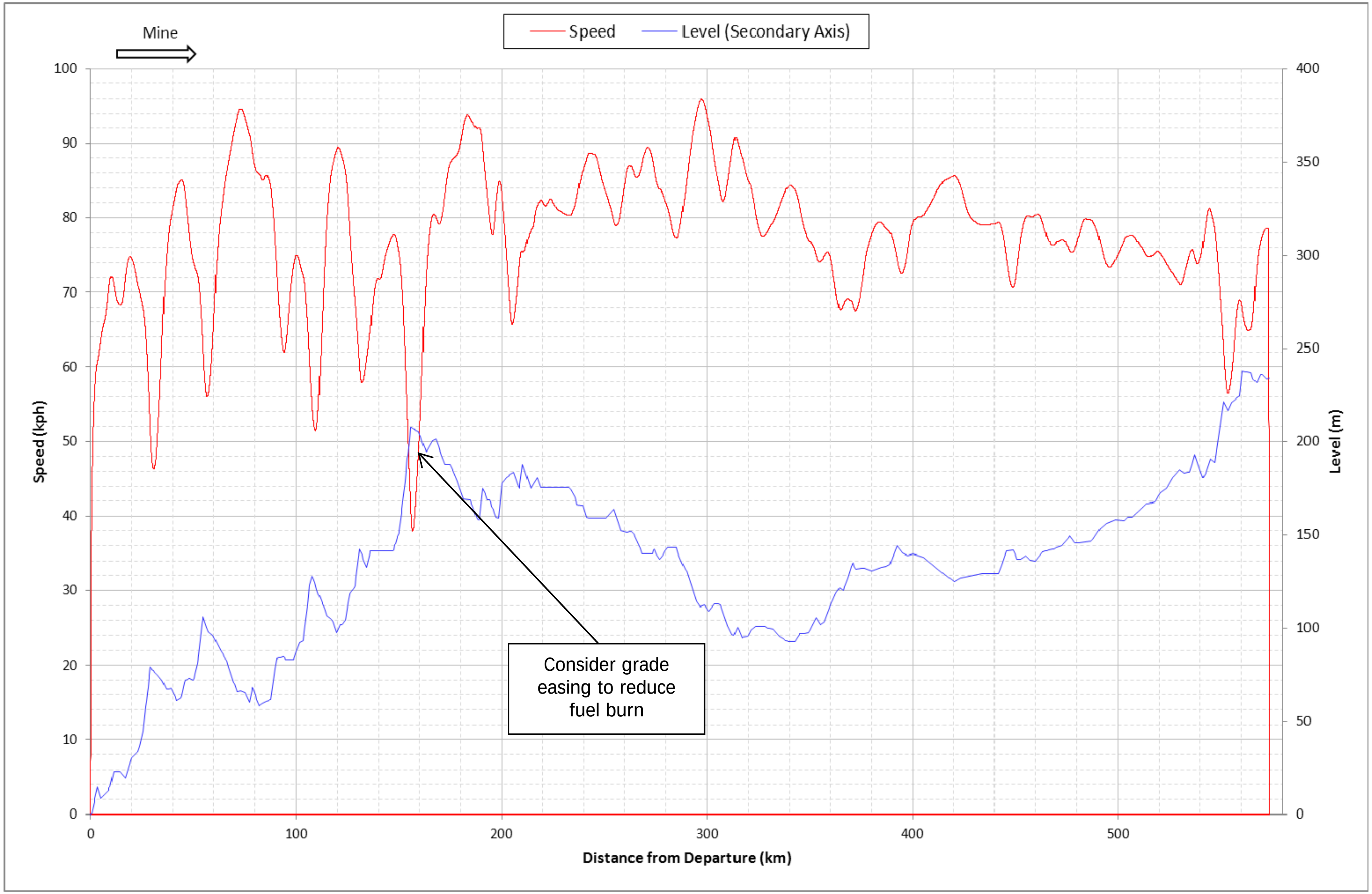
Speed Graph EWLP Eastern GIC 32.5tal Empty Train


Speed
Level (Secondary Axis)
Mine
Speed (kph)
Level (m)
Distance from Departure (km)
0
10
20
30
40
50
60
70
80
90
100
0
50
100
150
200
250
300
350
400
0
100
200
300
400
500
Consider grade easing to reduce fuel burn

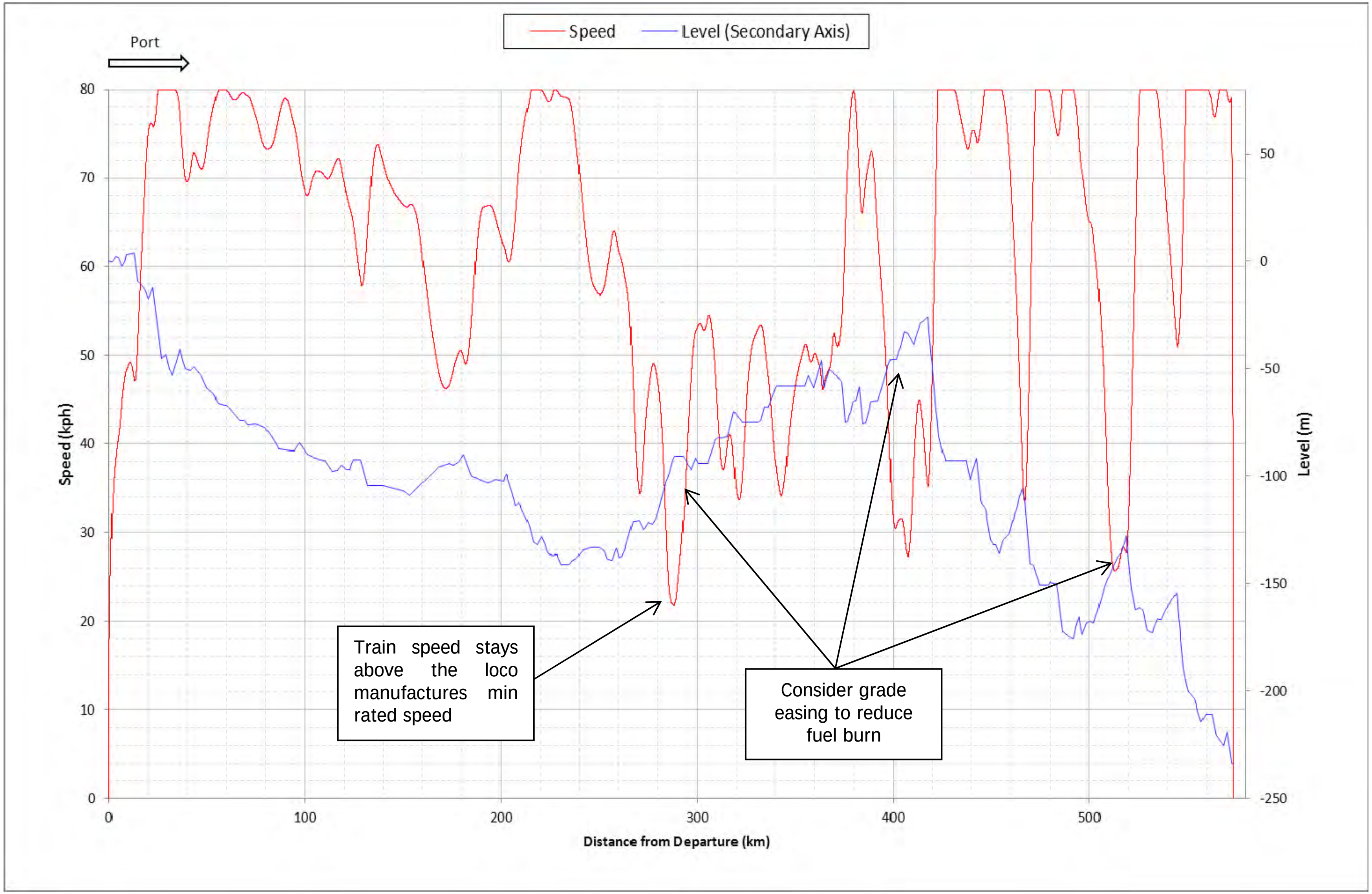
Speed Graph EWLP Eastern GIC 32.5tal Loaded Train


Speed
Level (Secondary Axis)
Port
Speed (kph)
Level (m)
Distance from Departure (km)
Train speed stays above the loco manufactures min rated speed
Consider grade easing to reduce fuel burn
80
70
60
50
40
30
20
10
0
50
0
-50
-100
-150
-200
-250
100
200
300
400
500

Speed Graph EWLP Eastern GIC 40.0tal Empty Train


Speed
Level (Secondary Axis)
Mine
Speed (kph)
Level (m)
Distance from Departure (km)
Consider grade easing to reduce fuel burn
0
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500
0
50
100
150
200
250
300
350
400

Speed Graph EWLP Eastern GIC 40.0tal Loaded Train


Speed
Level (Secondary Axis)
Port
Speed (kph)
Level (m)
Distance from Departure (km)
0
10
20
30
40
50
60
70
80
100
200
300
400
500
50
0
-50
-100
-150
-200
-250
Train speed stays above the loco manufactures min rated speed
Consider grade easing to reduce fuel burn