17th July 2023

Network Rail's Freight Growth Forecasts (2024 – 2029)

In 2022 Network Rail commissioned MDS Transmodal to review and forecast rail freight demand for Control Period 7 (CP7). The work provided constrained and unconstrained forecasts by region and commodity for CP7. This has been used, alongside earlier work by MDS to provide longer-term unconstrained forecasts, to develop freight growth forecasts for our CP7 Strategic Business Plan (SBP).

- Our England and Wales SBP forecasts 7.5 % growth in demand for rail freight from 2023/24 to 2028/29. This is rolled up from separate forecasts for each of the four England & Wales regions and all commodities.

- Scotland's Railway has worked with operators to develop a specific view of paths and commodities demand that will change over CP7 and how this can be facilitated through the CP7 funding settlement. This has led to Scotland's Railway setting out how they can deliver the High Level Output Specification (HLOS) target from Transport Scotland for freight growth of net 8.7 % tonne kilometres. Scotland's Railway believe that there is potential to deliver more than net 8.7 % tonne kilometres of growth, but this is subject to robust business cases being produced to secure additional investment and/or timetable trade-offs.

The MDS Transmodal report utilised by Network Rail is shown below.

2028/29 Rail freight demand forecasts with capacity constraint for Network Rail

Final report

8th September 2022

MDS Transmodal

Ref: 221057r7.docx

CONTENTS

EXECUTIVE SUMMARY

Unconstrained rail freight demand has been forecast for 2028/29 under five different scenarios:

	Low market growth	High market growth
Factors which favour rail relative to road	Scenario A	Scenario B
Factors which disfavour rail relative to road	Scenario C	Scenario D
Neither favouring or disfavouring rail relative to road	Scenario E: Central	

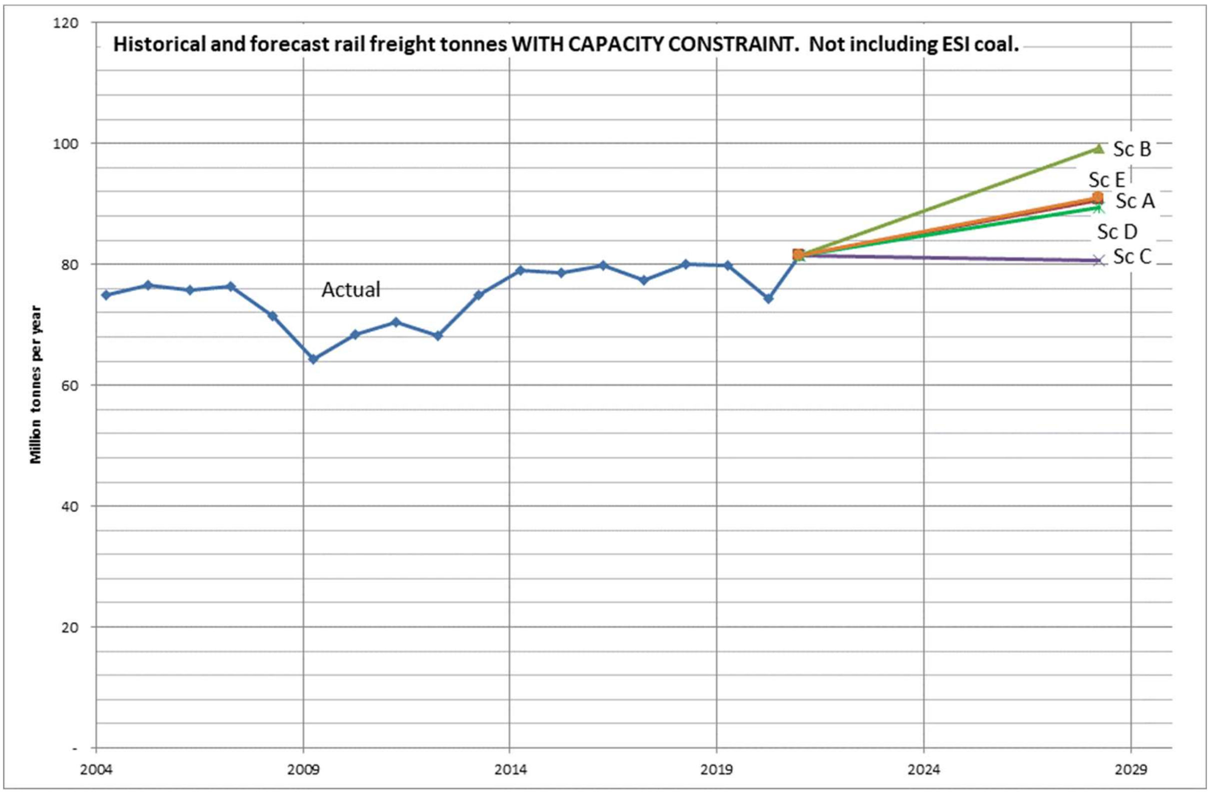
The forecasts for most sectors were produced using the GB Freight Model (GBFM). GBFM describes the freight market for both road and rail transport within Great Britain and takes into account competition between ports, with links to the Continental mainland. The assumptions input into the models were agreed during a consultation process with stakeholders.

It is likely that freight demand growth in some areas may not be able to be accommodated without network enhancement or reductions in passenger services. In such locations, forecast freight trains have been scaled down to fit within estimated available freight capacity.

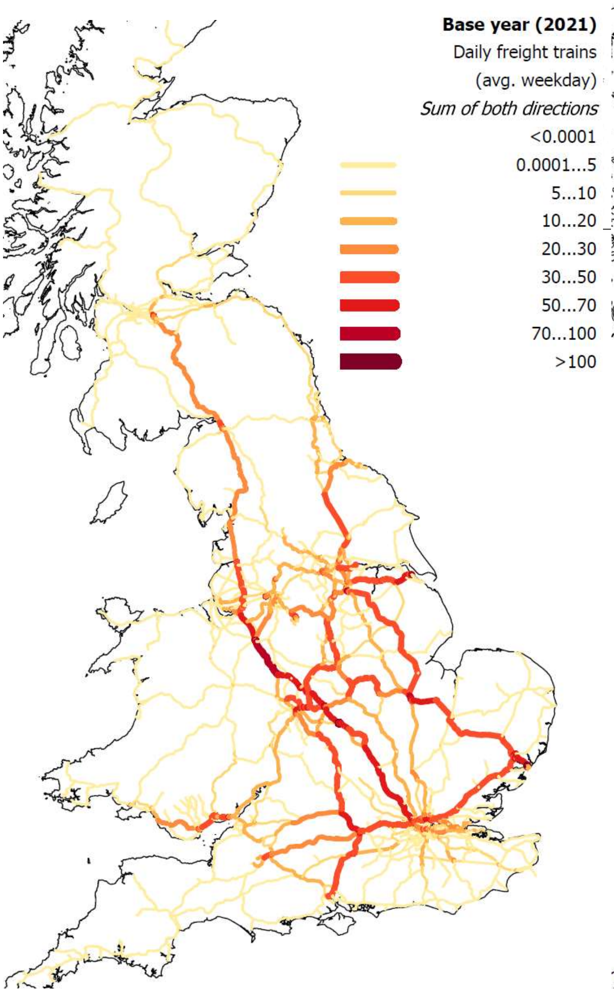
The summary results for tonnes, tonne kms and trains per weekday for the base year (2021) and the five 2028/29 scenarios are shown below:

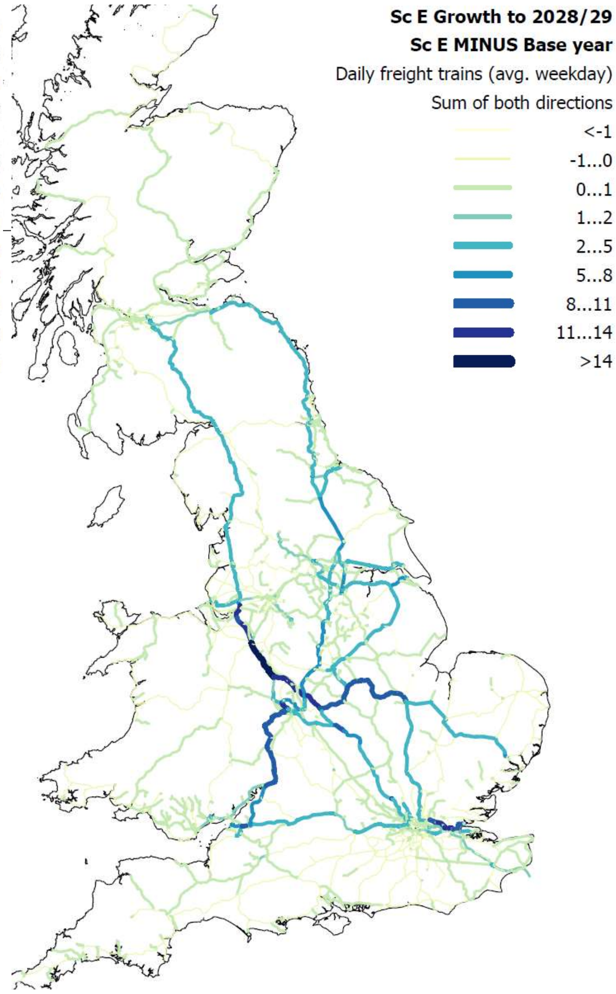
	2021	A	B	C	D	E
UNCONSTRAINED demand						
Tonnes (thousand)	82,303	103,427	118,259	84,534	97,175	101,531
Tonne kms (million)	18,145	24,243	27,290	19,630	22,222	23,443
Trains per weekday	520	678	769	558	636	664
AFTER capacity-constraint						
Tonnes (thousand)	82,303	90,632	99,280	80,721	89,375	91,084
Tonne kms (million)	18,145	20,176	21,422	18,342	19,702	20,144
Trains per weekday	520	587	636	529	580	589
% of demand able to run after constraint						
Tonnes		87.6%	84.0%	95.5%	92.0%	89.7%
Tonne kms		83.2%	78.5%	93.4%	88.7%	85.9%
Trains per weekday		86.6%	82.8%	94.9%	91.2%	88.8%
% Growth from 2021 after capacity constraint						
Tonnes		10.1%	20.6%	-1.9%	8.6%	10.7%
Tonne kms		11.2%	18.1%	1.1%	8.6%	11.0%
Trains per weekday		13.0%	22.4%	1.9%	11.5%	13.4%

Historically power station (ESI) coal used to dominate rail freight, but has now largely disappeared from the rail network and is forecast to disappear completely by 2028/29. The graph below shows how these forecasts compare with historical trend, once power station (ESI) coal is removed.



These capacity-constrained forecasts are assigned to the network in terms of freight trains per weekday. The figures below show the base year (2021), and the forecast growth in traffic AFTER capacity-based constraint has been applied for scenario E (Central scenario).





Rail mode share (as compared to road, measured in tonne kms) is forecast to increase slightly from 11.3% in 2021 to 11.9% in scenario E.

1. INTRODUCTION

In 2019 MDS Transmodal produced unconstrained forecasts for Network Rail for 2033/34 and 2043/44. These followed on from our capacity-constrained forecasts for 2023/24. These all had a base year of 2016/17. The routing for these forecasts was agreed with the industry through a consultation process in early 2020. These reports are published on Network Rail's "Long Term Planning page"[1].

We have adopted a similar process to forecast rail freight demand for 2028/29 with a calendar-year 2021 base. These latest forecasts use the same routing principles agreed with the industry in early 2020, and also include capacity constraint through busy areas of the network.

The forecasts are assigned to the rail network with detailed database-style spreadsheets provided with origin-to-destination information on each rail network link.

The project has involved consultation with stakeholders in order to agree forecast assumptions. Network Rail were consulted on which junctions (and to what extent) we should consider to be capacity-constrained, to suppress forecast demand.

[1] https://www.networkrail.co.uk/running-the-railway/long-term-planning/

2. CONSULTATION PROCESS

The consultation process consisted of identifying a number of stakeholders who would provide guidance as to assumptions to input to the modelling process. In each case, a proposed assumptions note was forwarded to these stakeholders and a meeting (generally one hour) was held to discuss those assumptions and to ask what other factors might be considered. A revised version of the proposed assumptions, taking into account observations made, is to be found below.

2.1. Stakeholders consulted

The stakeholders interviewed were:

Container / Sea dredged aggregates Ports
Peel, ABP, Hutchison, PD, DP World

FOCS
DB Cargo, Freightliner, GB Railfreight, Colas Rail, Rail Operations Group (ROG), Victa Railfreight

Aggregators
Maritime Transport, Russell Logistics, Malcolm Group

Warehousing Developers
Goodman, Kilbride Group

Shipping Line
DFDS

Aggregates (Construction materials) Companies
Tarmac, Cemex

In summary, observations were:

- All the respondents were in broad agreement with our cost assumptions
- There was some debate about the rate at which some of the rail linked distribution parks would develop. A couple of the respondents believed 1 or more of the sites would not develop. As a result "Rail Central" was removed but no other changes were made.
- In so far as growth assumptions were concerned, there was little disagreement. On deep-sea containers, two of the ports thought we were marginally pessimistic and one of the aggregators thought we were a little optimistic.
- The express parcels market is the hardest to model because it is, as yet, not clearly defined and therefore difficult to cost out. We have, however, developed our ideas as to what the

most likely operation will look like and discussed this with those respondents able to sensibly comment. This is detailed below in section 3.6.

Additionally there is an industry view that over the next 30 years, land won sand and gravel will be replaced by **sea-dredged aggregates**, which currently only account for some 20% of total sand and gravel won. Investments are already being made in large dredgers which will be limited to serving the larger ports. Coastal areas and those areas with waterways that can accommodate large barges (i.e. Greater Manchester and West and South Yorkshire) will continue to be served by short haul road delivery but it is to be expected that larger urban areas some distance from the ports will be served by rail. Given the structure of the aggregates industry, where they are available such flows can be expected to be moved from large ports to the same or similar inland depots that currently handle crushed rock in the West Midlands. New or re-opened rail terminals maybe required in the East Midlands. We expect some increase in flows to inland areas of the South East.

The following section therefore represents our conclusions on inputs and assumptions - amended based on the consultation responses.

3. ASSUMPTIONS FOR 2028/29 SCENARIOS

There will be five capacity-unconstrained 2028/29 scenarios – with assumptions that vary by sector. The scenarios are equivalent to the 5 demand forecast scenarios (A-E) for 2033/34 and 2043/44 produced in 2018/19:

Table 1: The five 2028/29 scenarios

	Low market growth	High market growth
Factors which favour rail relative to road	Scenario A	Scenario B
Factors which disfavour rail relative to road	Scenario C	Scenario D
Neither favouring or disfavouring rail relative to road	Scenario E	

3.1. Base Year

We have used calendar-year 2021. This is as up-to-date as realistically possible. This avoids the Covid impact of the first lockdown and includes a whole post-Brexit year (2021).

Every potential base year is likely to have some unusual features. For example, 2021 had some disruption to world-wide container shipping and high shipping prices. However overall, we believe it was a relatively normal year compared to other potential base years, and therefore suitable to be used as the base year for these forecasts.

3.2. General cost assumptions (all commodities)

The tables below show the assumptions agreed for 2028/29 based on data available in December 2021. Note that all % changes are in real terms (i.e. the change in costs, if economy-wide inflation were to be zero) for the 7.25 years from the 2021 base year to 2028/29.

Table 2: General cost assumptions (all commodities)

	Sc A and Sc B	Sc C and Sc D	Sc E
Rail drivers' wages	+9.3%	+9.3%	+9.3%
HGV drivers' wages	+18.3%	+10.3%	+14.3%
Source: TAG v1.17, table A.1.3.2 gives +9.3% for wages. However since the mid-point of the base year, HGV drivers' wages have increased significantly to represent a central case 5% higher (+14.3%)			
Diesel cost (resource; Gas Oil)	+65.4%	-11.7%	+21.1%
Source: TAG v1.17, table A.1.3.7 for Central scenario: +21.1% Source for low & high: BEIS, June 2021. Table 7 (Industrial series), low and high relative to Central for 2028 & 2029; • Sc A & B (favour rail = high diesel cost) = 37% higher than central • Sc C & D (disfavour rail = low diesel cost) = 27% lower than central			
Fuel duty for road and rail	+7.6%		
Source: TAG v1.17, table A.1.3.7			

3.3. Track Charges. Variable Usage Charges (VUC) and Freight Specific Charge (FSC)

VUC is scheduled to increase from the base year to 2023/24. Source for changes from base year to 2023/24: "Track Usage Price List 21-22 prices.xlsx" on https://www.networkrail.co.uk/industry-and-commercial/information-for-operators/cp6-access-charges-2/

Traffics in the 2021 base year (by wagon type and sector) are multiplied by the wagon-specific VUC rates for the base year and for 2023/24.

VUC is expected to continue rising through Control Period (CP) 7 to 2028/29. Source for uncapped rates: Equivalent wagon and sector specific spreadsheet from the ORR for 2028/29 uncapped rates. The focus of the rises is on loaded wagons, with VUC for empty wagons being largely unchanged.

Table 3: Wagons; Variable Usage Charge changes from base year 2021

	Sc A and Sc B	Sc C and Sc D	Sc E
VUC	**Remaining at 2023/24 rates**	**Sc E VUC + 20%**	**Uncapped rates**
Loaded wagons			
Biomass	15.4%	79.5%	49.6%
Chemicals	6.5%	51.4%	26.2%
Coal ESI	13.9%	73.8%	44.8%
Coal Other	12.1%	66.9%	39.1%
Construction Materials	14.7%	76.6%	47.2%
Domestic Automotive	3.2%	32.3%	10.2%
Domestic Intermodal	2.7%	30.3%	8.6%
Domestic Waste	7.7%	49.6%	24.7%
General Merchandise	5.7%	50.4%	25.3%
Industrial Minerals	12.8%	69.9%	41.5%
Iron Ore	12.7%	67.6%	39.6%
Other	5.1%	39.6%	16.4%
Petroleum	5.9%	42.6%	18.9%
Steel	10.2%	59.0%	32.5%
Total Loaded wagons	**9.3%**	**55.5%**	**29.6%**
Empty wagons			
Biomass	0.7%	22.8%	2.4%
Chemicals	0.0%	21.8%	1.5%
Coal ESI	0.6%	22.2%	1.9%
Coal Other	0.9%	23.6%	3.0%
Construction Materials	0.7%	22.6%	2.2%
Domestic Automotive	0.2%	20.6%	0.5%
Domestic Intermodal	0.9%	23.4%	2.8%
Domestic Waste	0.0%	20.0%	0.0%
General Merchandise	0.0%	21.8%	1.5%
Industrial Minerals	0.0%	20.0%	0.0%
Iron Ore	1.5%	24.6%	3.8%
Other	1.2%	24.8%	4.0%
Steel	0.4%	21.5%	1.3%
Total Empty wagons	0.7%	22.6%	2.2%
Total	**8.6%**	**52.8%**	**27.4%**

Table 4: Locomotives; Variable Usage Charge changes from base year

	Sc A and Sc B	Sc C and Sc D	Sc E
VUC	**Remaining at 2023/24 rates**	**+20% on top of Sc E**	**Uncapped rates**
Biomass	11.3%	63.7%	36.4%
Chemicals	7.3%	48.2%	23.5%
Coal ESI	9.3%	56.0%	30.0%
Coal Other	9.0%	54.7%	28.9%
Construction Materials	10.0%	58.8%	32.4%
Domestic Automotive	6.6%	44.6%	20.5%
Domestic Intermodal	8.5%	52.7%	27.3%
Domestic Waste	6.6%	45.4%	21.1%
General Merchandise	8.4%	52.4%	27.0%
Industrial Minerals	7.6%	49.5%	24.6%
Iron Ore	9.7%	57.4%	31.2%
Other	9.4%	56.3%	30.3%
Petroleum	9.2%	55.7%	29.8%
Steel	9.2%	55.5%	29.6%
Total	**9.0%**	**54.6%**	**28.8%**

Freight Specific Charge

- Biomass FSC is £0 in 2020/21, £0.3118/kgtm in 2021/22 and £1.5589/kgtm in 2023/24 (2021/22 price base).
- The average for the base year (2021) was £0.2339, so the increase from base year to 2023/24 is X 6.7
- Coal ESI, Iron Ore and Spent Nuclear Fuel FSCs are constant throughout CP6 (2018/19 – 2023/24)
- No change in FSC assumed beyond 2023/24 for any scenario
- The commodities subject to the freight specific charge are intended to be the commodities where the traffic levels are unlikely to be significantly affected by increased prices. These are therefore the sectors that we typically do not model using a cost-based approach, and instead make specific assumptions on future traffic levels.

3.4. Other commodities and sectors

Table 5: Other commodities and sectors

	Sc A	Sc B	Sc C	Sc D	Sc E
Deep-sea unitised trade growth - for maritime containers	+11.0%	+27.0%	+11.0%	+27.0%	+19.0%
Container port growth for deep sea containers	Container port growth for deep sea containers. In line with market demand – with the following port developments coming on stream to cater for demand if required: a. London Gateway full use of existing quay b. Liverpool full use of existing quay c. London Gateway full development to the west of the existing quay				
European unitised trade growth (for short sea (European) trade including Channel Tunnel containers)	+13.7%	+29.7%	+13.7%	+29.7%	+21.7%
Source: MDST's World Cargo Database[2] (WCD version date 13th Dec 2021) gives central forecasts of +19.0% for deep sea cargo and +21.7%[3] for short sea cargo. We have varied this by 8% for the low and the high market growth scenarios					
Domestic non-bulk traffic market growth	No change	+4.6%	No change	+4.6%	+2.3%
Defined by population growth: +2.3%. Source: TAG v1.17, table "Annual Parameters" Double for high market growth. Zero for low market growth					
Power station (ESI) coal	Zero rail traffic				

[2] The main purpose of our World Cargo Database (WCD) is to be able to provide forecasts of world trade on a country to country by commodity basis for each future quarter-year. These are based on observing past trends in trade by origin country, destination country and commodity. The trends are forecast to continue into the future, with near-future forecasts much more focussed on recent trends, and long term forecasts based on long term trends. This is achieved by weighting historical data based on how recent it is, with the extent of the weighting determined by the forecast quarter-year required. To calculate the trend for a very-near-future forecast, recent historical data will be weighted very highly, with older data having a low weighting. For a very distant future year, all historic data would be weighted equally, with a standard least-squares trend used. As we move from calculating near future forecasts to longer term forecasts, the weighting of very recent history gradually reduces and the influence of the long term trend is increased. Overall world trade for each commodity in total is forecast in a similar way and constrains the whole world market forecast for that commodity.

[3] Early 2021 is a bit depressed because of pre-Brexit stockpiling in late 2020, new Brexit rules and adapting… So the apparently large growth is getting back to normal from the 2021 low

Biomass	Central case to stay constant[4]. Low market growth: -20%. High market growth: +20%.
Construction materials market growth	The low market growth figures (scenarios A & C) are based on population growth: +2.3%. The high market growth figures (scenarios B & D) are based on GDP growth: +17.7%. (Source: TAG v1.17, table "Annual Parameters") Scenario E is the mid-point: +10.0% In addition to this we anticipate long distance flows of sand and gravel (sea dredged aggregates) to develop which could be attracted to rail which we have estimated on the basis of recent survey data to be (Scenario E): • 0.14 m tonnes by rail from Dagenham Dock to Theale • 0.21 m tonnes by rail from Angerstein Wharf to Woking • 1.29 m tonnes by rail from Immingham to Ratcliffe power station • 1.29 m tonnes by rail from Avonmouth to Walsall In reality other nearby terminals could be used instead. Scenarios A & D are taken to have the same flows as scenario E, but scenario B is 20% higher and scenario C is 20% lower.
Petroleum, Chemicals, Industrial Minerals, Metals, Automotive	No major changes forecast in the overall markets, but fuel prices and drivers' wages impact on rail's mode share. Overall market: Low market growth: -5%. High market growth: +5%. Central market growth (scenario E): No change
Waste, Ore, Other Coal, Other and Network Rail Engineering	Rail traffics assumed largely stable into the future Low market growth: -5%. High market growth: +5%. Central market growth (scenario E): No change

3.5. Rail served warehousing sites

Historically there have typically been between 1 and 2 million square metres of new large-scale warehousing (warehouses of >9,000 square metres) built each year in Britain based on long term

[4] For Drax (the dominant biomass user), the assumptions are based on their current investment plans, which are an investment in carbon capture, to operate 2 burners continuously and 2 burners at 'peak' times, overall to lead to a consumption very similar to current levels. High gas prices may encourage the burning of more biomass but if carbon capture proves difficult or expensive, this may reduce the attractiveness of using biomass

trends, although the recent new-build rate has been (and is expected to continue to be) higher than this[5].

Based on known plans, realistic build-out rates, and the likelihood that some sites will proceed while others may face delays, we have assumed the following additional rail-served large warehousing will be built between the base year 2021 and 2028/29:

- Scenarios A & B (high): 4.4 million square metres
- Scenarios C & D (low): 2.7 million square metres
- Scenario E (Central): 3.6 million square metres

The table below presents the list of identified sites alongside the amount of ***additional*** rail-served floor space that we expect to be developed at each site.

[5] Our discussions with developers and market knowledge give us a good handle on the likely future of the warehousing market. However if the warehouse developers are discouraged from building warehousing at rail-served sites, due to being told that long-term rail capacity will not be available for their trains, then some of this warehousing will be built at road-only sites instead

Table 6: Planned Additional Rail-served Warehousing. Additional thousand square metres

	Sc A & B High	Sc C & D Low	Sc E Central
London Gateway Logistics Pk	647	374	498
Radlett	146	84	113
DIRFT	429	248	330
Northampton Gateway	468	351	468
East Midlands Gateway	65	49	65
East Midlands Distribution Centre	80	60	80
East Midlands Intermodal Pk	98	56	75
Hinckley SRFI	293	169	225
West Midlands Interchange	488	281	375
J10 M42 (Birch Coppice)	65	38	50
Oxfordshire SRFI	146	84	113
iPort	210	158	210
3MG	45	34	45
Port Salford or Parkside*	293	169	225
Port Warrington	200	115	154
Teesport	293	169	225
Mossend IRFP	200	150	200
Ravenscraig	78	45	60
Port of Grangemouth	130	75	100
Total	**4,372**	**2,707**	**3,609**

*subject to local network capacity constraint

3.6. Light logistics / express freight and Royal Mail

There has been considerable interest in the development of express freight services by rail in recent years. However, no clear model has yet to develop as to how these opportunities will be realised. From a modelling perspective this raises different issues as compared with the remainder of this study in that the only existing such traffic is that carried by Royal Mail between just four dedicated depots as part of an entirely 'in-house' door to door business so that modelling through incremental cost changes is not really possible.

We have therefore taken a more fundamental approach and considered the cost effectiveness that such services could offer, still using more or less the same cost models as to analyse other freight markets, using the cost structures used for other cargo within this modelling for the sake of good order and consistency.

We have not considered the 'courier' service market whereby urgent parcels are carried on and off passenger trains, such as are offered by 'Inter City Rail Freight', as these do not generate additional trains on the network.

The Continuing Survey of Road Goods Transport identified a mean of 4.82m HGV movements p.a. carrying mail and parcels corresponding to 39.23m tonnes of goods between the years 2015 and 2018, which equates to 8.14 tonnes per vehicle movement. Currently, Royal Mail operate some 50 trains per week with a mean train consist of around 10 carriages, which corresponds to some 25,000 carriage movements p.a., serving just 4 terminals, 3 of which are along the West Coast Main Line and the fourth in Gateshead. Each carriage has an internal cubic capacity of around 120m3, which can be compared with around 100 m3 for a high cube HGV semi-trailer. Based on 8.14 tonnes/HGV the Royal Main trains could therefore be assumed to be carrying 0.26m tonnes of goods p.a., suggesting the overall road + rail market is 39.5m tonnes, of which rail carries just 0.6% of total tonnes. However, it should be borne in mind that 48% of total road tonnes recorded in CSRGT by HGV is intra-regional, for which rail would probably not be competitive, and that in the case of the busiest rail leg (Scotland with the North West) rail market share appears to be much higher of around 8% (11 trains per week, reflecting an estimated 50,000 tonnes annually per direction at 9-10 tonnes per car). Total mail and parcels traffic to and from Scotland (source: CSRGT) accounts for around 4m tonnes.

Currently the maximum length train being operated is 12 carriages, which would equate to the capacity of around 15 HGVs. If that relationship is used as the cost comparator to assess rail viability for long distance transport then we can conclude that if there is no incremental handling or collection and delivery costs then (for the truck haul) rail can be cheaper than road and for specific flows faster (but probably not more frequent). However, any additional handling costs render rail more expensive at more or less any distance.

Several modes of operation appear to be under consideration.

One, being pioneered by Orion, is to operate converted EMUs that are very similar to the train sets already operated by Royal Mail. 'Dry runs' have been operated into passenger railway stations (i.e. Euston) with a view to operating from large rail linked distribution parks. This implies an immediate transfer of goods to small vans (presumably electric to minimise emissions) or even cycles although it is important to recognise that the volume arriving in a single train would equate to large numbers of light road vans (100-150), which could itself create logistical challenges given the absence of storage capacity at such locations. Such activity may only be practical overnight when, in any event, roads are uncongested and few receiving premises could receive goods. A more practical variation could be using EMUs at the 'country end' of trains arriving into London termini from the Golden Triangle and joining shorter off-peak trains to share paths from, say, Milton Keynes or Bedford etc.. This provides a competitive daytime frequency for office deliveries, servicing restaurants and sandwich bars and convenience stores.

This does not address the challenge of platforms heights being lower than rail vehicle floor decks which would render the use of roll cages difficult. It would also require trains to discharge and reload very rapidly if passenger train asset and station platform utilization is to be acceptable. While using passenger stations might just be viable where goods can be loaded directly to 'conventional' trains, by comparison with using road haulage (HGVs) from distribution centres that do not include internal tracks, rail does not currently appear to be viable. This is because double handling of goods at the parcel level would be required between existing parcel company sheds and rail served sheds, even where both sheds are on the same rail linked distribution park.

In all these circumstance the investment by Royal Mail in an 80,000m2 shed (to open in 2023) with internal tracks at DIRFT promises easily the most competitive approach for parcel traffic by rail, particularly because it appears to offer access for other operators. Given the storage, racking and the way the building is equipped, we shall assume this corresponds to a building with the ability to store 80,000m3 of goods, which would equate to the capacity of 800 high capacity HGV trailers.

Royal Mail has indicated that its terminal will be available to independent operators currently planning to enter the light logistics and parcels market. The shed is also expected to permit the transfer of air freight between southern Britain and Scotland from air (via East Midlands Airport) to rail, adding a further estimated 30,000 tonnes p.a..

That is, established parcels companies will enjoy a choice of train service suppliers (and presumably depot space within other Royal Mail sheds) and are therefore much more likely to find rail freight commercially acceptable. Goods that are for delivery to regions for which a rail service is viable and available could be held at the large shed and loaded to rail for cross docking when required.

In this context it is important to note that Orion's trial service (started November 2021), using converted type 319 passenger rolling stock (but initially loco hauled), operated between Royal Mail's existing rail connected Shieldmuir (Glasgow) and Willesden depots, offering a 7.5 hour transit including a 30 minute stop at Royal Mail's depot at Warrington. These facilities will allow parcel companies to consolidate traffic adjacent to railway platforms and therefore eliminate double handling, effectively shifting the origin and destinations of goods to rail linked sites. In this respect, the Royal Mail sites will play the same role as intermodal terminals on rail linked sites in attracting warehouses to sites that render rail freight much more competitive than hitherto.

Rail freight growth in the parcels sector can therefore be anticipated as a result of the Royal Mail investment. The three sites along the West Coast Main Line at Shieldmuir, Warrington and Willesden offer a total of around 55,000m2 and will presumably operate as cross-docking facilities, allowing the facility at DIRFT to act as distribution centre by cargo owners where goods can be 'called off' as required by receivers. A fourth terminal is available at Low Fell (Gateshead) while a fifth site at Bristol Parkway could also be brough back into action. However, growth beyond the existing Royal Mail traffic will depend heavily on the extra space available at distribution parks such as at DIRFT, their capacity to hold goods and the range of rail services each will offer. As currently understood, no other new sites beyond that at DIRFT will be open before the end of this forecasting period (in 2028/9).

Not all the goods held at such a site can be expected to use rail. The existing Royal Mail sheds, acting as cross-docking facilities, serve Greater London, the North West, Scotland and the North East. Taken together, these regions account for around 50% of non-intraregional mail and parcels traffic destinations in Great Britain.

The volume of rail freight that a building of finite size and capacity can support will depend upon the turnover of goods passing through it. Overall, large distribution centres may hold goods for an average of around one month (12 p.a.), but a facility of this type can expect a much faster turnover rate. Based upon a 350 day year, we shall assume a mean turnover rate of 75 p.a. for goods held on the site (4.67 days for each turn), which would imply a shed 'throughput' of 17,143 m3 goods per day (i.e. 80,000 m3/4.67 day turnover = 17,143m3). If 50% left by rail that would be 8,571m3 per day or 3.0m m3 of goods p.a. or 300,000 tonnes p.a., occupying 71 rail carriages per day departing.

Inbound traffic is less likely to be rail borne because much of it would be derived from DCs in the Midlands that are relatively local to a Golden Triangle site, and we shall assume only a 50% load factor for inbound trains (therefore 150,000 tonne p.a. inbound), making a total of approximately 0.45m tonnes of extra potential rail freight as a consequence of the new facility. Diverted air freight would add a further 0.03m tonnes raising total extra parcels traffic by rail to 0.48m tonnes. Added to our current estimate of 260,000 tonnes of current parcel traffic p.a. by rail this will produce a forecast volume of 0.74 tonnes of parcels traffic. We adopt this figure for Scenario E (Central) and scenarios A and D. The lowest-traffic scenario (C) has a 20% reduction and the highest-traffic scenario (B) has a 20% increase on these tonnages.

Our conclusion is that further growth would depend upon more such 'rail sheds' as being developed at DIRFT being built. Our modelling of parcels potential beyond 2028/29 will be based upon the assumption that some further rail linked distribution parks after 2028/9 will include such parcel-based rail loading facilities.

3.7. Tonnes per train by sector

The forecasts are made on an origin to destination tonnage basis. However it is useful to be able to translate these tonnes into numbers of trains. The tonnes per train depends on a number of factors. High volumes of high density cargoes to and from terminals able to handle large trains are likely to result in high tonnes per train. Small volumes mean insufficient traffic will be available to fill a full-length train. Similarly it may not be worth waiting for a full trainload for high value or time-sensitive cargo. If a backload is impractical (typically possible for intermodal containers and swap bodies, but normally not practical for bulk commodities), the returning train will be empty thus halving the average tonnes of cargo per train in that market sector.

The tonnes per train varies within a commodity / sector and by origin and destination. However using the sector average gives a means of translating tonnes into an estimate of the number of trains likely to be required to carry the cargo.

The current average tonnes per train have been calculated for each commodity / sector as described below:

- All wagon movements (from Network Rail's PALADIN – see section 4.6) for the full year 2021 were grouped into trains.
- Loaded wagons have commodity / sector information attached, but empty wagons do not. For all empty wagons, the wagon movement was associated with the commodity / sector of its previous loaded movement.
- If a simple mean average of these trains was calculated, then short distance trains which impinge little on the network would have the same importance as long distance trains that cover a lot of the network.
- To represent the average use of the network, a distance-weighted mean average tonnage per train was found for each commodity / sector.

The average cargo tonnes per train by commodity / sector is shown below

Table 7: Average cargo tonnes per train by commodity / sector (2021)

Commodity / Sector	Average Cargo Tonnes per train
Automotive	104
Biomass	724
Chemicals	299
coal other	298
Construction materials	693
Domestic Waste	675
Empty returns for containers carrying bulks	212
Engineering	376
ESI Coal	856
General Merchandise	412
Industrial Minerals	630
Intermodal	440
Iron Ore	639
Metals	554
Nuclear	55
other	87
Petroleum	804
All commodities	**513**

Notes:

- These average cargo tonnages include all trains-with-wagons associated with the commodity, including the empty-wagon return trains typical for bulks. For example if all Petroleum trains were fully loaded in one direction and empty for the return, that would imply the average cargo tonnage for a ***loaded*** Petroleum train is 804 x 2 = 1,608 tonnes. Intermodal trains are typically loaded in both directions, so there are very few empty return trains for intermodal, but where there are any, they are included in the overall intermodal tonnes per train calculation.
- For intermodal (and empty returns for containers carrying bulks) the average cargo tonnes per train include the weight of the container.
- For all commodities the average cargo tonnes per train exclude the weight of the locomotive and wagons

For the results tables for each commodity, the total forecast tonnes are translated into trains using these average figures. It should be noted that mean tonnes/train by commodity have changed over recent years; tonnes per train have generally increased but in the case of port based intermodal trains there has been a fall of around 15% between 2019 and 2021. It is believed this is a result of congestion at port and inland terminals caused in part by ship arrivals being more irregular.

Train lengths (and therefore tonnes per train) are assumed to remain constant into the future. The recent reduction in tonnes per train for intermodal is therefore maintained at 440 tonnes per train for the future scenarios. This does not impact on the growth rates, but does mean for both the base year (2021) and the 2028/29 forecasts, that more intermodal trains are required per million tonne kms, than was the case 5 years previously.

3.8. Path utilisation, days per week and hours per day

HGVs can simply access the road network at any time, albeit potentially imposing congestion costs on existing users. However in order for freight trains to operate, they need to have agreed timetabled routes from origin to destination ("paths"). Some rail freight sectors such as intermodal operate scheduled services, so the requirement for paths is relatively predictable, and a path can be allocated for each scheduled service, with a confidence that most services should run; resulting in a relatively high path utilisation.

However in some sectors such as the construction sector, the demand for the cargo is more variable. In order to accommodate such variable demand, it is helpful to have several available paths – often to several different destinations, even though not all of them will be used; resulting in low path utilisation.

In the 2013 Freight Market Study and our 2018/19-produced 2023/24, 2033/34 and 2043/44 forecasts, assumptions were made for each rail freight commodity / sector as to the utilisation of paths (i.e. of the allocated timetabled paths, how many are actually used). We have retained these same utilisation factors to convert trains into required paths for the base year (2021) and all future years.

If the path utilisation factors (e.g. 85% for intermodal) we assume here are higher than actual path utilisations, that could result in forecast demand being translated into too few paths for timetabling, such that operators would have to achieve higher path utilisation rates in order to run their trains.

An updated analysis of path utilisation factors is likely to produce a conversion from demand forecasts of trains into paths-required in line with current operations. This would be more reliable than using estimates in the 2013 Freight Market Study, and would open up the possibility to make assumptions on improvements in path utilisation factors. These utilization factors are used for both the unconstrained and capacity constrained cases.

Table 8: Path utilisation by commodity / sector

Commodity / Sector	Path utilisation
Intermodal	85%
ESI Coal	45%
Biomass	75%
Waste	50%
Construction materials (not spoil)	37%
Spoil	50%
Petroleum	56%
Chemicals	50%
Industrial Minerals	50%
Metals	51%
Automotive	50%
Ores	50%
Coal Other	45%
Other	50%
Empty returns for containers carrying bulks	50%

Source: Estimates from Network Rail in consultation with the FOCs, 2013

Note: Network Rail's engineering trains operate differently from rail freight carrying commercial cargo. NR Engineering trains are assumed to directly translate 1:1 into required paths.

We convert from annual trains into trains per weekday (Monday-Friday) by dividing by 297. This is based on analysis of freight movements for 5 separate non-bank-holiday weeks spaced out across the year (2021); these show that 87.7% of freight traffic is operating on weekdays[6]. Table 9 shows that there is variability throughout the week.

Table 9: Average tonnes departing per day by day of the week (excluding bank holidays) throughout 2021

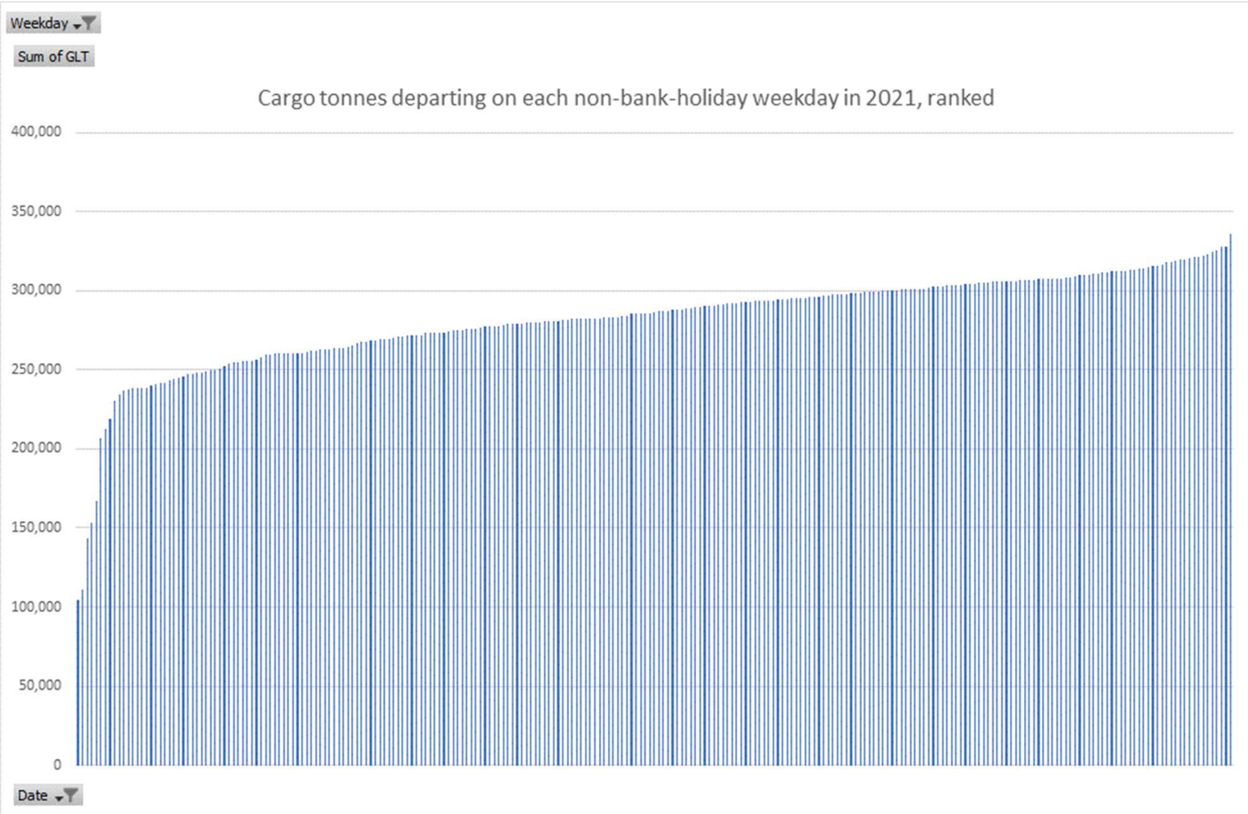
Day	Average tonnes departing
Mon	257,246
Tue	294,016
Wed	292,296
Thu	293,058
Fri	269,542
Sat	117,015
Sun	68,435

[6] To avoid e.g. a long train journey starting at 23:59 on a Friday evening being classified as a weekday train, traffic is represented by a count of the number of en-route location timings for freight trains, where the en-route location timings are grouped into weekdays and weekends.

This shows that Tuesdays, Wednesdays and Thursdays are the busiest days of the week. Mondays and Fridays are around 90% of this, with Saturdays 40% and Sundays just 23%.

The figure below ranks the cargo tonnes departing for each non-bank-holiday weekday in 2021. The busiest day was 24th June (336,000 cargo tonnes) and the least busy was Christmas Eve (104,000 cargo tonnes).

Figure 1



We have calculated the 297 factor to convert from annual trains to trains per weekday using 2021 data. This is a larger conversion figure than the approximate figure we used for our 2016/17-based forecasts several years ago (260). Therefore when translated to daily trains, this reduces the result as compared to the 2016/17 figure. Our 2021 trains per weekday are estimated to be 520, while our estimate for 2016/17 was 572.

These trains represent trains with wagons that carried a commodity or are an empty return. This therefore excludes locomotives moving without wagons and trains without identified cargo being transported such as Railhead Treatment Trains. This is lower than the number of freight trains per weekday reported by TOPS data. One factor that reduces our count of trains as compared to TOPS is that we are tracking the cargo origin and destination. For example if a train of construction materials goes from Merehead Quarry to Acton TC, and then another loco takes those same loaded wagons from Acton TC to Crawley, we would count that as 1 movement (1 train) from Merehead Quarry to Crawley. If counting trains in the TOPS data, this would be counted as 2 trains. It's a similar situation for intermodal trains using Crewe Basford Hall.

Freight traffic typically avoids busy parts of the network during peak times, and is normally able to run at night without capacity concerns due to passenger trains. When estimating junction capacity utilisations, we typically consider paths traffic during the 6-hour day-time off-peak (10:00-15:59). By analysing when freight movements take place during the day, the average conversion factor from daily to day-time off-peak hour is to divide by 27.

We use these conversion factors for the base year (2021) and the future year (2028/29). In reality there will be some variation between different commodities and for different origins and destinations, and these may potentially change over time. Using these averages should give reasonably realistic estimates overall.

3.9. General

The forecasts do not take into account the impact of planned infrastructure projects such as East-West Rail (EWR) beyond the already-committed reopening of Oxford – Bletchley.

These assumptions were chosen using the available information at the time (December 2021). There may be subsequent changes to some of these exogenous assumptions prior to publication of the final report which have not been taken into account in the modelling and quantified results.

The forecasts therefore do not reflect changes in other official projections, forecasts and policies since December 2021, such as labour and fuel cost assumptions.

Diesel versus electric traction

No assumptions have been made in terms of a possible switch towards more electric traction, and our cost models are based on the use of diesel locomotives. This can be interpreted as an assumption that electric traction will not offer significantly lower costs when all its limitations are taken into account. However if

- more routes and terminals used by freight trains were electrified
- the cost of using electric traction rose at a slower rate than using diesel
- or environmental restrictions were put on the use of diesels

then it may become cost effective for the rail freight industry to move faster towards electric traction.

Bimode or trimode locomotives offer a compromise solution for where parts of the journey are not electrified, and diesel (and/or battery electric or hydrogen) can be used for these sections.

In the short term (up to 2028/29), we do not think there will be a significant change in electrification that significantly affects these forecasts.

4. METHODS AND MODELS EMPLOYED

4.1. Establishing base year traffics

A base year of calendar year 2021 has been used as the basis of the forecasting.

Base year traffics have been calculated by processing Network Rail's traffic movement database (PALADIN). See section 4.6.

4.2. GB Freight Model (GBFM)

Our default approach for modelling any rail freight sector is to use the GB Freight Model (GBFM) - a comprehensive freight transport model available for analysing current and forecasting future freight flows to, from and within Great Britain by mode, origin/destination, routing and commodity. The latest version of the model (version 6.2) consists of several modules, including:

- A multi-dimensional base matrix, built up from several sources, which describes the origin, destination and commodity of goods moving within Great Britain and to/from Great Britain (over 7000 GB zones). Sources include the DfT's Continuing Survey of Road Goods Transport (CSRGT), Network Rail movement data, Revenue and Customs trade data and Maritime Statistics;
- Modal cost models, validated against industry data, which replicate transport rates in the market and can be adjusted for different factor costs;
- A calibration process that allows current mode shares to be replicated;
- A road network that allows unit loads to be assigned as a function of minimum cost paths; and
- A rail assignment model that is based upon current operating behaviour (route choice, tonnes/trains by commodity).

To give a bit more detail, GBFM v6.2 is similar to a classic 4-stage model (trip generation, trip distribution, modal share, route assignment):

- Employment data by industrial category for each zone is combined with "supply" and "use" tables[7] to estimate cargo connections between zone pairs. These connections are controlled by commodity-specific gravity models – which estimate the cargo between each zone pair for domestic traffic.
- Warehouses generate and attract cargo and their locations are known. In the model, cargo is generated and attracted to each warehouse based on its land area and location (warehouses in the Midlands are more likely to be National Distribution Centres, but warehouses in

[7] Supply & Use tables show the linkages between different industrial sectors

Cornwall are likely to be serving the local area). Equivalent gravity models are used to distribute the warehouse traffic

- International traffic is well described by trade and port data. Distribution inland to/from each port is modelled, based on equivalent gravity models, and calibrated to average inland length of hauls based on CSRGT and Network Rail data.
- Once an origin-destination-by-commodity cargo matrix is established, it is subject to mode choice. Options involving rail include a road leg to get to from the origin to a rail terminal, and another road leg to get from the destination terminal to the final destination. If the origins or destinations are in the same zones as the terminals, no road leg is required. Commodity-specific rail service options from terminal to terminal are input into the model based on actual rail traffic in the base year
- For each origin-to-destination-by-commodity, road and rail costs are calculated. A cost-based Logit model is applied to split between road and rail. The resultant rail traffics are calibrated in the base year to the known tonnes on each rail service.

Once a base year model is established, future scenarios can be described by:

- Applying long-run cargo demand trends, which includes assuming different growth rates for domestic and international freight;
- Adjusting factor costs such as labour and fuel costs; and
- Adjusting land uses resulting in changes in transport costs through increasing or reducing the proportion of trip ends at rail linked sites.

For this work, planned infrastructure upgrades have not been taken into account (apart from the committed Oxford to Bletchley section of EWR). The forecasts (and routeings) therefore reflect the network of early 2022 and do not reflect upgrades implemented since then or planned upgrades. However the calculated costs for rail services to/from the new rail-served warehousing sites follow the same cost model as services between established terminals on the W10 gauge network (high-bridges allowing high containers and wagons). There is therefore an implicit assumption that the gauge on routes serving new warehousing sites will be upgraded to W10, or trains able to cope with lower gauge are able to run without significant additional cost; such as by using lowliner wagons (allows 9ft 6 inch containers on most W8 routes without the need for expensive and inefficient well-wagons).

Changes in road and rail costs due to congestion are not taken into account. Increased road costs due to worsening road congestion could encourage a mode switch from road to rail for some traffic, or the upgrading of or building of new roads could encourage a switch from rail to road. Similarly rail ‘congestion’ or capacity constraint could suppress some rail freight demand – see section 6.

There are some important sectors, where components of GBFM need to be adapted, and/or different approaches adopted. Broadly the approach for most sectors is based on GBFM principles:

1. Establish the traffic in the base year
2. Consider changes to the underlying demand for the cargo (often not relating to transport)
3. Consider potential changes to origins and destinations.
4. Model the impact of changing modal economics
5. Assign results to the rail network

4.3. Intermodal containers

Intermodal container traffics serve a diverse market, typically for non-bulk traffic, with 3 main distinct markets:

- Maritime containers
- Domestic (non-port) intermodal
- Channel Tunnel intermodal containers

4.3.1. Maritime containers

The transporting of maritime containers is an already well-established rail market with containers travelling between ports and inland terminals. This is typically traffic to/from deep sea container ports, although there are also some traffics from short sea container ports which are discussed below.

Deep sea container ports are defined here as those ports which have sufficient deep water and infrastructure to handle large container ships – typically travelling from around the world. The container shipping industry has decided that using these ports is an effective and economic way of unloading containers from these large container ships to serve Britain. Some deep sea ports are also used for short sea (European) traffic too.
We assume that deep sea container port capacity growth will keep pace with demand after 2021, as existing and planned developments (more use of Liverpool, and London Gateway with extra berths built) provide sufficient capacity for forecast demand up to 2028/29.

In terms of **additional** container units handled at the deep sea ports, this is input into the model as follows:

Table 10: Additional import container units (thousand) handled at the deep sea ports in 2028/29

Scenario	London Gateway	Liverpool	Total
Scenarios A & C	158	26	183
Scenarios B & D	327	123	450
Scenario E	230	86	316

Note:

- The 2021 base is 1,666,000 container units imported through the deep sea ports
- Some of this is currently-unused capacity (as at 2021) that already exists at Liverpool and London Gateway.
- Even in the high growth scenarios of B & D, only 72% of the extra capacity available is used if London Gateway is fully developed.

GBFM distributes this cargo inland in line with existing deep sea cargo inland distributions, while also incorporating the new-build warehousing as new inland destinations.

Short sea shipping for maritime containers (international traffic)

As well as deep sea container ships calling directly at British deep sea ports, some deep sea containers are transhipped at continental ports (e.g. Rotterdam) onto smaller ships that then take the containers to other British regional (feeder) ports. Container traffic through these feeder ports is assumed to retain the same (relatively small) proportion of the whole container port market as it has now.

Unitised trade between Europe and Britain is currently dominated by HGVs and trailers on roro ferries (e.g. Dover – Calais. Eurotunnel's Folkestone - Calais HGV shuttle is included in this market too). This HGV-on-ferry traffic is normally unsuitable for rail in Britain and is not considered in these forecasts. However some goods between Europe and Britain are carried in intermodal containers – which are included in the modelling as potential Channel Tunnel traffic, and traffic between British ports and inland.

Deep sea ports typically serve the whole of England and Wales and some of the Scottish market. However ports handling feeder traffic and European traffic typically serve a much more regional market. The short distances between feeder port and regional hinterland tend to favour road instead of rail. This is why the focus for rail is on containers to/from deep sea ports. However, the regional ports handling feeder traffic and European traffic still enjoy some modal shift to rail with the assumed favourable changes in modal economics in the future in scenarios A & B.

As with the deep sea ports, it is assumed that short sea container port capacity keeps pace with demand.

Coastal Shipping (shipping between British ports)

There is also some coastal container traffic by sea between British deep sea ports and regional ports (e.g. Felixstowe to Tees and Felixstowe to Grangemouth). However coastal shipping and rail are often generally considered as largely separate markets - with rail offering a regular, quick service, and coastal shipping offering an infrequent but cheaper service for transferring deep-sea containers between ports, although there is some competition between them. Almost all coastal container traffic is between deep sea hub ports and regional ports where the real competition is between a UK and a

Continental hub port. Because the main intermodal container cost changes modelled (fuel and wages increasing) would have a similar effect on coastal shipping as rail, we do not foresee significant changes in modal shares between rail and coastal shipping. Therefore we have not included coastal shipping in these calculations or modelling. We do not foresee port capacity constraints as being a limiting factor restricting the growth in coastal or feeder shipping within the time period covered by these forecasts.

Developments inland

The development of inland rail-served warehousing sites (see section 4.3.2) encourages mode switch from road to rail for maritime containers because there is no need for a local road haul between inland terminal and warehouse.

4.3.2. Assumptions for Domestic (non-port) intermodal

Domestic (non-port) intermodal trains are typically carrying fast-moving consumer goods (FMCGs) to, from and between National Distribution Centres (NDCs) and Regional Distribution Centres (RDCs) (warehouses). It is a very large transport market of nearly 1 billion tonnes lifted per year, currently dominated by road (much of this tonnage is accounted for by multiple legs between different warehouses). For rail it is a relatively small but growing market. As land use planning policy encourages more new-build, large warehousing sites to be rail-served, for any rail journey to/from such a warehouse, a local road haul is not required. This cost saving makes rail an increasingly viable option.

We describe our assumptions on where new large warehousing will be built in section 3.5. It is difficult to accurately predict which rail-served warehousing sites will be developed and come on-stream by a particular year. The sites listed in section 3.5 may not be the exact locations where development will happen but they are intended to be broadly representative of the likely extent of development in each region.

4.3.3. Channel Tunnel through-rail intermodal containers

The Channel Tunnel is in competition with ferry and lolo services to/from the continent. Hence the market is very elastic – highly sensitive to costs and service quality.

The cost change assumptions described in section 3.2 for road versus rail for each scenario impact on Channel Tunnel traffics as well as the assumptions on market growth.

4.3.4. Methodology for intermodal containers and swap bodies

GBFM v6.2 incorporates an input of large warehousing development. Each site's stock turnover is based on land area and type of warehouse (with RDCs having double the stock turnover per square metre of NDCs). For NDCs, incoming cargoes are assumed to come from around the country and as imports. Their outgoing cargoes are to RDCs across the country. For RDCs, incoming cargoes are from NDCs and imports. Outgoing cargoes are more focussed on the local area.

If these warehousing sites are rail-served, intermodal rail services are set up in the model to/from existing intermodal rail freight terminals (including at the ports) and other new rail-served warehousing sites.

The true generalised cost of a rail service per container unit is dependent on the traffic volume. High traffic volumes mean full, long, frequent, direct trains resulting in a low generalised cost to the user. However low volumes mean infrequent services (which may not be well suited to the needs of the logistics industry), or the need to transfer cargo at a hub en-route (splitting up and joining sections of trains, or transferring containers from one train to another) with associated time and cost penalty.

An iteration is therefore performed in the modelling process; Any services with annual traffic volumes below 10,000 tonnes are assumed to be non-viable and are removed for the 2nd iteration.

4.3.5. Cost models and mode share

For all movements (between ports, rail-served warehouses and non-rail-served sites), road and rail cost models are applied along with a mode choice algorithm, which take into account

- the distance
- whether the origin and destination are rail-served (no need for a road haul to/from a local rail terminal)

The road & rail cost models are built up from the individual cost components that a road or rail haulier experiences and include:

- Capital cost of vehicles & interest rates
- Depreciation
- Fuel cost with associated consumption rate
- Taxes and duty
- Maintenance & insurance
- Labour costs – e.g. drivers' wages
- Overheads and office costs
- Track access charges (rail)

Assumptions include:

- Mean speed
- Annual distance travelled per vehicle and hours operational
- Hours worked per employee
- Tonnes of cargo carried per vehicle
- Asset utilisation

Also included for rail journeys are the terminal charges at both ends, along with an internal site shunt where the origin or destination is on-site, and a local road haul where the origin or destination is off-site. If the journey is rail-served at both ends, the overall cost is therefore *lower*. If the rail journey is *not* rail-served at either end, the cost is *higher*.

As described in the earlier assumptions section, several components of the cost model are forecast to change from the base year.

The model outputs the tonnes of non-bulk cargo by road and rail between each port, each rail-served warehouse and non-rail-served sites for the forecast year.

Rail traffic to/from non-rail-served sites will have to use a local intermodal terminal. This may be an existing terminal or a terminal associated with one of the new rail-served warehousing sites. For each origin zone to destination zone traffic, the lowest generalised cost rail service is found (incorporating local road hauls if required). Once the rail mode share (versus road) for that origin-to-destination is found using a Logit model, all rail traffic is allocated to that service.

4.3.6. Integrating the model's results with present day traffics

As new rail-served warehousing sites with intermodal terminals are built, they will effectively be in competition with existing nearby intermodal terminals. In the very long term, in general, the transport cost savings associated with having on-site warehousing are likely to favour the terminals with on-site warehousing. However at least in the medium term, most existing terminals without on-site warehousing are likely to continue to operate.

To represent this inertia, we make the simple assumption (where there is forecast intermodal rail growth), that all existing terminal to terminal intermodal tonnages at least maintain their base year traffic levels. The model's forecast tonnages are then scaled down and added to the existing traffics such that the *total* forecast intermodal tonnage for ports and domestic is in line with the model's original total forecast tonnage.

This is not a perfect solution because competition from new rail-served warehousing sites could potentially lead to traffic reductions at some existing terminals - e.g. Port Salford could potentially take some of Trafford Park's traffic. However this simple approach avoids the need for a site-by-site analysis of the competitive dynamics between new rail-served warehousing sites and existing intermodal terminals.

4.4. Bulks

GBFM v6.2's approach to modelling rail journeys is best suited to intermodal containers because they often do include an on-road element, and the costs associated with running intermodal container rail services are reasonably predictable and consistent.

For other bulks such as Construction materials, attempting to generate the origin-to-destination traffic and then model modal share at such a small zone level is challenging. We therefore revert to an earlier version of GBFM (version 4) which works at a county level (much larger zones than GBFM v6.2). Operating at such a large-zone level makes the model more stable and easier to calibrate to both road and rail in the base year because both road and rail data is available at the county level.

For the forecasts, the counties are aggregated into regions and modelled growth factors are derived; origin region by destination region by commodity. These are then applied to the base year (2021) tonnes. This means that specific new services are not represented, and all flows of one commodity from one region to another all grow at the same rate.

This bulk modelling approach applies to: Automotive, Chemicals, Construction materials, General Merchandise, Industrial Minerals, Metals and Petroleum.

Forecasts for other bulk sectors are exogenously defined as described in the assumptions chapter and do not rely on modelling: Biomass, Coal, Waste, Empty returns for containers carrying bulks, Iron Ore, Network Rail Engineering and Other.

4.5. Modelling limitations

In an ideal world where the model was able to accurately reflect all factors affecting rail freight, the model's output would exactly reflect real world traffics. However a model is a simplification of the real world that attempts to reflect the most important drivers that are likely to affect rail freight volumes. We would expect some differences between the model's output and the real world, and we comment on those differences below.

One omission from the modelling of real world conditions is current capacity constraint. Calibrating to existing traffics resolves this to the extent that current traffics are replicated in the base year. However it is not clear whether a high calibration factor (additional cost added to a service for the model to produce the 'correct' traffic in the base year) is due to capacity constraint or another reason based upon rail's competitiveness. By retaining these calibration factors the model effectively assumes that factors such as train speed (often the consequence of interaction with passenger trains on a busy network and which significantly affects unit costs) are retained. Our forecasts do, therefore, implicitly assume a consistent level of service.

The road cost model is based on road distance. Rail distances are assumed to be similar such that road distances are used to represent rail distances from terminal to terminal in the rail cost model. This means that there is no automatic link between building new lines to reduce distances, and reductions in rail cost for relevant origin-to-destinations. If such enhancements were to affect costs, these cost improvements would have to be added to the relevant services. Normally there are many considerations that affect the cost of using a route as well as just distance, such as loading gauge, maximum axle weights, speed of traffic on a route and how busy it is such that freight trains may need to wait in a passing loop for faster trains to pass.

Both versions of GBFM used (version 6.2 for intermodal and version 4 for some bulks) include the whole road and rail market by origin and destination, with growth to the future year such that there is a mode choice between road and rail based on cost. The responses are based on cost changes.

The model implicitly assumes an equilibrium has been reached such that the market has fully adjusted to the costs in the forecast year. However in reality, the market can take time to adjust.

In the calibration to actual traffics on intermodal container services, there is a range from positive to negative calibration factors. Adding new services requires a decision to be made as to what calibration factors to apply to the new services. We have not actively applied a calibration factor (i.e. we have assumed calibration factors of zero) – with the implication that our cost models accurately represent the cost of operating intermodal services.

4.6. Comparison to ORR published tonnes lifted figures

The source of the rail tonnes lifted figures in this report is PALADIN billing data provided to us by Network Rail. We process this data to generate an origin-destination database by filtering out double-counting and en-route terminals, to arrive at just one cargo tonnage record from wagon journey start to wagon journey finish. Our overall tonnage for 2021 is 82.3 million tonnes (including estimates for postal), of which 2.4 million is coal (0.86m tonnes of power station coal and 1.58m tonnes of other coal). We have 8.6m tonnes of biomass.

Rail tonnes lifted data is also published by the ORR (table 1315). The data is sourced separately from each of the largest 5 Freight Operating Companies (FOCs) (DB Cargo UK, Freightliner (Intermodal & Heavy Haul), Direct Rail Services (DRS), GB Railfreight and Colas Freight)8. Their total (79.1 million tonnes) is slightly below our total (82.3 million tonnes). They report 6.4 million tonnes of coal (compared to our 2.4m t). It is difficult to directly compare these coal figures because there may be other cargo categories associated with the coal industry that some FOCs may have included within the coal business sector such as gypsum, limestone and pulverised fly ash, and possibly biomass.

If the ORR data was available at greater disaggregation (both by commodity and geographically for origins and destinations), it would be possible to investigate the differences further.

[8] Source: ORR Freight rail usage quality report: https://dataportal.orr.gov.uk/media/1233/freight-quality-report.pdf

5. SUMMARY RESULTS – WITHOUT CAPACITY CONSTRAINT

5.1. Historical context

To put the forecasts into context, the rail freight tonnes by sector from 2004/05 to 2021/22 is shown in the table and graph below. Even though the base year for the forecasts is 2021 we are now able to extend this data to include 2021/22.

The main historical change is that ESI (power station) coal used to dominate rail freight, but is now a minor part of the overall picture. Construction dipped in the recession but then recovered strongly. Intermodal rail grew up to the recession and then performed well through the recession, but has since been reasonably stable overall. Covid briefly impacted cargo movements in the first lockdown but there was a much quicker recovery for freight than for passenger traffic. The lack of growth is partly due to capacity constraint restricting train numbers and discouraging investment in rail-served warehousing and other terminals.

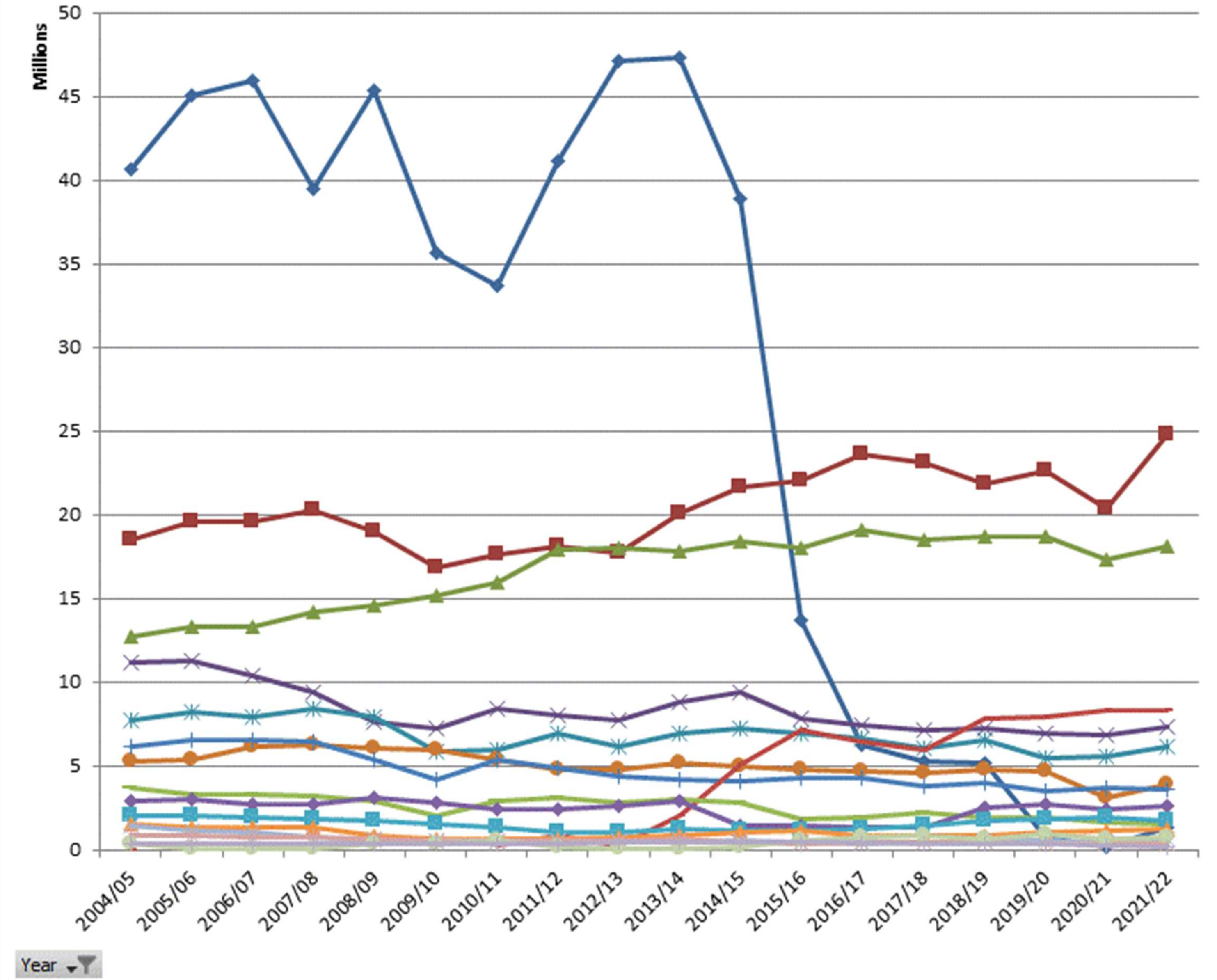
World-wide container shipping has been in turmoil in recent months meaning that numbers of containers at the port wanting to travel inland have been less predictable leading to fewer containers per train and this almost certainly led to a fall in mean load factors on intermodal trains.

Table 11: Rail freight TONNES by sector from 2004/05 to 2021/22. Million tonnes per year.

Sector	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22
Intermodal	12.7	13.3	13.3	14.2	14.6	15.2	15.9	17.9	18.0	17.8	18.4	18.1	19.1	18.5	18.7	18.7	17.4	18.1
ESI Coal	40.7	45.1	45.9	39.5	45.4	35.7	33.7	41.1	47.1	47.4	38.9	13.7	6.3	5.2	5.2	0.7	0.2	1.3
Biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.8	0.3	2.1	5.1	7.1	6.5	5.9	7.8	8.0	8.3	8.3
Waste	2.1	2.0	1.9	1.8	1.7	1.5	1.3	1.1	1.1	1.3	1.1	1.2	1.2	1.4	1.7	1.8	1.9	1.8
Construction	18.9	19.6	19.6	20.3	19.4	17.2	18.1	18.3	17.8	20.2	21.8	22.6	24.3	24.0	22.5	23.6	21.0	25.5
of which spoil	0.4	0.0	0.0	0.1	0.4	0.3	0.6	0.1	0.0	0.1	0.2	0.5	0.7	0.9	0.6	1.0	0.6	0.8
Petroleum	5.3	5.4	6.1	6.2	6.1	5.9	5.3	4.8	4.8	5.1	5.0	4.8	4.7	4.5	4.7	4.7	3.1	3.9
Chemicals	1.6	1.4	1.4	1.3	0.9	0.7	0.7	0.7	0.8	0.8	1.0	1.1	0.9	0.9	0.8	1.1	1.1	1.3
Ind' Minerals	2.9	3.0	2.8	2.8	3.1	2.8	2.4	2.4	2.6	3.0	1.4	1.4	1.3	1.3	2.5	2.7	2.4	2.6
Metals	11.1	11.3	10.4	9.3	7.6	7.3	8.4	8.0	7.7	8.8	9.4	7.8	7.4	7.2	7.2	6.9	6.8	7.3
Automotive	0.4	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.4	0.4	0.4	0.3	0.2	0.2
Ores	6.1	6.5	6.5	6.5	5.4	4.2	5.4	4.9	4.4	4.2	4.1	4.3	4.3	3.8	4.0	3.5	3.7	3.6
Coal Other	3.7	3.3	3.3	3.2	3.0	2.1	2.9	3.1	2.8	3.0	2.8	1.9	2.0	2.2	1.9	2.0	1.7	1.6
Other	1.4	1.2	1.1	0.8	0.5	0.5	0.4	0.5	0.5	0.5	0.5	0.5	0.3	0.4	0.5	0.5	0.5	0.7
Empty return bulk containers	0.9	0.8	0.8	0.8	0.6	0.6	0.6	0.5	0.5	0.6	0.5	0.3	0.4	0.5	0.5	0.4	0.4	0.4
NR Engineering	7.7	8.2	7.9	8.4	7.9	5.8	6.0	6.9	6.2	7.0	7.2	6.9	6.7	6.0	6.5	5.4	5.5	6.1
Total	**115.4**	**121.3**	**121.3**	**115.5**	**116.6**	**99.7**	**101.7**	**111.3**	**115.1**	**122.1**	**117.7**	**92.2**	**85.8**	**82.3**	**85.0**	**80.3**	**74.2**	**82.6**
Total excluding ESI coal	*74.7*	*76.3*	*75.4*	*76.0*	*71.2*	*64.0*	*68.1*	*70.2*	*68.0*	*74.8*	*78.7*	*78.4*	*79.5*	77.1	79.8	79.6	74.0	81.2

Postal tonnes are recorded separately. We estimate there are currently 260,000 tonnes per annum

Figure 2 **Rail freight TONNES from 2004/05 to 2021/22 by sector**



Postal tonnes are recorded separately. We estimate there are currently 260,000 tonnes per annum

5.2. Forecasts

This section presents the unconstrained forecast rail freight demand results for the 2028/29 scenarios A-E. The tables and charts below cover the forecast annual rail freight tonnes, annual tonne kms, and daily trains by sector for:

- actual traffic in 2021 base year
- scenario A: Factors which favour rail relative to road, with low market growth
- scenario B: Factors which favour rail relative to road, with high market growth
- scenario C: Factors which disfavour rail relative to road, with low market growth
- scenario D: Factors which disfavour rail relative to road, with high market growth
- scenario E: Central assumptions neither favouring or disfavouring rail relative to road, with central market growth.

Table 12: UNCONSTRAINED Rail freight TONNES forecast for_2028/29 scenarios by sector. THOUSAND tonnes per year

Sector	2021	A	B	C	D	E
Intermodal. To/from Ports	15,632	25,202	27,650	19,990	21,908	23,629
Intermodal. Inland-Inland	2,134	4,267	4,346	2,961	3,037	3,716
Intermodal. Channel Tunnel	365	899	1,026	431	491	654
Automotive	207	260	287	200	221	254
Biomass	8,565	6,852	10,278	6,852	10,278	8,565
Chemicals	1,218	1,348	1,490	1,227	1,356	1,349
Coal Other	1,578	1,499	1,656	1,499	1,656	1,578
Construction materials	24,668	35,313	40,774	25,431	29,492	33,350
Domestic Waste	2,506	2,381	2,631	2,381	2,631	2,506
Empty returns for containers carrying bulks	378	360	398	360	397	379
ESI Coal	859	-	-	-	-	-
General Merchandise	626	701	755	669	724	712
Industrial Minerals	2,542	2,841	3,140	2,246	2,483	2,697
Iron Ore	3,857	3,664	4,050	3,664	4,050	3,857
Metals	7,487	7,971	8,798	7,088	7,825	8,054
NR Engineering	5,738	5,451	6,025	5,451	6,025	5,738
Other	31	30	33	30	33	31
Petroleum	3,651	3,651	4,036	3,466	3,830	3,726
Postal / Light logistics	260	737	884	590	737	737
Total	**82,303**	**103,427**	**118,259**	**84,534**	**97,175**	**101,531**

Table 13: UNCONSTRAINED Rail freight Tonne KILOMETRES forecast for 2028/29 scenarios by sector. MILLION tonne kilometres per year

Sector	2021	A	B	C	D	E
Intermodal. To/from Ports	5,388	8,854	9,770	6,919	7,649	8,256
Intermodal. Inland-Inland	1,022	2,023	2,059	1,392	1,427	1,756
Intermodal. Channel Tunnel	107	264	301	127	144	192
Automotive	50	58	64	48	53	57
Biomass	1,079	863	1,294	863	1,294	1,079
Chemicals	189	211	233	187	207	208
Coal Other	121	115	127	115	127	121
Construction materials	5,030	6,645	7,670	5,114	5,924	6,442
Domestic Waste	448	425	470	425	470	448
Empty returns for containers carrying bulks	74	71	79	71	78	75
ESI Coal	126	-	-	-	-	-
General Merchandise	183	206	222	197	213	209
Industrial Minerals	401	441	488	359	397	424
Iron Ore	131	125	138	125	138	131
Metals	1,471	1,548	1,706	1,385	1,526	1,563
NR Engineering	1,331	1,264	1,397	1,264	1,397	1,331
Other	9	8	9	8	9	9
Petroleum	871	866	957	826	913	887
Postal / Light logistics	113	255	306	204	255	255
Total	**18,145**	**24,243**	**27,290**	**19,630**	**22,222**	**23,443**

Table 14: UNCONSTRAINED Rail freight DAILY TRAINS forecast for 2028/29 scenarios by sector

Sector	2021	A	B	C	D	E
Intermodal. To/from Ports	119.5	192.6	211.4	152.8	167.5	180.6
Intermodal. Inland-Inland	16.3	32.6	33.2	22.6	23.2	28.4
Intermodal. Channel Tunnel	2.8	6.9	7.8	3.3	3.8	5.0
Automotive	6.7	8.5	9.3	6.5	7.2	8.3
Biomass	39.8	31.9	47.8	31.9	47.8	39.8
Chemicals	13.7	15.2	16.8	13.8	15.3	15.2
Coal Other	17.8	17.0	18.7	17.0	18.7	17.8
Construction materials	119.8	171.5	198.1	123.5	143.3	162.0
Domestic Waste	12.5	11.9	13.1	11.9	13.1	12.5
Empty returns for containers carrying bulks	6.0	5.7	6.3	5.7	6.3	6.0
ESI Coal	3.4	-	-	-	-	-
General Merchandise	5.1	5.7	6.2	5.5	5.9	5.8
Industrial Minerals	13.6	15.2	16.8	12.0	13.3	14.4
Iron Ore	20.3	19.3	21.4	19.3	21.4	20.3
Metals	45.5	48.5	53.5	43.1	47.6	49.0
NR Engineering	51.4	48.8	54.0	48.8	54.0	51.4
Other	1.2	1.2	1.3	1.2	1.3	1.2
Petroleum	15.3	15.3	16.9	14.5	16.0	15.6
Postal / Light logistics	8.8	30.2	36.2	24.1	30.2	30.2
Total	**520**	**678**	**769**	**558**	**636**	**664**

Figure 3

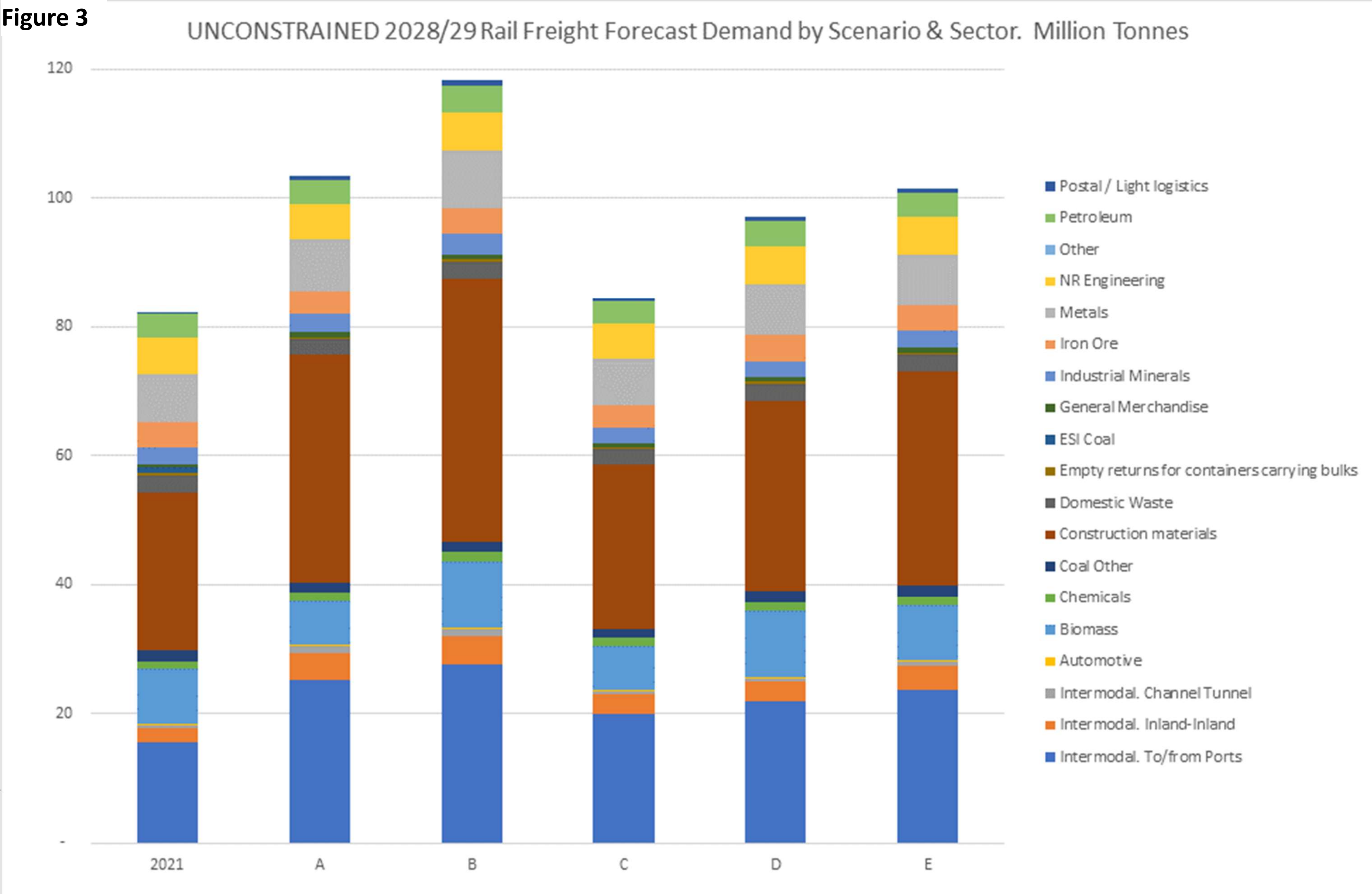

UNCONSTRAINED 2028/29 Rail Freight Forecast Demand by Scenario & Sector. Million Tonnes
120
100
80
60
40
20
-
2021
A
B
C
D
E
Postal / Light logistics
Petroleum
Other
NR Engineering
Metals
Iron Ore
Industrial Minerals
General Merchandise
ESI Coal
Empty returns for containers carrying bulks
Domestic Waste
Construction materials
Coal Other
Chemicals
Biomass
Automotive
Intermodal. Channel Tunnel
Intermodal. Inland-Inland
Intermodal. To/from Ports

Figure 4

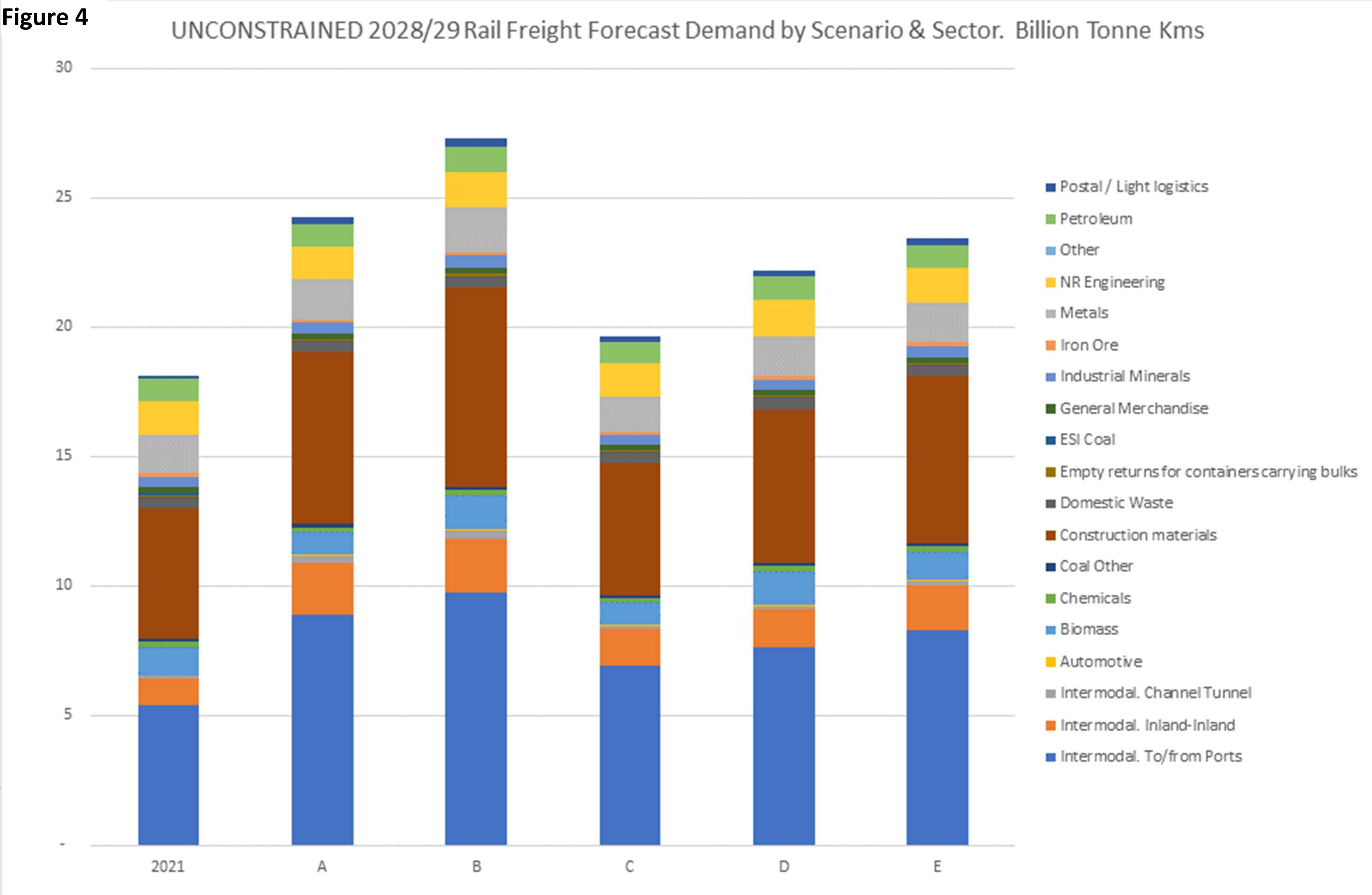
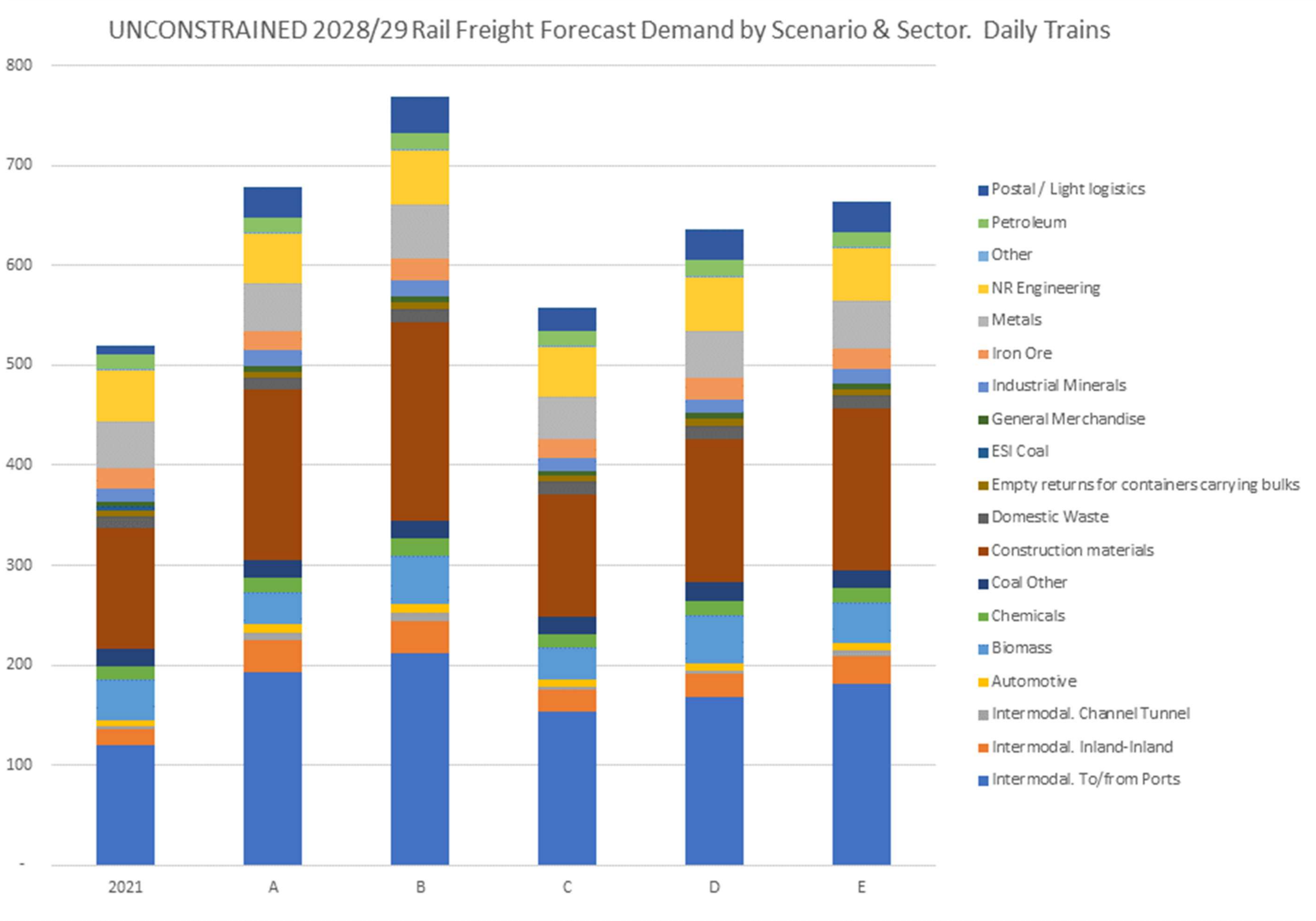

UNCONSTRAINED 2028/29 Rail Freight Forecast Demand by Scenario & Sector. Billion Tonne Kms
30
25
20
15
10
5
-
2021
A
B
C
D
E
Postal / Light logistics
Petroleum
Other
NR Engineering
Metals
Iron Ore
Industrial Minerals
General Merchandise
ESI Coal
Empty returns for containers carrying bulks
Domestic Waste
Construction materials
Coal Other
Chemicals
Biomass
Automotive
Intermodal. Channel Tunnel
Intermodal. Inland-Inland
Intermodal. To/from Ports

Figure 5


UNCONSTRAINED 2028/29 Rail Freight Forecast Demand by Scenario & Sector. Daily Trains
800
700
600
500
400
300
200
100
-
2021
A
B
C
D
E
Postal / Light logistics
Petroleum
Other
NR Engineering
Metals
Iron Ore
Industrial Minerals
General Merchandise
ESI Coal
Empty returns for containers carrying bulks
Domestic Waste
Construction materials
Coal Other
Chemicals
Biomass
Automotive
Intermodal. Channel Tunnel
Intermodal. Inland-Inland
Intermodal. To/from Ports

6. CAPACITY CONSTRAINT

The sections above described how we have produced our UNCONSTRAINED demand forecasts. However, there may be insufficient capacity on some parts of the rail network to accommodate the forecasts, given freight demand growth and aspirations to increase passenger trains too.

We have a generic method to estimate the indicative capacity of each junction. We therefore assign our forecast freight demand with the aspirational passenger trains to the network, and compare the traffic through each junction to its estimated capacity. This enables us to identify likely problematic junctions. We have also manually identified additional locations that may be over-capacity in future.

For each over-capacity junction, we have arrived at values for how much we should scale freight traffic down by. These values have been arrived at in consultation with Network Rail. This chapter describes these scale factor values.

6.1. Background

We constrained demand in our 2023/24 forecasts for Network Rail 5 years ago with a method summarised below:

- Manually identify several key junctions which are likely to be capacity constrained in future.
- Make an estimate of each junction's maximum freight capacity. For each junction in 2023/24 this capacity was taken as 20% higher than freight traffic in the base year.
- Constrain demand in line with this capacity by the following process:
  - Find the junction with the highest percentage over freight capacity
  - Scale down all freight trains through that junction throughout their route to reduce demand to match capacity
  - Re-calculate the traffic through each junction
  - Find the next junction with the highest percentage over freight capacity and scale down trains through that junction (and throughout their route)
  - Repeat this process until none of the identified junctions are over-capacity

The advantage of this approach was that it did not require any specific assumptions to be made about future passenger train levels, or an explicit calculation of capacity through each junction. However these simplifications reduced the robustness of the selection of the junctions and their future freight capacity estimates; it would be easy to overlook some junctions that could be capacity-constrained.

In our recent work for DfT on the potential freight-capacity benefits of HS2 and East-West Rail (and similar work for Transport for the North (TfN) on Northern Powerhouse Rail (NPR) and for Midlands

Connect), we have used a more robust estimate of freight capacity through most junctions in the network[9]. This relies on:

- Unconstrained rail freight demand forecasts
- Passenger train aspirations
- A future network definition in terms of junction capacities[10]

When overall (passenger + freight) demand exceeds capacity, we have taken the approach that passenger trains take priority, and freight trains must be scaled down to fit within the capacity unused by passenger trains. We have retained the assumptions on path utilization as indicated above; higher levels of path utilization would reduce the forecast rail freight volumes lost through capacity suppression.

We have sought guidance from the DfT as to what would be an appropriate passenger aspiration scenario for 2028/29. They suggested that the passenger aspiration timetable (SPG) files (“PfMv10 TSS”, version 28th May 2021) would be appropriate. The passenger scenario used is the “Do-Minimum” (“Committed Future Year services from 2029 onwards”, but no HS2).

6.2. Approach for 2028/29 rail freight forecasts

We have adopted this new calculation-based method (based on unconstrained forecast freight-plus-passenger demand and junction capabilities) to identify problematic junctions. This results in an estimate of how much scaling down of freight traffic is required at each junction (assuming passenger aspirations have priority over freight demand).

The calculated over-capacity junctions are shown below, along with the calculated scale-factors required to be applied to reduce traffic to the estimated capacity.

[9] This approach was presented with slides to Network Rail on 14th January 2021. These slides are given as an appendix to this report.

[10] This junction capacity estimate takes account of numbers of tracks through the junction, train service speed variation (more trains fit on a track if they’re all going the same speed), whether there is a flyover or not, the distance between passing opportunities, along with a generic approach to headways. However junction design and the traffic it is designed to cope with is quite varied. This generic approach is therefore a capacity estimate and cannot be relied upon to precisely predict real-world capacities for all junctions under all timetabling options.

Table 15: Over-capacity junctions in 2028/29 requiring scaling down of freight traffic. Scenario E (Central). Scale factors to be applied to reduce traffic to the estimated capacity.

Junction	Calculated scale factor to apply
Castlefield J	0.546
Digswell	0.662
Woolmer Green J	0.662
Clapham Jn	0.771
Ludgate Jn No 1	0.778
Southcote J	0.897
Nunnery Main Line Jn	0.944
Wincobank J	0.950

An additional factor is that the Castlefield Corridor is deemed full by Network Rail and so should not have any freight traffic growth.

Digswell and Woolmer Green J are on a very capacity constrained part of the ECML. However most freight bypasses this constraint by using the Hertford loop, so growth would be likely to use the Hertford loop rather than being suppressed. We therefore ignore this capacity constraint.

Clapham Jn and Ludgate Jn No. 1 are difficult to represent as standard junctions in the network. We retain Clapham Jn's scale factor and also apply it to Latchmere No. 2 junction.

Most freight avoids Nunnery Main Line Jn and Wincobank J by using the Old Road line to avoid Sheffield. Also the proposed scale down factors have minimal effect, so we ignore these junctions from the suppression.

We also adopt the principle that freight cannot be suppressed to a level below its current level, even if this implies that aspirational passenger plus current freight traffic exceeds capacity.

6.3. Manually chosen locations

There are several other locations that we believe are likely to be potentially capacity constrained, even though our generic modelling methodology does not explicitly identify them as over-capacity. The table below represents these locations. We have limited freight growth at these locations to either +5% or +10% above base year such that any growth above that is suppressed. This is similar to the approach of 5 years ago. However, given the increased capacity challenges across the network since the previous work, we have applied a 5% or 10% growth limit instead of the 20% growth limit of the previous work.

Table 16: Manually chosen capacity-constrained locations with their forecast freight demand growth from base year (2021) to Scenario E, and their manually chosen freight growth limits

Junction	Forecast Freight Path Demand Growth	Manually chosen freight growth limits
Camden Road W J	15%	10%
Forest Gate J	27%	5%
Woodgrange Park J	61%	10%
Kensal Green J	22%	10%
Ely	40%	5%
Water Orton	16%	10%
Carstairs S J – representing Northern WCML	57%	10%
Weaver J representing Winsford – Weaver J	40%	5%
Heathrow Airport J - representing GWML East of the junction	18%	5%
Stalybridge J representing the Diggle route	39%	5%

All of these junctions exceed their 5% or 10% growth limit in scenario E.

So taking on board the junctions we calculate to be over-capacity and the junctions we have manually added, the list of junctions with suggested freight scale factors is as follows:

Table 17: Junctions with their suggested freight scale factors for Scenario E

Junction	Scale factor to apply to forecast freight demand[11]
Castlefield J *	0.814
Clapham Jn	0.771
Latchmere No. 2	0.771
Southcote J	0.897
Woodgrange Park J	0.683
Carstairs South Jn - representing Northern WCML	0.702
Ely North J	0.750
Weaver J - representing Winsford – Weaver J	0.752
Forest Gate Jn	0.828
Stalybridge J - representing the Diggle route	0.756
Kensall Green Jn	0.899
Heathrow Airport J - representing GWML East of the junction	0.886
Camden Rd West Jn	0.958
Water Orton E	0.945

* For Castlefield J, the calculated scale factor (X 0.546) would have reduced traffic to below its base year level. We therefore adopt the scale factor to retain the base year level of freight traffic (X 0.814).

[11] Note that the scale factors need to be applied to the freight traffic such that the junction is not over capacity. For example Woodgrange Park J's 0.683 scale factor means that freight traffic through the junction has be multiplied by 0.683. I.e. it is reduced by 31.7%.

6.4. Other scenarios

We have presented results above for 2028/29 scenario E (Central forecast) and have arrived at a freight scale factor for each problematic junction. This is either adopting the automated approach (where we have assumed that passengers take priority), or the manual approach where we assume freight growth is limited to 5% or 10%.

Both the automated approach (with passengers taking priority) and the manual approach (+5% or +10% freight growth limit) effectively define the capacity available for freight irrespective of freight demand.

The other scenarios have higher or lower volumes of freight traffic demand across the network. These same junction capacity limits are used for the other scenarios.

6.5. Limitations to the capacity utilisation modelling

The capacity constraint methodology slides we presented to Network Rail on 14th January 2021 are given as an appendix to this report. This explains the methodology in the model. The footnote for section 6.1 above briefly summarises the approach.

The method can be easily applied to many junctions across the network, but because it is generic, it cannot replicate real-world capacities for all junctions under all timetabling options. There are several issues that do impact on capacity that are not incorporated in this method:

1. Signalling capabilities: A simple assumption is that signalling on the busiest routes is normally likely to allow trains through at 3 minute headways. In the long term in-cab signalling is likely to mean that all junctions are effectively well-signalled with low headways.
2. Speeds through junctions: The faster trains are travelling, the longer it takes to brake – therefore more time is required between trains. The slower trains are travelling, the longer it takes for long trains to pass - therefore more time is required between trains.
3. Non-standard junction designs: Some of the busiest sections of the railway are on approaches to major stations, where there are often many tracks and a wide variety of junction designs. This approach does not represent complex junction designs well.
4. Interacting junctions: Nearby junctions impinge upon each other and ideally should be considered together. For example Earlestown East & Earlestown West are dependent on each other, and should really be considered and measured together
5. It is difficult to consistently define the number of tracks on the joined route. Sometimes there is an extra track that soon disappears
6. It can be difficult to define passing opportunities and therefore the distance between them.
7. It does not deal with single-track sections well (e.g. Felixstowe branch line)
8. Gradients and bends. These affect the speed trains can travel at.

Overall, we believe this approach has value for giving an initial indication of junction capacity utilisation prior to more detailed timetable design work being done.

The capacity constrained junctions are identified by the model, and are then supplemented by the additional manually chosen junctions, before the capacity constraint part of the model is implemented. However when manually choosing the additional junctions, it is not practical to estimate junction capacities across the whole network. Therefore there may be parts of the network that are not being identified as problem areas which actually do struggle for capacity. The net result of this is to potentially slightly overstate the traffic that can fit on the network.

6.6. Example of a capacity-constrained calculation: Southcote Junction (South of Reading)

For our capacity calculations, our assumption is that passenger services will be operating in line with the “Do-Minimum” (“Committed Future Year services from 2029 onwards”, but no HS2) scenario from “PfMv10 TSS”, version 28th May 2021. This includes 258 trains through Southcote junction per day; 160 to/from the West and 98 to/from the South. Our unconstrained forecast rail freight demand (scenario E) is for 119.78 freight paths required through Southcote junction per day (64.59 to/from the South and 55.19 to/from the South.

Passenger trains are divided by **18** hours and 2 directions to give an approximate value for hourly day-time off-peak paths per direction. Similarly freight paths are divided by **27** hours and 2 directions to give an approximate value for hourly day-time off-peak paths per direction.

Figure 6: Southcote Junction traffic for capacity calculation

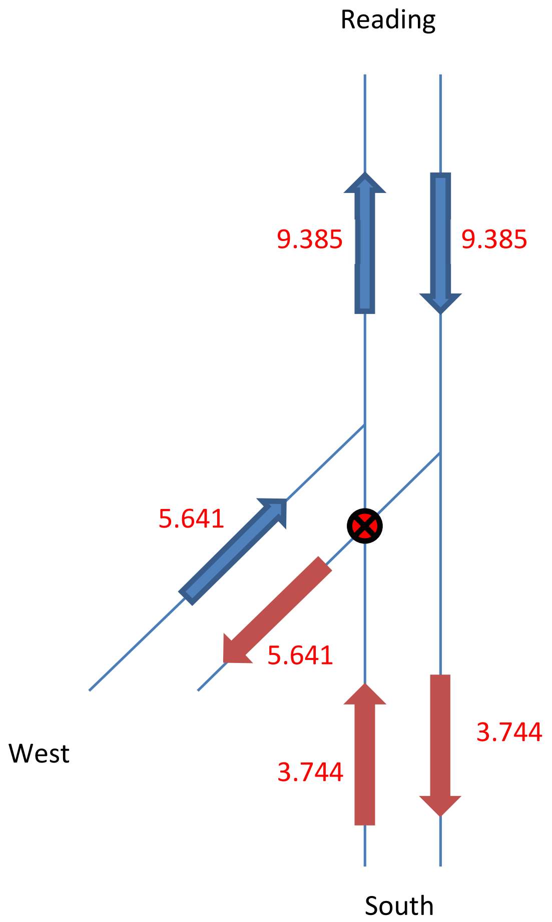


Table 18: Components of the traffic on each link (paths per hour per direction)

Route	West	South
Passenger	4.444	2.722
Freight 2028/29 Sc E	1.196	1.022
Total	**5.641**	**3.744**

The calculation of estimated junction capacity utilisation is as follows:

- Through conflict : 5.641 heading West + 3.744 heading North. But then we also need to add the Southbound 3.744 on the minor link because that also needs timetable space (assuming the timetable can't be optimized around this junction) = 13.13 quasi paths per hour (brown arrows)
- No flyover (which would remove the Southbound 3.744 from the conflict). Quasi paths remains: 13.13
- Variety of service speeds combined with length of track sections between passing opportunities increases quasi paths:

  Quasi paths X (1 + Standard deviation in mph X section length between passing opportunities in kms / 900)
- Std dev of service speeds = 21.8 mph. Section length = 30km (this is the standard value)
- Quasi paths = 13.13 X (1 + 21.8 X 30/900) = 22.67
- Number of tracks: 2 track railway to the North: No further scaling of quasi paths = 22.67
- We consider 20 to be indicative of the junction approaching capacity, with additional traffic challenging to accommodate. Therefore Southcote junction is considered over-full and therefore subject to capacity constraint.

7. SUMMARY RESULTS – AFTER CAPACITY CONSTRAINT

Section 5 showed the rail freight **demand** forecast results PRIOR to capacity constraint. This section shows the equivalent results AFTER capacity constraint. For tonne kms, an implied result for 2023/24 is estimated such that implied growth rates from 2023/24 to 2028/29 can be estimated.

Table 24 shows the suppression that had to be applied for each step of the suppression for scenario E.

Table 19: AFTER CAPACITY-CONSTRAINT: Rail freight TONNES forecast for 2028/29 scenarios by sector. THOUSAND tonnes per year. (2021 is unchanged)

Sector	2021	A	B	C	D	E
Intermodal. To/from Ports	15,632	19,160	19,242	17,747	17,922	18,588
Intermodal. Inland-Inland	2,134	3,094	2,925	2,596	2,475	2,885
Intermodal. Channel Tunnel	365	791	866	418	457	588
Automotive	207	214	221	188	189	213
Biomass	8,565	6,477	9,487	6,675	9,747	8,090
Chemicals	1,218	1,289	1,410	1,204	1,318	1,301
Coal Other	1,578	1,487	1,635	1,497	1,652	1,572
Construction materials	24,668	31,736	34,913	24,855	27,785	30,559
Domestic Waste	2,506	2,058	2,122	2,250	2,340	2,185
Empty returns for containers carrying bulks	378	311	317	341	351	329
ESI Coal	859	-	-	-	-	-
General Merchandise	626	604	619	660	673	620
Industrial Minerals	2,542	2,797	3,070	2,235	2,461	2,667
Iron Ore	3,857	3,664	4,050	3,664	4,050	3,857
Metals	7,487	7,709	8,349	7,040	7,721	7,922
NR Engineering	5,738	5,091	5,496	5,348	5,807	5,434
Other	31	27	29	29	31	29
Petroleum	3,651	3,493	3,814	3,418	3,732	3,599
Postal / Light logistics	260	630	716	558	665	647
Total AFTER CAPACITY-CONSTRAINT	**82,303**	**90,632**	**99,280**	**80,721**	**89,375**	**91,084**
Total UNCONSTRAINED	82,303	103,427	118,259	84,534	97,175	101,531
% able to run after constraint		87.6%	84.0%	95.5%	92.0%	89.7%

Table 20: AFTER CAPACITY-CONSTRAINT: Rail freight Tonne KILOMETRES forecast for 2028/29 scenarios by sector. MILLION tonne kilometres per year

Sector	2021	A	B	C	D	E
Intermodal. To/from Ports	5,388	6,656	6,695	6,118	6,209	6,436
Intermodal. Inland-Inland	1,022	1,393	1,307	1,193	1,124	1,308
Intermodal. Channel Tunnel	107	219	235	120	129	165
Automotive	50	44	44	43	42	45
Biomass	1,079	791	1,143	829	1,193	987
Chemicals	189	193	209	180	196	194
Coal Other	121	110	118	114	125	119
Construction materials	5,030	5,936	6,485	4,981	5,521	5,856
Domestic Waste	448	360	367	399	412	383
Empty returns for containers carrying bulks	74	63	65	68	71	67
ESI Coal	126	-	-	-	-	-
General Merchandise	183	177	181	194	197	182
Industrial Minerals	401	429	469	356	391	416
Iron Ore	131	125	138	125	138	131
Metals	1,471	1,451	1,543	1,366	1,486	1,511
NR Engineering	1,331	1,177	1,269	1,239	1,341	1,256
Other	9	7	8	8	9	8
Petroleum	871	827	901	815	889	857
Postal / Light logistics	113	218	248	193	230	224
Total AFTER CAPACITY-CONSTRAINT	**18,145**	**20,176**	**21,422**	**18,342**	**19,702**	**20,144**
Total UNCONSTRAINED	18,145	24,243	27,290	19,630	22,222	23,443
% able to run after constraint		83.2%	78.5%	93.4%	88.7%	85.9%

We have forecast 2028/29 scenarios, from a base year of 2021. We have not forecast intervening periods. However it is possible to calculate an implied compound annual growth rate (CAGR) for each sector to estimate 2023/24, and then work out the implied growth from 2023/24 to 2028/29 for each sector[12]. This implicitly assumes a steady annual growth rate, which might not transpire in practice. The table below shows this calculation for total tonne kms after capacity constraint for scenario E split by commodity/sector. The table below that shows the equivalently calculated totals for the other scenarios.

[12] Note that the maths of this calculation of implicit total 2023/24 traffic produces a slightly different result depending on how the cargo is disaggregated

Table 21: Forecast Constrained Rail Freight Tonne kms for Scenario E. Calculated implied CAGR and implied growth rate from 2023/24 to 2028/29. MILLION tonne kilometres per year

Sector	2021	2028/29	Implied CAGR	Implied 2023/24	Implied growth from 2023/24 to 2028/29
Intermodal. To/from Ports	5,388	6,436	2.48%	5,694	13.0%
Intermodal. Inland-Inland	1,022	1,308	3.46%	1,103	18.6%
Intermodal. Channel Tunnel	107	165	6.08%	123	34.3%
Automotive	50	45	-1.59%	48	-7.7%
Biomass	1,079	987	-1.21%	1,050	-5.9%
Chemicals	189	194	0.36%	191	1.8%
Coal Other	121	119	-0.26%	121	-1.3%
Construction materials	5,030	5,856	2.12%	5,273	11.1%
Domestic Waste	448	383	-2.12%	427	-10.2%
Empty returns for containers carrying bulks	74	67	-1.48%	72	-7.2%
ESI Coal *	126	-		87	-100.0%
General Merchandise	183	182	-0.12%	183	-0.6%
Industrial Minerals	401	416	0.51%	405	2.6%
Iron Ore	131	131	0.00%	131	0.0%
Metals	1,471	1,511	0.36%	1,484	1.8%
NR Engineering	1,331	1,256	-0.79%	1,307	-3.9%
Other	9	8	-1.52%	9	-7.4%
Petroleum	871	857	-0.22%	866	-1.1%
Postal / Light logistics	113	224	9.84%	140	59.9%
Total	**18,145**	**20,144**	**1.45%**	**18,713**	**7.6%**

* ESI coal is assumed to decline to zero in 2028/29 linearly because a CAGR cannot be calculated for a zeroing

Table 22: Implied Rail Freight Tonne kms growth rate from 2023/24 to 2028/29 for all constrained scenarios. MILLION tonne kilometres per year

Sector	A	B	C	D	E
2021	2021 base for all scenarios: 18,145				
2028/29 Constrained	20,176	21,422	18,342	19,702	20,144
Implied CAGR	1.47%	2.32%	0.15%	1.14%	1.45%
Implied 2023/24	18,694	19,066	18,179	18,600	18,713
Implied growth from 2023/24 to 2028/29	**7.9%**	**12.4%**	**0.9%**	**5.9%**	**7.6%**

Table 23: AFTER CAPACITY-CONSTRAINT: Rail freight DAILY TRAINS forecast for 2028/29 scenarios by sector

Sector	2021	A	B	C	D	E
Intermodal. To/from Ports	119.5	146.5	147.1	135.7	137.0	142.1
Intermodal. Inland-Inland	16.3	23.7	22.4	19.8	18.9	22.1
Intermodal. Channel Tunnel	2.8	6.0	6.6	3.2	3.5	4.5
Automotive	6.7	7.0	7.2	6.1	6.2	6.9
Biomass	39.8	30.1	44.1	31.0	45.3	37.6
Chemicals	13.7	14.5	15.9	13.6	14.9	14.7
Coal Other	17.8	16.8	18.5	16.9	18.7	17.8
Construction materials	119.8	154.2	169.6	120.7	135.0	148.4
Domestic Waste	12.5	10.3	10.6	11.2	11.7	10.9
Empty returns for containers carrying bulks	6.0	4.9	5.0	5.4	5.6	5.2
ESI Coal	3.4	-	-	-	-	-
General Merchandise	5.1	4.9	5.1	5.4	5.5	5.1
Industrial Minerals	13.6	15.0	16.4	12.0	13.2	14.3
Iron Ore	20.3	19.3	21.4	19.3	21.4	20.3
Metals	45.5	46.9	50.8	42.8	46.9	48.2
NR Engineering	51.4	45.6	49.2	47.9	52.0	48.7
Other	1.2	1.1	1.1	1.1	1.2	1.1
Petroleum	15.3	14.6	16.0	14.3	15.6	15.1
Postal / Light logistics	8.8	25.8	29.3	22.8	27.2	26.5
Total AFTER CAPACITY-CONSTRAINT	**520**	**587**	**636**	**529**	**580**	**589**
Total UNCONSTRAINED	520	678	769	558	636	664
% able to run after constraint		86.6%	82.8%	94.9%	91.2%	88.8%

Figure 7

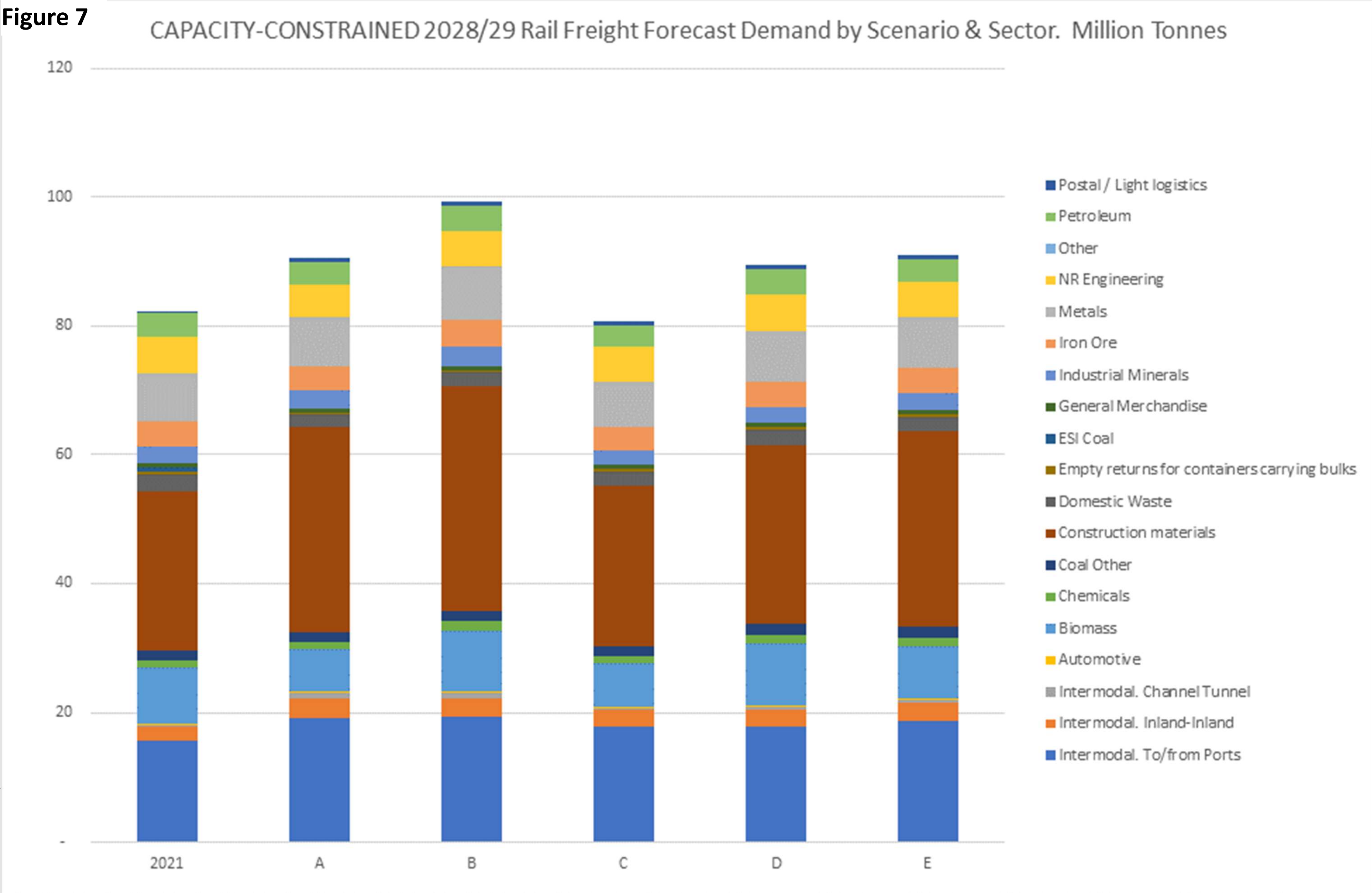

CAPACITY-CONSTRAINED 2028/29 Rail Freight Forecast Demand by Scenario & Sector. Million Tonnes
120
100
80
60
40
20
-
2021
A
B
C
D
E
Postal / Light logistics
Petroleum
Other
NR Engineering
Metals
Iron Ore
Industrial Minerals
General Merchandise
ESI Coal
Empty returns for containers carrying bulks
Domestic Waste
Construction materials
Coal Other
Chemicals
Biomass
Automotive
Intermodal. Channel Tunnel
Intermodal. Inland-Inland
Intermodal. To/from Ports

Figure 8

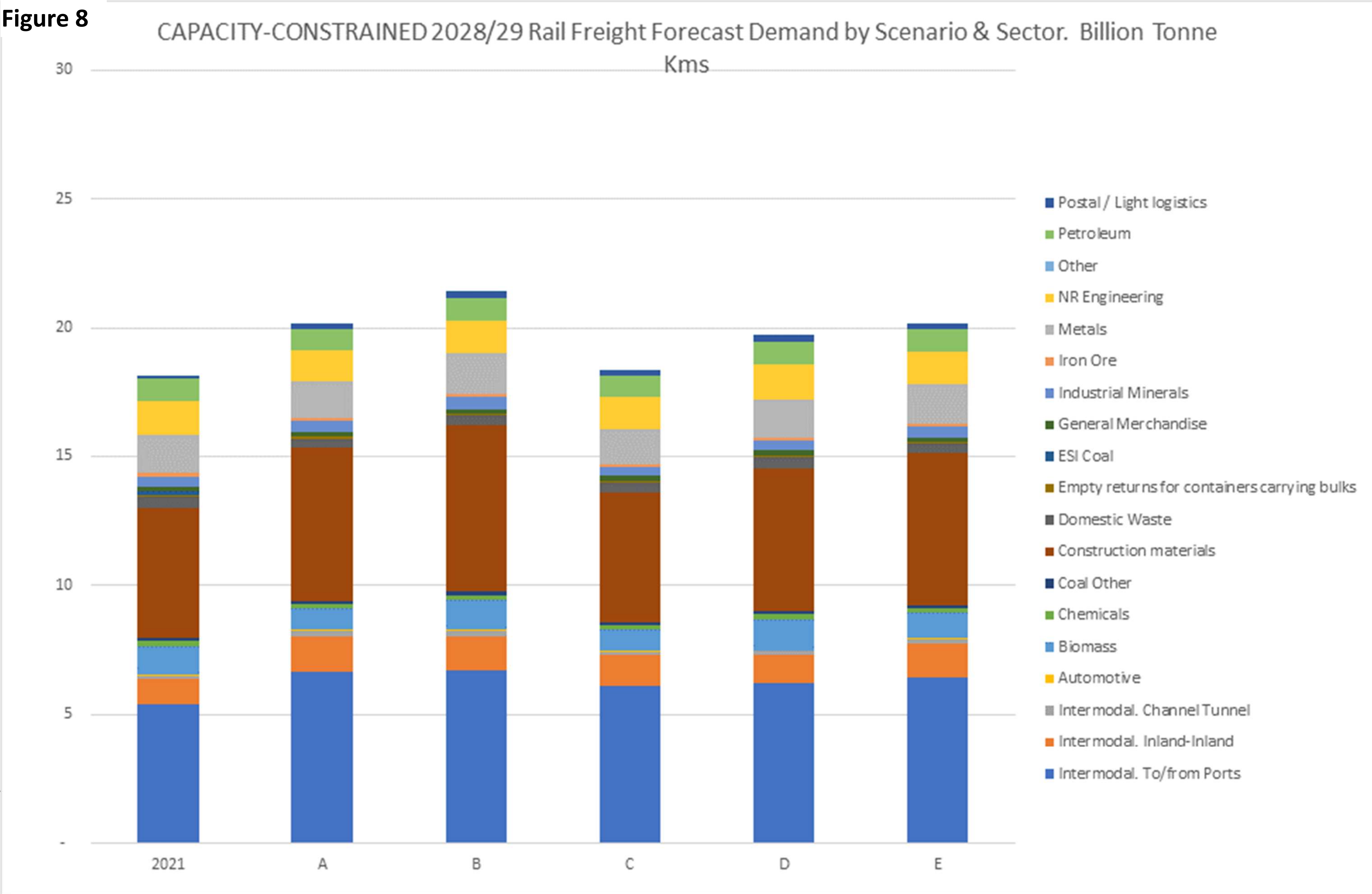

CAPACITY-CONSTRAINED 2028/29 Rail Freight Forecast Demand by Scenario & Sector. Billion Tonne Kms
30
25
20
15
10
5
-
2021
A
B
C
D
E
Postal / Light logistics
Petroleum
Other
NR Engineering
Metals
Iron Ore
Industrial Minerals
General Merchandise
ESI Coal
Empty returns for containers carrying bulks
Domestic Waste
Construction materials
Coal Other
Chemicals
Biomass
Automotive
Intermodal. Channel Tunnel
Intermodal. Inland-Inland
Intermodal. To/from Ports

Figure 9

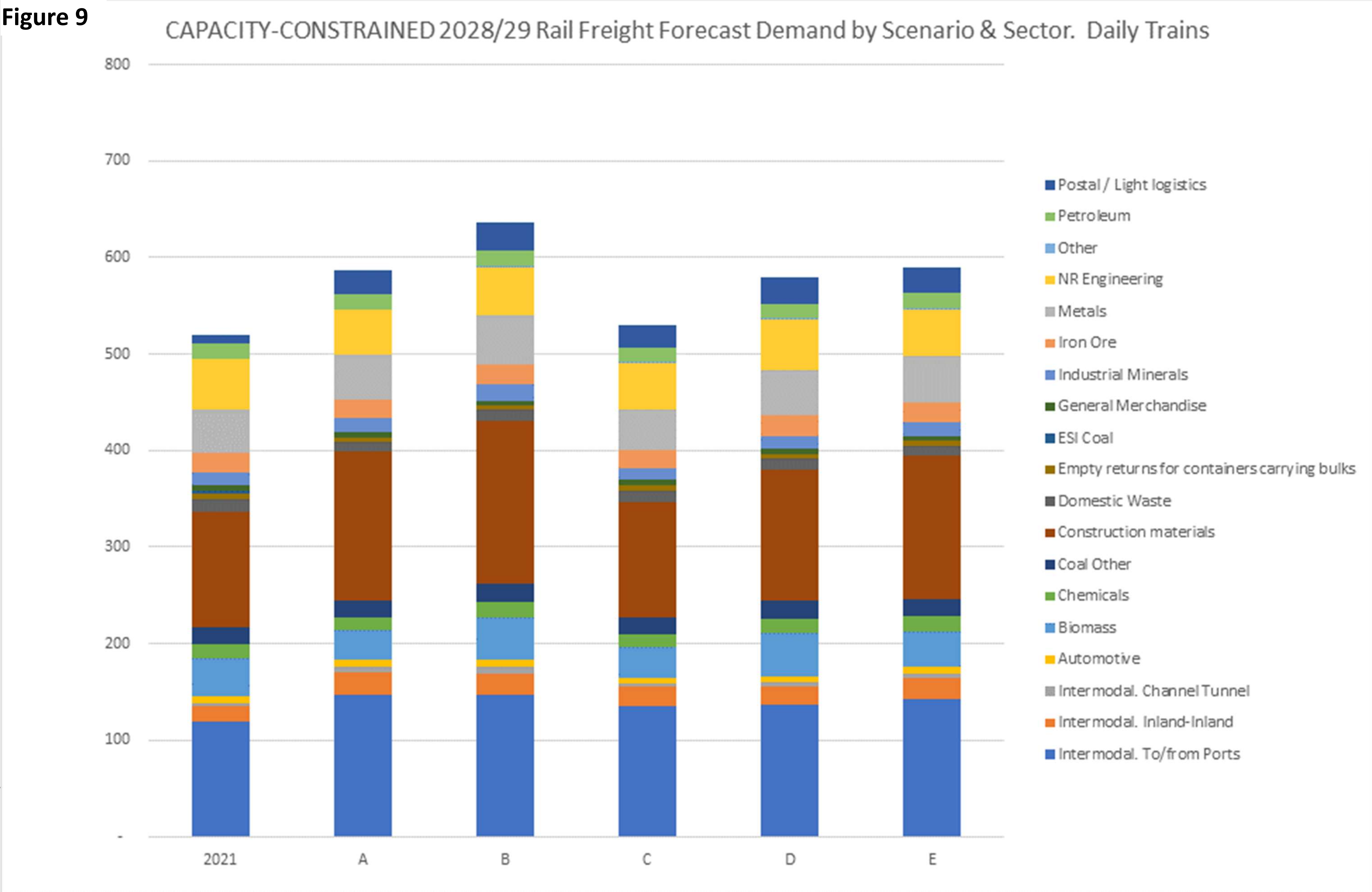

CAPACITY-CONSTRAINED 2028/29 Rail Freight Forecast Demand by Scenario & Sector. Daily Trains
800
700
600
500
400
300
200
100
-
2021
A
B
C
D
E
Postal / Light logistics
Petroleum
Other
NR Engineering
Metals
Iron Ore
Industrial Minerals
General Merchandise
ESI Coal
Empty returns for containers carrying bulks
Domestic Waste
Construction materials
Coal Other
Chemicals
Biomass
Automotive
Intermodal. Channel Tunnel
Intermodal. Inland-Inland
Intermodal. To/from Ports

Table 24: Junctions with the freight scale factors that had to be applied in Scenario E

Step	Junction	Scale factor applied to forecast freight demand
1	Woodgrange Park J	0.683
2	Carstairs S J – representing Northern WCML	0.705
3	Ely North J	0.751
4	Stalybridge J - representing the Diggle route	0.756
5	Clapham Jn	0.772
6	Latchmere No. 2	0.775
7	Weaver J representing Winsford – Weaver J	0.786
8	Castlefield J	0.906
9	Southcote J	0.916
10	Heathrow Airport J - representing GWML East of the junction	0.926
11	Water Orton E	0.9999

The largest scale-down from table 17 is applied first: X 0.683 for Woodgrange Park J. Applying this resolves the capacity issue at Forest Gate J, Kensall Green Jn and Camden Rd West Jn, so no further suppression is required through these junctions.

A small fraction of trains through Woodgrange Park J also travel through Carstairs S J and are therefore scaled down in the first stage, so in step 2 there is slightly less need to scale down the remaining Carstairs S J trains as compared to table 17 (prior to any suppression).

By step 8, many trains through Castlefield J have already been scaled down, so there is only limited need for further scale down as compared to table 17 (prior to any suppression).

For the final step, Water Orton E is very nearly resolved but still needs to lose 0.01% of its trains.

7.1. Consequences of the capacity constraint

If a junction has a lot of forecast demand growth through it, yet its capacity is limited, this leads to all the forecast traffic being suppressed to some extent – with existing traffic and the demand growth being treated equally. Therefore even if a junction's freight capacity may be increasing slightly, some existing traffic can be suppressed to allow some additional demand growth (also suppressed) to pass through. Therefore the suppression approach we have adopted can lead to some routes being suppressed below their base year levels, even if the *unconstrained demand* is increasing (or remaining stable). This can be seen in the summary results tables for some commodity groups as a whole; For example in scenario E, Automotive unconstrained demand (in tonne kms) increases by 15% from 2021 to 2028/29, but because much of this Automotive traffic is;

- along routes where other commodities (e.g. intermodal) have even greater demand growth

- and through capacity constrained junctions,

the Automotive traffic is supressed to below-2021 levels: an 11% decline from 2021 to 2028/29.

A similar effect can be seen if there is re-routing of demand prior to the capacity analysis. The industry advice upon which the demand forecast assignment was based was that a higher proportion of container traffic from Felixstowe (to reach 70%) was to be routed via Ely rather than via London. As a consequence, the further advice that Ely's capacity was likely to be limited to just an extra 5% has, cumulatively, led to the overall network capacity available from Felixstowe to be marginally reduced in our 2028/9 forecasts.

The consequent release of some capacity via London would allow container volumes from London Gateway to grow, which also reflects its growth in port capacity through the construction of an extra berth by 2028/9. That investment is likely to lead to some diversion between the ports and commercial pressure on the rail industry from the shipping lines for train capacity to also divert to reflect any switch in vessel sailings. This is reflected in our modelling, whereby overall port container traffics are forecasts to grow despite capacity constraints but traffic via Felixstowe to fall slightly.

8. ASSIGNMENTS TO THE RAIL NETWORK

It can be easier to visualise the impact of these forecasts by assigning the base year and forecast traffic to the rail network. It is often more meaningful to describe the number of freight trains on each route, rather than the tonnage. In terms of capacity and timetabling, the number of hourly paths required on each route is often the most useful means of quantifying rail freight demand.

All freight trains using the network are assigned to the network for each of the 365 days separately in the base year 2021. For each wagon on each individual train, the traffic is scaled up in line with the origin to destination by commodity tonnage forecasts. This ensures that for each train, the routing and the tonnes per train are maintained in the forecasts (i.e. base year routings are assumed to continue, apart from where they are actively re-routed[13]).

The maps show the routes that the trains actually take in the base year; primary routes as well as timetabled secondary and diversionary routes. For example for trains from Southampton to the West Midlands and beyond, the main route is via Winchester with many trains, and the main diversionary route is via Laverstock junctions with just a handful of trains. For all commodities, because the base year assignments include the diversionary routes, these same diversionary routes are included in the forecasts by default.

The exception to this is for new forecast intermodal services to/from new rail-served warehousing sites, because there are no base year trains to scale up. For intermodal trains, the current average cargo tonnage per train is 440 tonnes.

By default routes for new forecast intermodal services to/from new rail-served warehousing sites are assumed to be along the shortest path between origin and destination sites, along a route with a loading gauge of at least W8. Diversionary routes are not considered. However for various terminal to terminal flows, we have stipulated specific en-route 'via-points', to ensure that those routes are more realistic – with a preference for W10 routes.

The Oxford to Bletchley section of East West Rail is due to be in place by 2028/29 and we have routed some intermodal trains on to it. The Eastern section of East West Rail (Bedford – Cambridge) is not due to be completed by 2028/29.

[13] The material re-routing agreed with the industry in January 2020 consisted of:

- For all freight trains travelling between Ipswich and Nuneaton, 70% should be routed by via Peterborough and 30% should be routed via London.
- For all freight trains travelling between Peterborough and Doncaster, 75% should be routed by via Lincoln and 25% should be routed along the East Coast Main Line (ECML)

Once a freight train assignment has been made for each day in the base year and each forecast scenario and year, they can be averaged to give a daily average for each year. There are fewer freight trains on Saturdays, Sundays and on bank holidays, so to give a more representative picture of the typical weekday traffic volumes, all Saturdays, Sundays and bank holidays are discarded when calculating the daily average.

Figures 10 – 17 show daily trains (sum of both directions) **AFTER CAPACITY-CONSTRAINT** for:

- 2021
- 2028/29 Scenario A
- 2028/29 Scenario B
- 2028/29 Scenario C
- 2028/29 Scenario D
- 2028/29 Scenario E
- Range of 2028/29 scenarios: Scenario B (high) MINUS Scenario C (low)
- Growth from Base year (2021) to 2028/29 Scenario E (central)

Figure 10

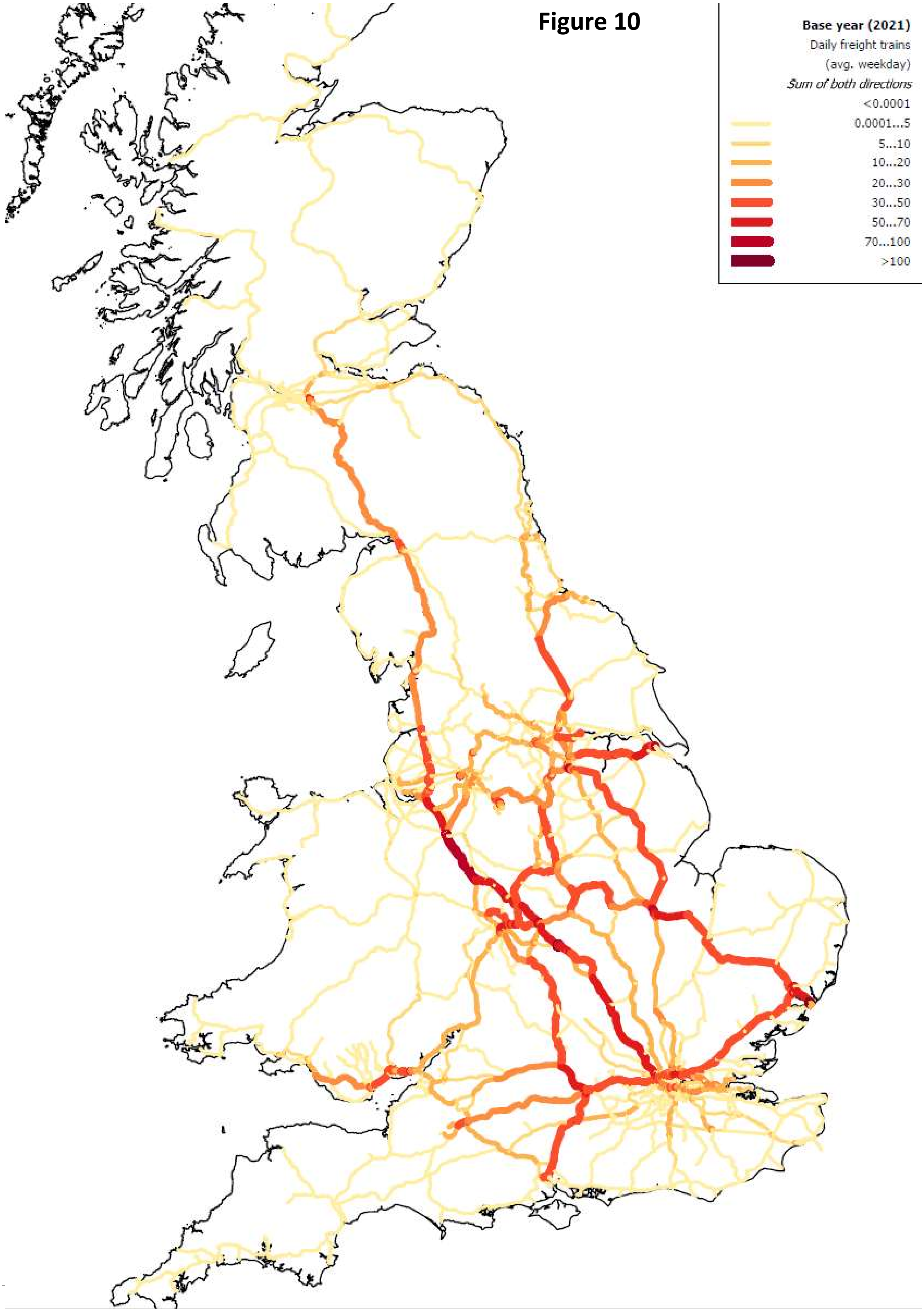

Base year (2021)
Daily freight trains
(avg. weekday)
Sum of both directions
<0.0001
0.0001...5
5...10
10...20
20...30
30...50
50...70
70...100
>100

Figure 11

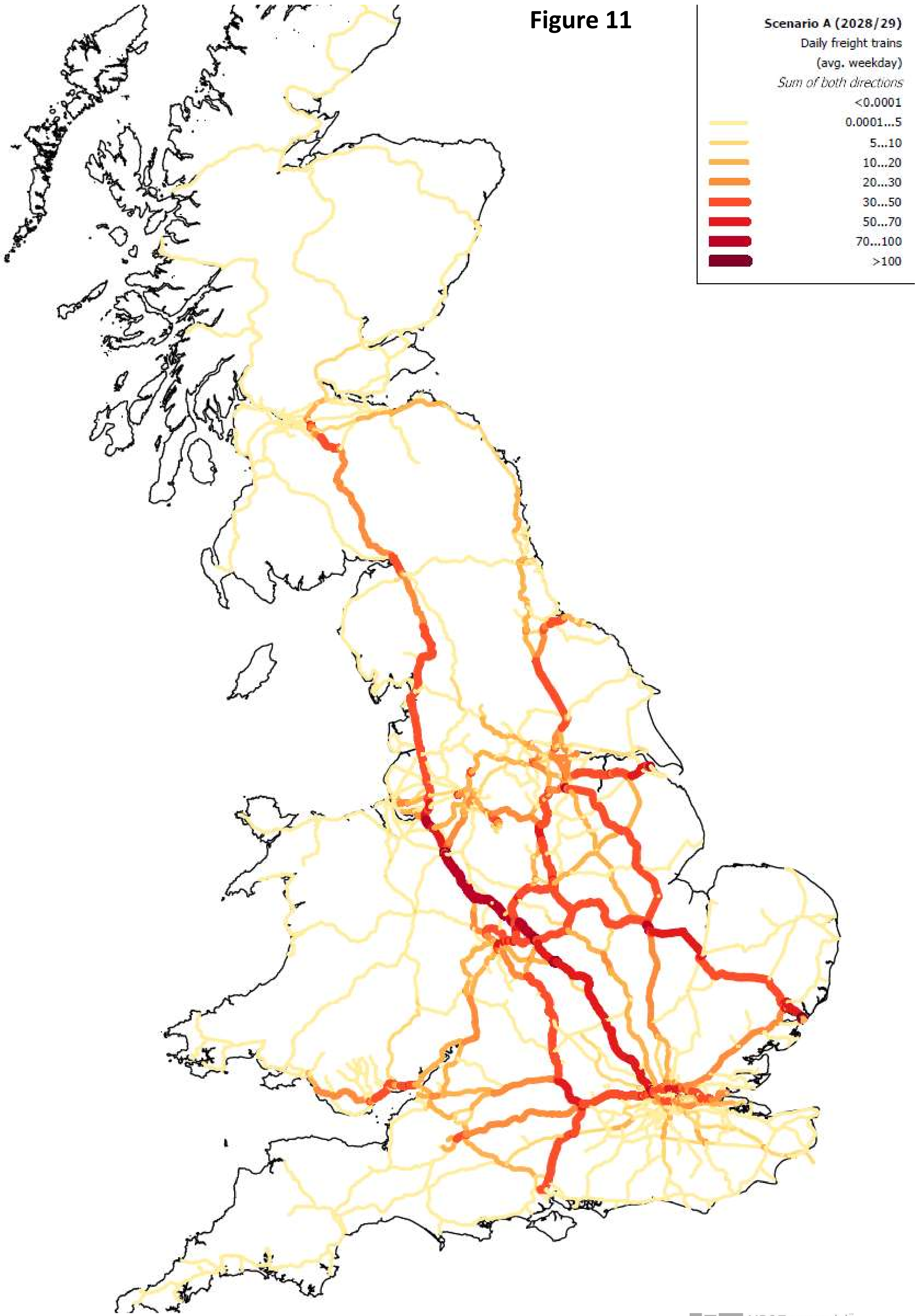

Scenario A (2028/29)
Daily freight trains
(avg. weekday)
Sum of both directions
<0.0001
0.0001...5
5...10
10...20
20...30
30...50
50...70
70...100
>100

Figure 12

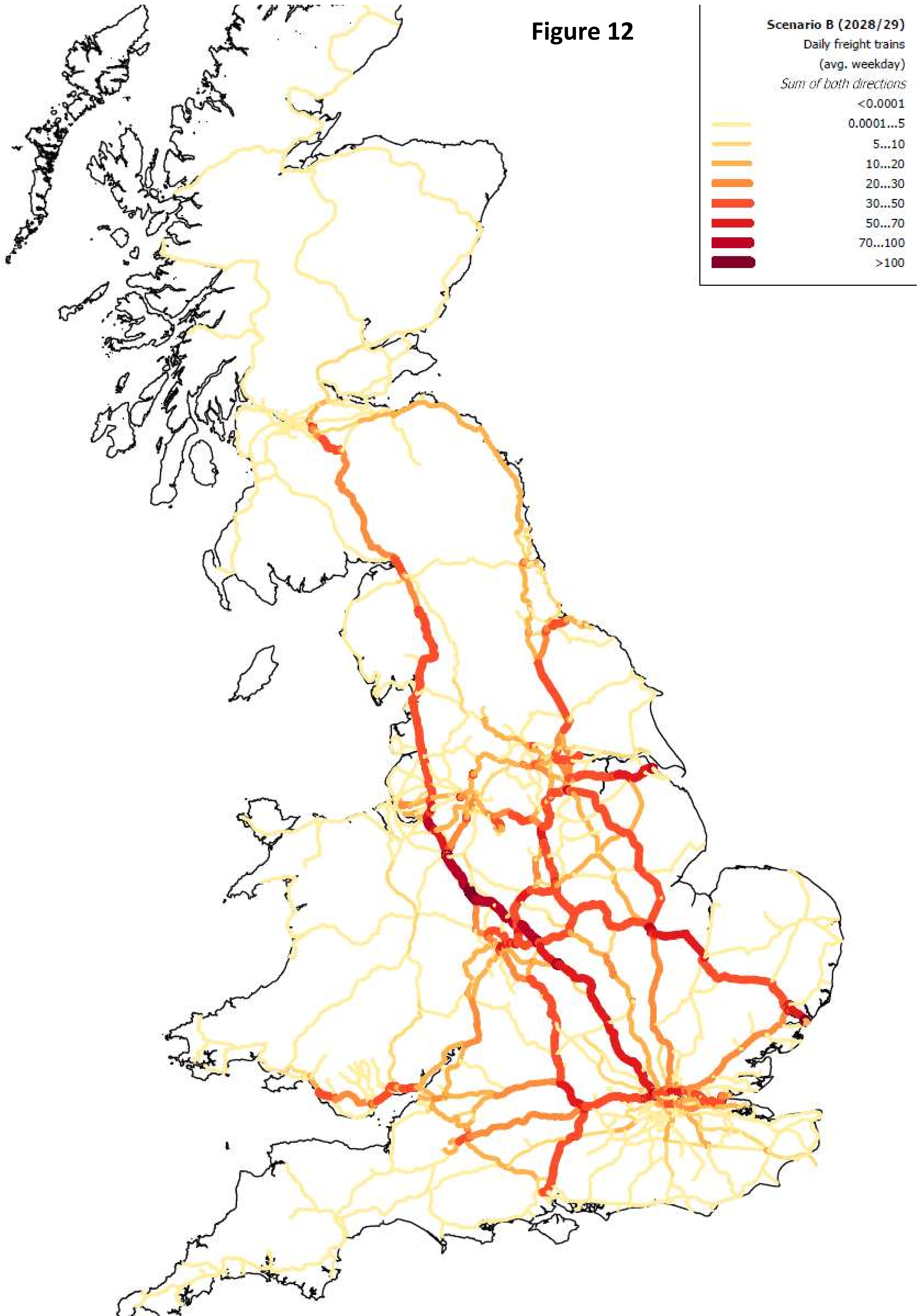
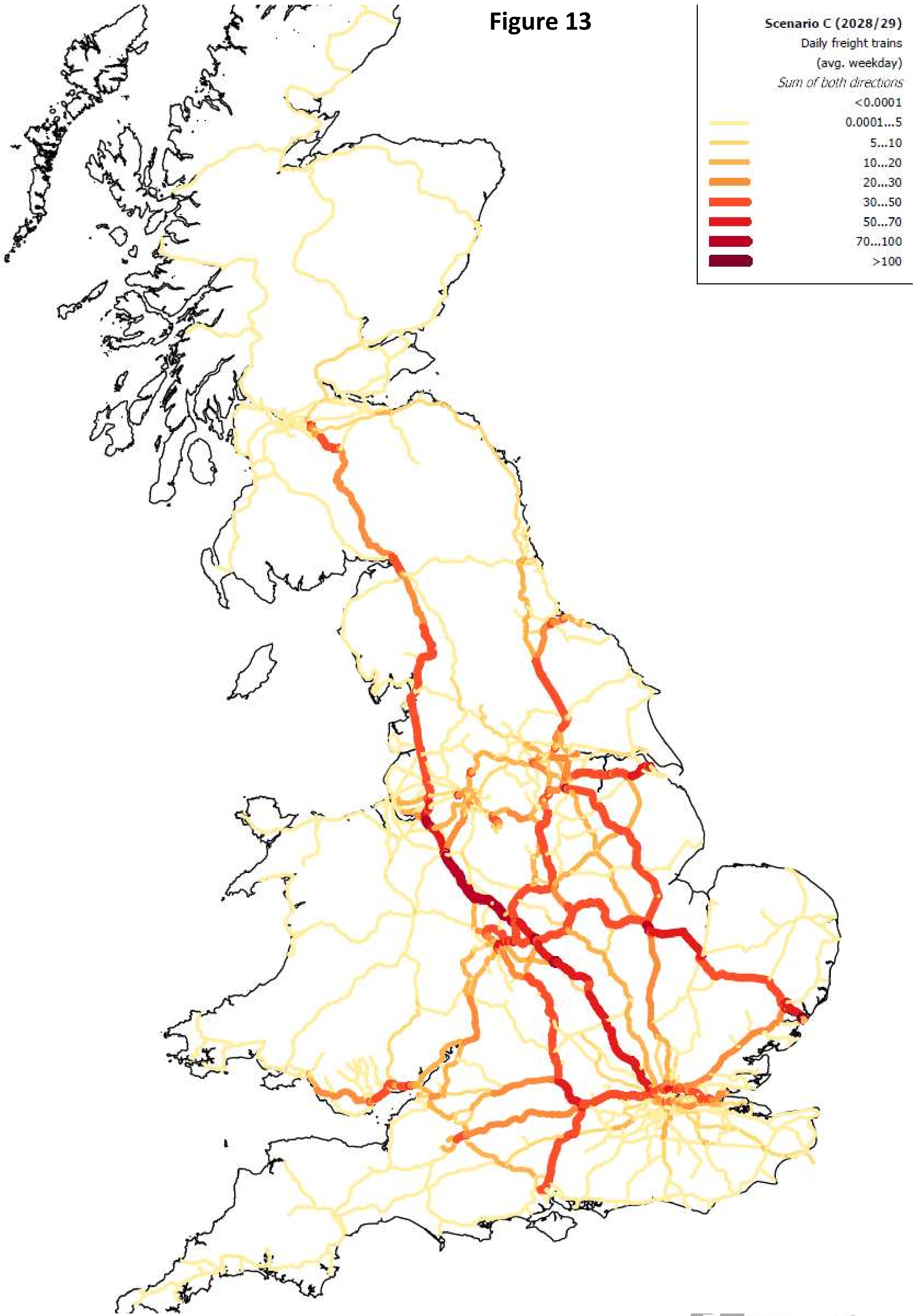

Scenario B (2028/29)
Daily freight trains
(avg. weekday)
Sum of both directions
<0.0001
0.0001...5
5...10
10...20
20...30
30...50
50...70
70...100
>100

Figure 13


Scenario C (2028/29)
Daily freight trains
(avg. weekday)
Sum of both directions
<0.0001
0.0001...5
5...10
10...20
20...30
30...50
50...70
70...100
>100

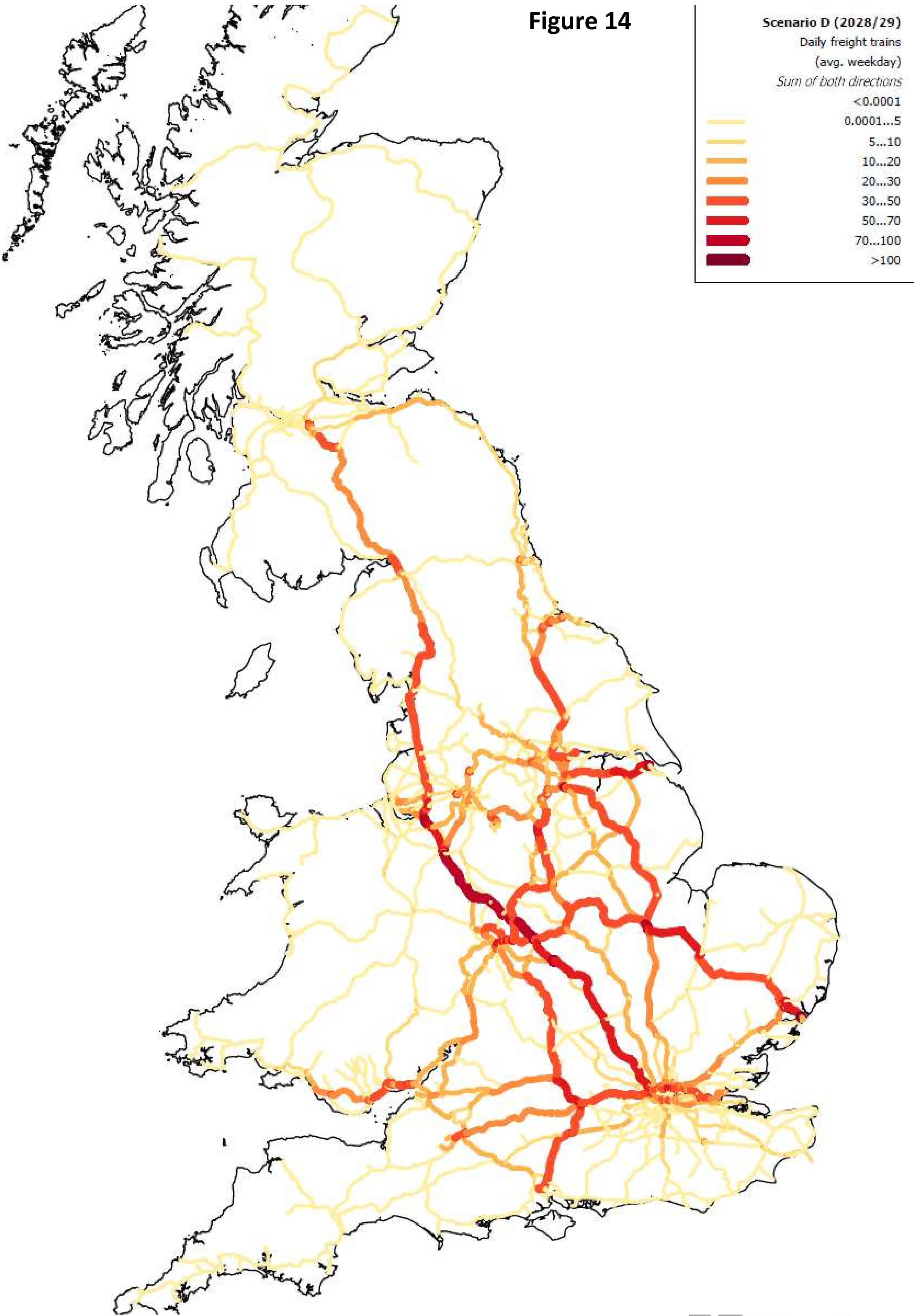


Figure 14
Scenario D (2028/29)
Daily freight trains
(avg. weekday)
Sum of both directions
<0.0001
0.0001...5
5...10
10...20
20...30
30...50
50...70
70...100
>100

Figure 15

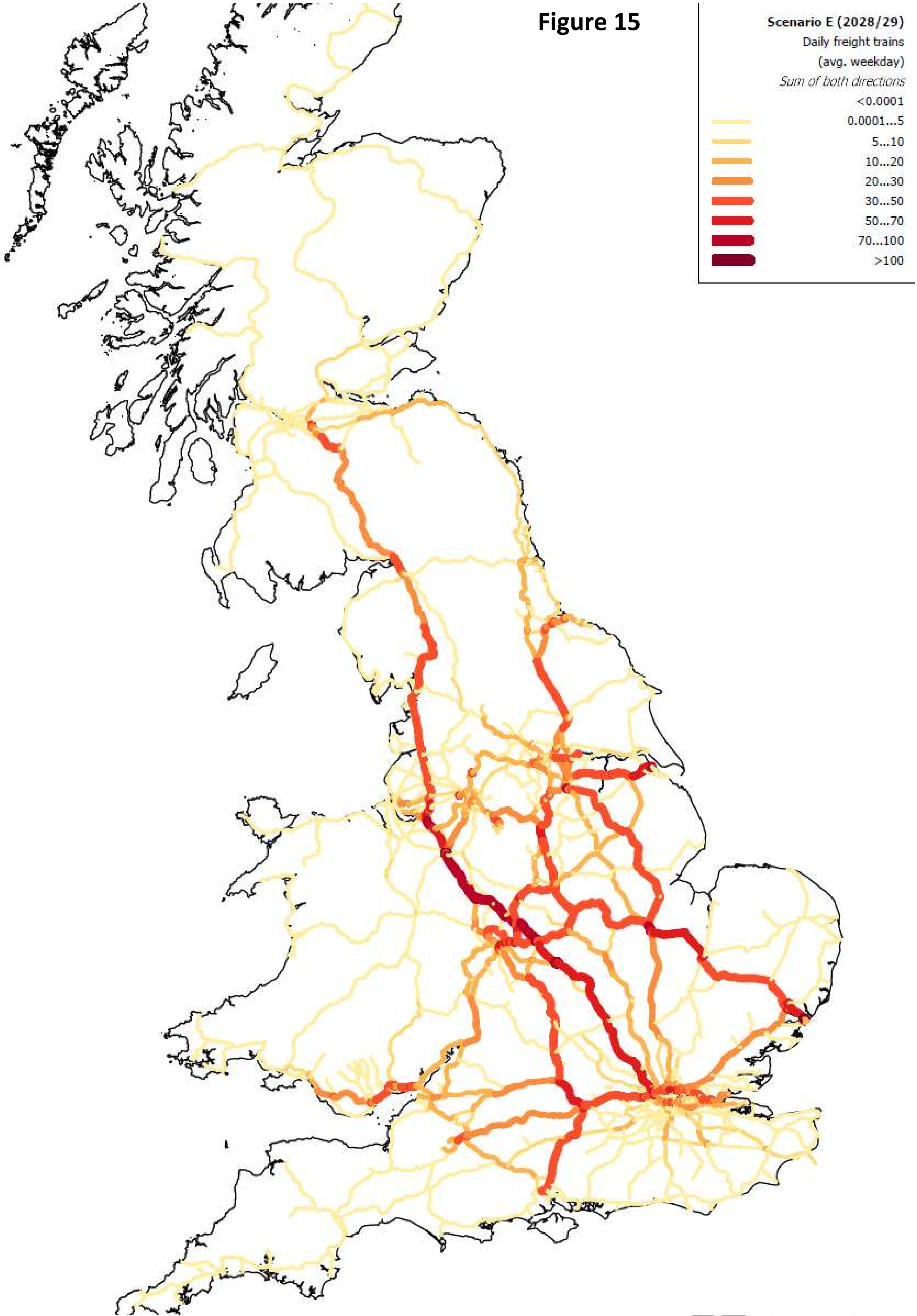

Scenario E (2028/29)
Daily freight trains
(avg. weekday)
Sum of both directions
<0.0001
0.0001...5
5...10
10...20
20...30
30...50
50...70
70...100
>100

Figure 16

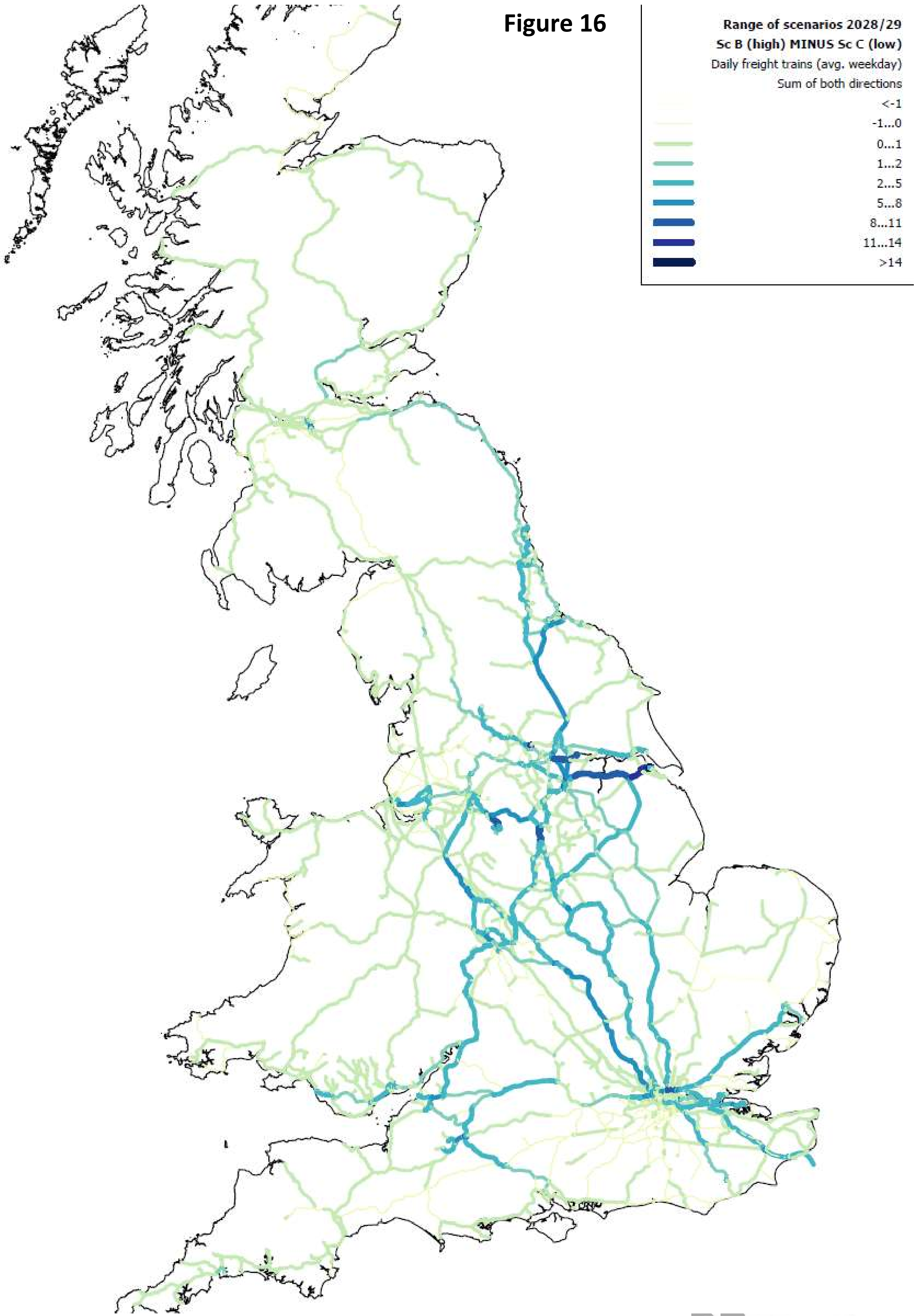
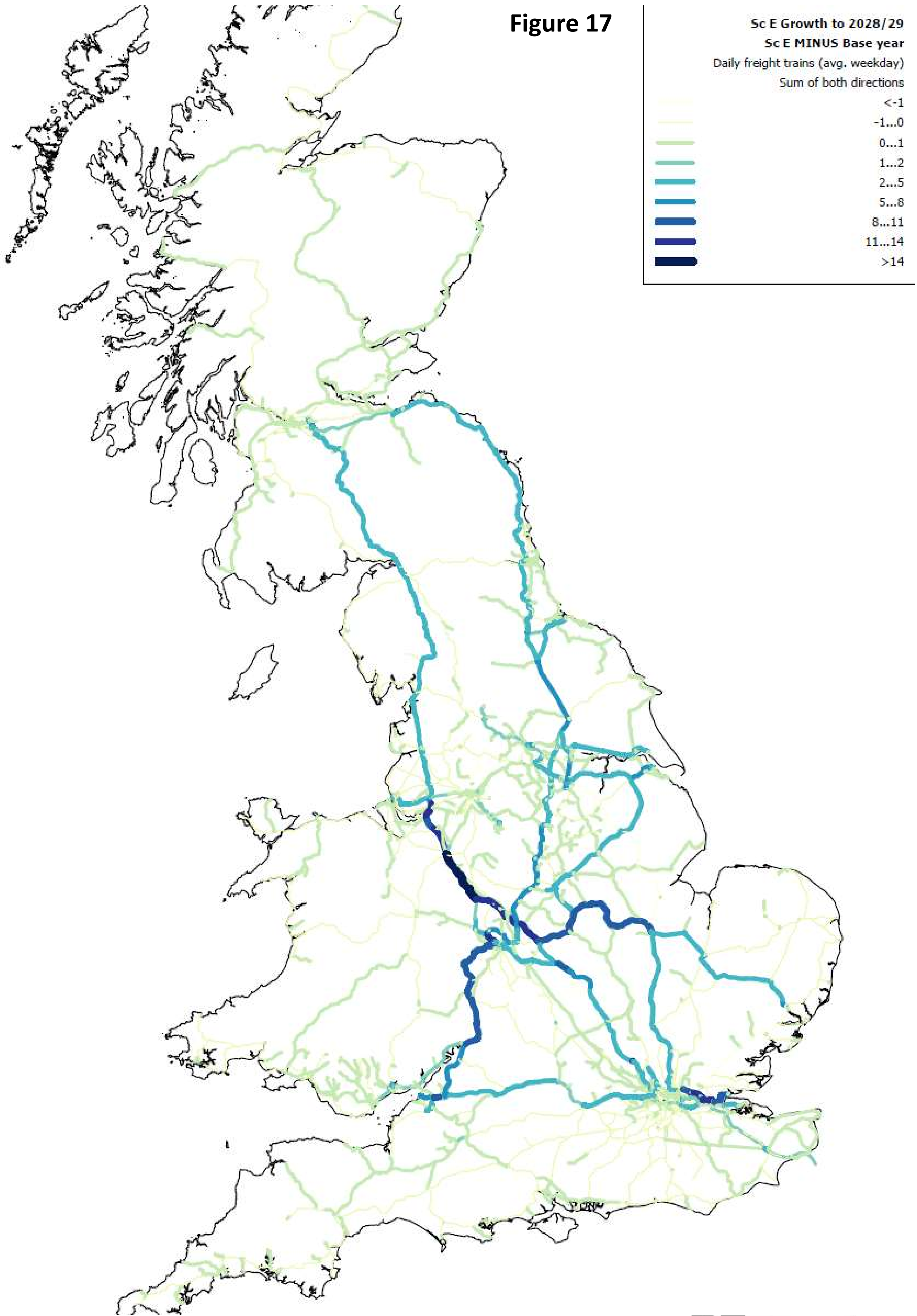

Range of scenarios 2028/29
Sc B (high) MINUS Sc C (low)
Daily freight trains (avg. weekday)
Sum of both directions
<-1
-1...0
0...1
1...2
2...5
5...8
8...11
11...14
>14

Figure 17


Sc E Growth to 2028/29
Sc E MINUS Base year
Daily freight trains (avg. weekday)
Sum of both directions
<-1
-1...0
0...1
1...2
2...5
5...8
8...11
11...14
>14

8.1. Splitting Tonne kms into regions

The freight train assignment enables the Tonne kms to be split into regions[14] as per the following table.

Table 25: Tonne kms (million) by region for base year (2021) and 2028/29 capacity constrained scenarios A-E

Scenario	Eastern	North West & Central	Scotland	Southern	Wales & Western	Grand Total	*England & Wales Total*
2021	7,459	5,686	1,029	1,276	2,695	**18,145**	*17,116*
A	8,236	6,448	1,199	1,365	2,929	**20,176**	*18,977*
B	8,884	6,750	1,263	1,422	3,103	**21,422**	*20,159*
C	7,425	5,912	1,098	1,214	2,692	**18,342**	*17,244*
D	8,123	6,230	1,153	1,277	2,920	**19,702**	*18,549*
E	8,268	6,396	1,188	1,327	2,964	**20,144**	*18,955*
Implied 2023/24, assuming a Compound Annual Growth Rate (CAGR)							
A	7,668	5,894	1,076	1,299	2,757	**18,694**	*17,618*
B	7,859	5,985	1,095	1,317	2,810	**19,066**	*17,971*
C	7,438	5,747	1,049	1,255	2,691	**18,179**	*17,130*
D	7,653	5,845	1,066	1,275	2,761	**18,600**	*17,534*
E	7,689	5,888	1,075	1,289	2,772	**18,713**	*17,638*
Implied Growth % from 2023/24 to 2028/29							
A	7.4%	9.4%	11.4%	5.1%	6.2%	**7.9%**	*7.7%*
B	13.0%	12.8%	15.4%	8.0%	10.4%	**12.4%**	*12.2%*
C	-0.2%	2.9%	4.7%	-3.2%	0.1%	**0.9%**	*0.7%*
D	6.1%	6.6%	8.2%	0.2%	5.7%	**5.9%**	*5.8%*
E	7.5%	8.6%	10.6%	2.9%	6.9%	**7.6%**	*7.5%*

[14] The daily train km regional splits from the assignments are used to approximately split the annual Tonne kms into regions for each scenario. The daily train km figures used for the splits *include* empty train movements after the delivery of cargo, but they *exclude* trains-with-wagons without identified cargo being transported ("No Commodity" trains), such as Railhead Treatment Trains.

9. DETAILED OUTPUTS

We have produced the detailed outputs for the capacity constrained scenarios. These follow a similar format to our previous 2023/24, 2033/34 and 2043/44 forecast outputs.

9.1. Capacity-constrained Tonnes, tonne kms and trains database-style spreadsheet:

A database-style spreadsheet with fields showing:

- Scenario (2021 or 2028/9 A, B, C, D or E)
- Origin terminal (Stanox code, name and region)
- Destination terminal (Stanox code name and region)
- Commodity or sector
- Annual Tonnes; capacity-unconstrained and capacity-constrained
- Annual Tonne kms; capacity-unconstrained and capacity-constrained
- Trains per weekday; capacity-unconstrained and capacity-constrained

9.2. Rail assignment maps

Rail assignment pdf maps (with accompanying GIS data) showing daily trains per weekday for the base year and each 2028/29 scenario (as per section 8).

9.3. Trains database (as a spreadsheet)

Detailed database-style spreadsheet showing the average number of trains per weekday on each network link by origin, destination and commodity group, with a GIS and pdf map to look-up the link IDs.

10. RAIL MARKET SHARES

In the base year (2021) there were 1.3 billion tonnes lifted and 143 billion tonne kms by road (source: DfT's Continuing Survey of Road Goods Transport (CSRGT)[15]). Therefore the base year rail mode share is 5.8% by tonnes and 11% by tonne kms.

Road traffic data for individual commodities / sectors is not always available in a consistent way to enable a direct comparison of road versus rail traffics. For example it is difficult to precisely define a road equivalent for rail's "domestic intermodal", and road data does not distinguish between ESI (power station) coal and "other coal".

However an indication of the road traffic and therefore rail's mode shares is given below for each rail sector. For the base year this is based on the rail data and the DfT's CSRGT. For 2028/29, the market is scaled up/down using the sectoral market growths described in the assumptions.

[15] At the time of writing, Road Freight Statistics 2021 was not yet released. 2021 figures are therefore based on 2020 commodity-specific results (table RFS0104) scaled up to estimates of 2021 based on overall HGV traffic growth from 2020 to 2021 (TRA2504b). This itself only includes traffic for the first 3 quarters of 2021. Historically, quarter 4 HGV traffic has been very similar to quarter 3, so we have assumed quarter 4 2021 was the same as quarter 3 2021.

Table 26: 2021. Million tonnes by road and rail by sector, and rail mode shares

Sector	Rail	Road	Total	Rail mode share	Notes
Automotive	0.2	28.3	28.5	0.7%	
Biomass	8.6	4.7	13.3	64%	1
Chemicals	1.2	49.2	50.5	2.4%	
Coal Other	1.6	5.2	6.8	23%	2
Construction materials	24.7	282.9	307.5	8.0%	
Empty returns for containers carrying bulks	0.4	0.0	0.4	100%	3
NR Engineering	5.7	0.0	5.7	100%	
ESI Coal	0.9	0.0	0.9	100%	4
Industrial Minerals	2.5	2.1	4.6	55%	5
Channel Tunnel Intermodal	0.4	0.0	0.4	100%	
Inland-Inland Intermodal	2.1	627.4	629.5	0.3%	6
Ports Intermodal	15.6	62.0	77.6	20%	7
Ores	3.9	0.0	3.9	100%	
Metals	7.5	26.2	33.7	22%	
Other	0.0	0.0	0.0	100%	8
Petroleum	3.7	41.9	45.6	8.0%	
Waste	2.5	158.2	160.7	1.6%	
Postal / Light logistics	0.3	41.9	42.2	0.6%	
General Merchandise	0.6	4.7	5.3	11.7%	9
Grand Total	**82.3**	**1,335**	**1,417**	**5.8%**	

Notes:

1. We have split the road tonnes of "Products of forestry and logging" between Biomass and General Merchandise
2. Some road coal may perhaps be to power stations
3. Not easy to find equivalent tonnage in road data
4. Some road coal may perhaps be to power stations, so the true rail share may be slightly lower than 100%
5. Difficult to define consistently with road data
6. Assumed to be the non-bulk cargoes, although difficult to consistently define for road
7. Road deduced from DfT's Port Freight Statistics minus transhipment and rail traffic. For Tonne km mode share, average length of haul for road is calculated based on adjusted CSRGT data
8. Difficult to define consistently
9. We have split the road tonnes of "Products of forestry and logging" between Biomass and General Merchandise

Table 27: Rail mode shares for the base year and 2028/29 scenarios. Tonnes

Sector	2021	A	B	C	D	E
Automotive	0.7%	0.8%	0.7%	0.7%	0.6%	0.7%
Biomass	64%	56%	63%	58%	65%	61%
Chemicals	2.4%	2.7%	2.7%	2.5%	2.5%	2.6%
Coal Other	23%	23%	23%	23%	23%	23%
Construction materials	8.0%	10%	9.6%	7.9%	7.7%	9.0%
Empty returns for containers carrying bulks	100%	100%	100%	100%	100%	100%
NR Engineering	100%	100%	100%	100%	100%	100%
ESI Coal	100%	0%	0%	0%	0%	0%
Industrial Minerals	55%	63%	63%	51%	51%	58%
Channel Tunnel Intermodal	100%	100%	100%	100%	100%	100%
Inland-Inland Intermodal	0.3%	0.5%	0.4%	0.4%	0.4%	0.4%
Ports Intermodal	20%	22%	20%	21%	18%	20%
Ores	100%	100%	100%	100%	100%	100%
Metals	22%	24%	24%	22%	22%	24%
Other	100%	100%	100%	100%	100%	100%
Petroleum	8.0%	8.1%	8.0%	7.9%	7.8%	7.9%
Waste	1.6%	1.3%	1.3%	1.5%	1.4%	1.4%
Postal / Light logistics	0.6%	1.6%	1.6%	1.4%	1.5%	1.5%
General Merchandise	11.7%	12%	11%	13%	12%	12%
Grand Total	**5.8%**	**6.4%**	**6.4%**	**5.7%**	**5.8%**	**6.2%**

Note: For derivation of 2021 figures, see table 26

Table 28: 2021. Billion tonne kilometres by road and rail by sector, and rail mode shares

Sector	Rail	Road	Total	Rail mode share
Automotive	0.1	3.5	3.6	1.4%
Biomass	1.1	0.7	1.7	62%
Chemicals	0.2	7.1	7.3	2.6%
Coal Other	0.1	0.5	0.6	21%
Construction materials	5.0	20.7	25.7	19.6%
Empty returns for containers carrying bulks	0.1	0.0	0.1	100%
NR Engineering	1.3	0.0	1.3	100%
ESI Coal	0.1	0.0	0.1	100%
Industrial Minerals	0.4	0.1	0.5	74%
Channel Tunnel Intermodal	0.1	0.0	0.1	100%
Inland-Inland Intermodal	1.0	72.9	73.9	1.4%
Ports Intermodal	5.4	12.3	17.7	31%
Ores	0.1	0.0	0.1	100%
Metals	1.5	3.1	4.6	32%
Other	0.0	0.0	0.0	100%
Petroleum	0.9	4.1	5.0	17.5%
Waste	0.4	10.7	11.1	4.0%
Postal / Light logistics	0.1	6.5	6.6	1.7%
General Merchandise	0.2	0.7	0.8	21.8%
Grand Total	**18.1**	**142.8**	**160.9**	**11.3%**

See notes to above table 26

Table 29: Rail mode shares for the base year and 2028/29 scenarios. Tonne Kilometres

Sector	2021	A	B	C	D	E
Automotive	1.4%	1.3%	1.2%	1.3%	1.1%	1.2%
Biomass	62%	52%	58%	55%	61%	57%
Chemicals	2.6%	2.8%	2.7%	2.6%	2.6%	2.7%
Coal Other	21%	20%	20%	21%	21%	21%
Construction materials	19.6%	23%	21%	19%	18%	21%
Empty returns for containers carrying bulks	100%	100%	100%	100%	100%	100%
NR Engineering	100%	100%	100%	100%	100%	100%
ESI Coal	100%					
Industrial Minerals	74%	84%	83%	70%	69%	77%
Channel Tunnel Intermodal	100%	100%	100%	100%	100%	100%
Inland-Inland Intermodal	1.4%	1.9%	1.7%	1.6%	1.5%	1.7%
Ports Intermodal	31%	34%	30%	31%	28%	31%
Ores	100%	100%	100%	100%	100%	100%
Metals	32%	33%	32%	31%	31%	33%
Other	100%	100%	100%	100%	100%	100%
Petroleum	17.5%	18%	17%	17%	17%	17%
Waste	4.0%	3.4%	3.1%	3.8%	3.5%	3.4%
Postal / Light logistics	1.7%	3.5%	3.6%	3.1%	3.3%	3.4%
General Merchandise	21.8%	22%	21%	24%	22%	22%
Grand Total	**11.3%**	**13%**	**12%**	**11%**	**11%**	**12%**

Note: For derivation of 2021 figures, see table 28

11. CONCLUSION

This report describes rail freight forecast demand results for 5 different 2028/29 scenarios spanning factors favouring rail to factors disfavouring rail, and low market growth to high market growth. These are presented in terms of tonnes, tonne kms, and daily trains.

These demand forecasts are then suppressed through junctions expected to be over-capacity in 2028/29. Table 30 summarises the forecasts and the impact of capacity constraint.

Table 30: Rail freight forecasts for 2028/29 scenarios, unconstrained and after constraint

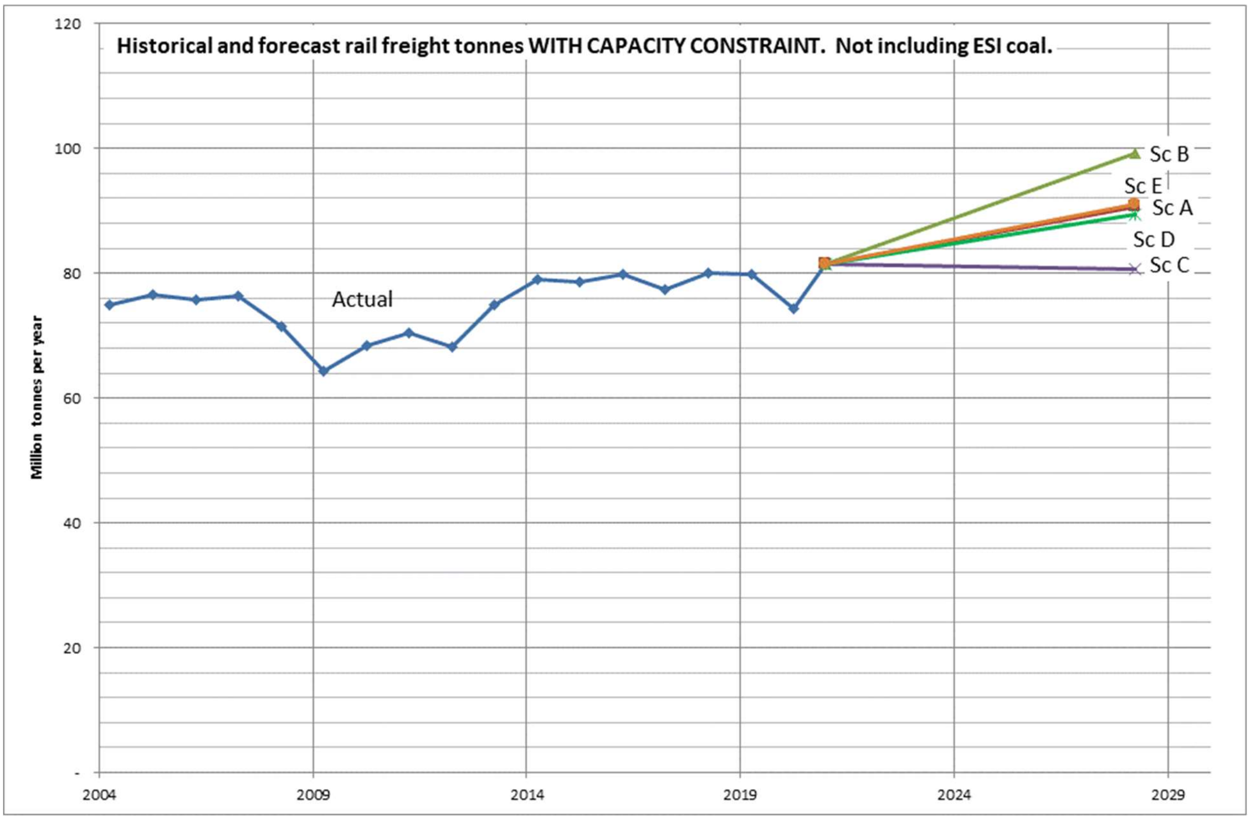
	2021	A	B	C	D	E
UNCONSTRAINED demand						
Tonnes (thousand)	82,303	103,427	118,259	84,534	97,175	101,531
Tonne kms (million)	18,145	24,243	27,290	19,630	22,222	23,443
Trains per weekday	520	678	769	558	636	664
AFTER capacity-constraint						
Tonnes (thousand)	82,303	90,632	99,280	80,721	89,375	91,084
Tonne kms (million)	18,145	20,176	21,422	18,342	19,702	20,144
Trains per weekday	520	587	636	529	580	589
% of demand able to run after constraint						
Tonnes		87.6%	84.0%	95.5%	92.0%	89.7%
Tonne kms		83.2%	78.5%	93.4%	88.7%	85.9%
Trains per weekday		86.6%	82.8%	94.9%	91.2%	88.8%
% Growth from 2021 after capacity constraint						
Tonnes		10.1%	20.6%	-1.9%	8.6%	10.7%
Tonne kms		11.2%	18.1%	1.1%	8.6%	11.0%
Trains per weekday		13.0%	22.4%	1.9%	11.5%	13.4%

The impact of capacity constraint has a much greater impact on the higher traffic scenarios – particularly scenario B (high market growth and factors which favour rail relative to road), where 16% of tonnes (21% of tonne kms) are suppressed. This is compared to scenario C (low market growth and factors which disfavour rail relative to road) where just 4% of tonnes (7% of tonne kms) are suppressed. This is because low growth can often be accommodated, and it's the higher growth that pushes junctions over their capacity and triggers capacity constraint.

We would expect more suppression when measured in tonne kms than in tonnes; the longer the journey, the more likely it is to pass through an over-capacity junction and be suppressed.

ESI (power station) coal has historically been a volatile commodity – dominating rail freight in the 2000s. It is now at a low level and is forecast to no longer be carried by rail in these scenarios. The graph below shows the recent historical trend of rail traffic tonnes, along with the new scenarios but with ESI coal excluded.

Figure 18



These capacity-constrained forecasts show:

- A variety of potential outcomes for the 5 scenarios tested.
- Growth focussed on
    - Intermodal; driven by:
        - The building of rail-served warehousing sites
        - Continued non-bulk trade growth
        - More favourable rail economics vs road
    - Construction; driven by:
        - Expected market growth
        - New sea-dredged aggregates flows from ports to inland terminals
        - More favourable rail economics vs road

The report describes the assumptions and methods for the various sectors, along with a market share analysis and the forecast results, both unconstrained and capacity-constrained.

These 2028/29 forecasts demonstrate that differences in exogenous circumstances can have a large impact on the rail freight industry, with the total forecast rail freight tonnage ranging from 81 million tonnes in scenario C to 99 million tonnes in scenario B. Scenario E (central scenario) results in 91 million tonnes. This is equivalent to a 1.4% growth per year from 2021 or a 1.6% growth per year if ESI coal is excluded.

Fuel prices in particular impact on rail's ability to compete with road – with high fuel prices adversely affecting road more than rail, thus encouraging a switch from road to rail. Drivers' wages are also important, as is the development of rail-served warehousing for intermodal traffic.

It should be noted that the model implicitly includes the assumption that the market will have fully adapted to the market conditions input into the model. However in the real world, many of the investments in assets are long-term – which gives the rail freight sector some inertia. For example, in the high growth scenarios, the wagon supply could struggle to keep pace with growing demand, and terminal capacity could be challenged in some areas.

There are many uncertainties in forecasting rail freight demand. We intend that the "low" and "high" scenarios cover the likely outcomes, although the low should not be considered to be the lowest possible outcome. Similarly the high should not be the highest possible outcome, albeit some of the higher demand would be choked off by the capacity constraints.

We have described the method for applying the capacity constraint, involving combining our forecast freight demand with assumptions on future passenger demand, and estimates on the capacity of each major junction in the network. We believe that this is a pragmatic way of approximately representing and applying capacity constraints across the whole network for a series of scenarios without having to conduct multiple timetabling exercises across the network. However there are uncertainties for all of the inputs into the calculation.

APPENDIX: CAPACITY CONSTRAINT METHODOLOGY SLIDES PRESENTED TO NETWORK RAIL