Office of Rail Regulation and Network Rail

Part A Reporter Mandate AO/030: PR13 Maintenance & Renewals Review

Policy and WLCC Model Review

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Contents

Glossary

ADAS	Data from a walkover survey of 65% of the Network (not including Wessex and Wales)
AMCL	Asset Management Consulting Limited
AMEM	AMCL Asset Management Excellence Model ¬TM
AMP	Asset Management Plan
ARL	Asset Remaining Life
ARS	Average Risk Score
ASI	Asset Stewardship Indicator
BCAM	Bridges Condition Asset Management
BCMI	Bridge Condition Marking Index (previously SCMI: Structure Condition Marking Index).
BRE	Building Research Establishment
BSL	Basic Safety Limit
CAF	Cost Analysis Framework
CAPEX	Capital Expenditure
CARRS	Civil Asset Register and electronic Reporting System.
CaSL	Cancelations and Significant Lateness Measure
CaSL	Cancelled and Seriously Late
CeCASE	Civil Engineering Cost And Strategy Evaluation
CECOST/CeCost	Civil Engineering Cost Modelling Structures Model (Tier 1 ICM for bridge structures)
CEFA	Civil Examination Framework Agreement
CET	Controlled Emission Toilet
CM	Coating Metallic / Cracked Masonry
CP4	Control Period 4 – April 2009 – March 2014
CP5	Control Period 5 - April 2014 – March 2019
DAMP	Drainage Asset Management Plan
DC	Direct Current
DfT	Department for Transport
DMP	Drainage Management Plan
DRAM	Director of Route Asset Management
DST	Decision Support Tool
E&P	Electrical and Power
EGT	Equivalent Gross Tonnage
ELLIPSE	planning and works management system

FMECA	Failure mode, effects and criticality analysis
FTN	Fixed Telecommunications Network
GEOGIS	Geographical Information System (track asset database)
GPR	Ground Penetrating Radar
GSM-R	Global Systems for Mobile Communications on the Railway
GTG	Good Track Geometry
HAM	Head of Asset Management (applies for each engineering discipline)
HD GPR	High Definition Ground Penetrating Radar
HLOS	High level Output Specification
HS1	High Speed 1
IDP	Integrated Drainage Project
IIP	Initial Industry Plan 2011
IP	Investment Projects
KPI	Key Performance Indicator
LADS	Linear Asset Decision Support
LMD	Light Maintenance Depot
LMDSM	Light Maintenance Depot Stewardship Measure
LNW	London North Western (Route)
LoBEG	London Bridges Engineering Group
LTSF	Local Track Selection Factor
M&R	Maintenance and Renewal
MAA	Moving Annual Average
MDU	Maintenance Delivery Unit
MEW	Minor Emerging Works
MRHI	Mineworkings Residual Hazard Index
MUC	Maintenance Unitised Cost
NDS	National Delivery Services
NERRP	National Earthworks Risk Reduction Programme
NPC	Net Present Cost
NPV	Net Present Value
NR	Network Rail
OPAS	Operational Property Asset System
OPEX	Operational Expenditure
ORBIS	Offering Rail Better Information Services
ORR	Office of Rail Regulation
PARL	Percentage Asset Remaining life
PL	Plain Line (track without switches and crossings)

PLBE	Principal Load bearing Element
PLPR	Plain Line Pattern Recognition
PoaP	Policy on a Page
POG	Planning Oversight Group (a Group which involves representatives of Network Rail, passenger and freight train operators and suppliers)
PPM	Public Performance Measure
PPM	Planned Preventative Maintenance
RA	Route Availability
RAM	Route Asset Manager (applies for each engineering disciplines)
RAMP	Route Asset Management Plan
RDMS	Rail Defect Management System
RSHI	Rock Slope Hazard Index
RSSB	Railway Safety and Standards Board
RUS	Route Utilisation Strategies
S&C	Switches and Crossings
SAF	Service Affecting Failures
SBP	Strategic Business Plan
SCAnNeR	Strategic Cost Analysis for Network Rail (Tier 1 ICM for Earthworks and Drainage assets)
SCMI	Structures Condition Marking Index
SevEx	Severity and Extent (used in bridge condition marking)
SoFA	Statement of Funds Available
SoS	Secretary of State for Transport (England & Wales)
SQUIRE	Service Quality Inspection Regime
SRM	Safety Risk Model
SRS	Strategic Route Section
SSHI	Soil Slope Hazard Index
SSM	Station Stewardship Measure
SSME	Senior Structure Maintenance Engineer
TCMI	Tunnel Condition Marking Index
TfL	Transport for London
TME	Track Maintenance Engineer
TOC	Train Operating Company
TRUST	Train Running System (TRUST) database
TSR	Temporary Speed Restriction
V/T SIC	Vehicle / Track System Interface Committee
VTISM	Vehicle Track Interface System Model
WLCC	Whole Lifecycle Costing

1 Executive Summary

1.1 General

1.1.1 Arup have been appointed by the Office of Rail Regulation (ORR) and Network Rail (NR) as Part A Independent Reporter to provide assurance as to the quality, accuracy and reliability of NR's data that is used to report performance to ORR, the Department for Transport (DfT) and the wider industry.

1.1.2 On 7th January 2013 Network Rail submitted their Strategic Business Plan (SBP) for Control Period 5 (CP5) which runs from April 2014 to March 2019.

1.1.3 This report summarises our findings from a review of NR's proposed CP5 Asset Policies and the Whole Life Cycle Cost Models (Tier 2 Models) that have been used in their development. The review has been undertaken by Arup in response to Independent Reporter Mandate AO/030 *'PR13 M&R review of asset policies and their application in planning: progressive assurance and SBP submission'*.

1.1.4 The findings detailed herein represent our current understanding based on our work to date. The findings have been reviewed with NR and ORR following submission of our Draft reports.

1.2 Purpose

1.2.1 The purpose of Mandate AO/030 is to support the ORR in assessing:

- The final CP5 Asset Policies submitted by NR in support of its SBP; and
- The application of its Asset Policies in developing SBP cost, volume, output and efficiency projections.

In doing so, we have considered:

- General compliance with the Network Licence, particularly Section 1 relating to Network Management; and
- Specific ORR tests of robustness, sustainability and minimum whole lifecycle, whole system cost and further criteria for assessing asset policy as shared with NR.

1.2.2 This report presents our key findings against the specific questions detailed in the Mandate in relation to the Asset Policies and the Tier 2 Whole Life Cycle Cost (WLCC) models. The models, which are closely allied to the Policy documents, have been used to analyse the way in which individual asset groups behave over time to provide a means of predicting the volumes of work required to meet Policy objectives.

1.3 Scope

1.3.1 The agreed scope under the Mandate AO/030 for the Part A Reporter (Arup) comprised a review of the following asset groups:

- Track;
- Civils (Structures and Earthworks);
- Buildings;
- Drainage;
- Off-track;
- Fleet.

In parallel, the Part B Reporter (AMCL) were appointed under Mandate BA/025 to review:

- Electrical Power;
- Signalling;
- Level Crossings; and
- Telecoms.

1.3.2 The scope of our work included review of:

- Asset Policy documents;
- Strategic planning tools;
- WLCC analysis tools;
- Route Asset Management Plan (RAMPs) documentation; and
- SBP documentation including costs, volumes and outputs tables.

1.3.3 We have also reviewed WLCC models for signalling and telecoms asset groups. The reviews of the models were provided to AMCL to assist their review of policy for these assets.

1.3.4 A full copy of our Mandate is included in Appendix A.

1.4 Approach

1.4.1 We have based our assessment on the SBP submission provided by NR on 7th and 8th January 2013.

1.4.2 The SBP submission, provided on 7th/8th January 2013, comprised over 440 individual documents. In the time available we have not been able to review all of these, so we have had to prioritise our effort and focus on documents that appear to be pertinent to our review. This may mean that we have not fully appreciated some aspects of the SBP submission. It has been assumed that any such factual errors will have been identified by NR during their review of our Draft reports.

1.4.3 The approach which has been adopted in the review has been principally based on a review of the submitted documentation, supported by a number of 'challenge' meetings undertaken at various levels, both centrally and at Route level. These meetings ranged from those providing a general overview of the SBP process to more detailed sessions considering individual asset discipline models.

1.4.4 In our assessment we have considered the additional explanation and clarification provided by NR in the Central M&R Challenge Sessions and the Asset Specific Route Meetings. Similarly we have considered the written answers provided by NR to specific questions raised in the M&R Question Logs. In some instances as well as a concise answer or as part of an answer to a question, NR have provided additional material such as reports, technical notes, spreadsheets, models etc.. We have treated this material as set out in the following paragraph.

1.4.5 A significant volume of additional material has been provided by NR after the 8th January 2013 to explain, supplement or amend details in the SBP submission. This amounts to over 390 individual documents such as reports, technical notes, spreadsheets, models etc. Due to time constraints we have generally not been able to consider this additional material supplied after $7^{th}/8^{th}$ January 2013 in our assessment. We have explicitly referenced any additional material we have used. This approach has been agreed with ORR.

1.5 Overall Findings

1.5.1 We recognise that a considerable effort has been expended by NR in assembling a highly complex SBP submission. Our overall view is that it is a strong piece of work which demonstrates a logically thought through process.

1.5.2 Our review has identified the following general findings that apply to a greater or lesser extent across all the asset groups that we have reviewed.

Asset Management System

1.5.3 The NR Asset Management System Document [Ref. SPBT3003] is relatively new (published December 2012) and has not yet been embedded in the business. Nevertheless, we consider that the principle of explicitly defining how all the asset management elements come together and defining the core processes is very significant step forward which aligns with 'good industry practice'.

Asset Output Measures

1.5.4 The principle of explicitly starting to define clear asset output measures is very positive and represents 'best industry practice'.

Asset Policies

1.5.5 We note that NR have made significant progress with developing their Asset Policies in a number of areas since CP4. Specific progress includes preparation of separate Asset Policies for Earthworks, Drainage, Mining, Off –Track and significant development of the Structures Policy.

1.5.6 The NR Asset Management Strategy [SPBT3002] sets out a standard '10 section' / '10 stage' structure for the Asset Policies which they have consistently adopted for all the Asset Policies to promote cross-asset consistency. This is very positive and represents 'best industry practice'.

Asset Knowledge

1.5.7 We recognise that there is generally a reasonable level of asset knowledge with the central data systems supported by good local understanding of the assets where there is a good Route maturity. We note that in a number of areas further work is being undertaken to enhance and broaden the level of asset knowledge. These developments are clearly to be welcomed.

Asset Behaviour, Degradation and Criticality

1.5.8 Overall we see that there has been a considerable amount of work undertaken by NR with regard to determining how assets behave and the use of this data in the WLCC models. We see these as generally positive moves and recognise that in some areas this development is continuing. In our IIP Review we identified concerns regarding degradation modelling and it is disappointing to note that there are still uncertainties in relation to degradation modelling of the Buildings Asset.

Policy Selection and Preferred Life Cycle Options

1.5.9 The principle of explicitly using WLCC modelling tools to analyse differing cost, performance and risk requirements and optimise Asset Policies is very positive and represents 'best industry practice'.

Deliverability

1.5.10 At a general level we have little issue with deliverability of the Asset Policies. There are, however, some specific areas where we remain unconvinced that the risks associated with deliverability have been fully addressed. This particularly applies where there is a reliance on novel or relatively untried techniques. One such area is S&C refurbishment.

1.6 Asset Specific Findings

General

1.6.1 The following sections of this summary provide an account, by asset discipline, using the following general headings:

- Policy commentary – a general view of the appropriateness of the policy;
- Robustness – does the policy deliver the required outputs in CP5?
- Sustainability – does the policy deliver these outputs over the longer-term? and
- Whole Life Cycle Costing – is the requirement to minimise WLCC delivered?

1.7 Track

Policy

1.7.1 The principles of the Track Asset Policy have been in existence since 2010 when NR introduced the revised CP4 Policy with a new track organisation. The CP5 SBP policy further develops this work, in particular introducing the concept of WLCC based decision making.

1.7.2 The overall aim of the Policy is to maintain the targeted end-CP4 overall track condition through CP5 whilst improving the high criticality / high traffic routes. The other main focus of the Policy is to improve the condition of switches and crossings (S&C).

1.7.3 For each of the 305 Strategic Route Sections (SRS), NR have defined the criticality banding of track by linking the impact of track failure to the historic costs of delay measured by Schedule 8 payments. There is an indirect relationship between this measure and speed and tonnage – the most heavily trafficked routes are those most likely to result in high delay costs in the event of a failure. This is a significant and positive change to the Policy.

1.7.4 We believe that in general, the Routes have adopted and challenged the Policy. The Policy is generally considered to demonstrate a good understanding of the behaviour of the track system.

1.7.5 NR recognise that there are some areas with less robust age and condition data. These include ballast, formation, drainage and some S&C components. NR are planning significant asset data improvements to address these issues. This is a positive development and should enable further modelling improvements to be made, particularly related to ballast and formation condition and formation stiffness.

1.7.6 We consider NR's knowledge of rail and track geometry degradation to be good; NR acknowledge, and we concur, that S&C degradation is less well understood compared with plain line and they are taking action to address this. NR's estimates of an effective increase in asset life for heavy refurbishment will only be realised if the underlying problems causing poor track geometry are understood.

1.7.7 The Track Tier 2 model indicates that by following the Track Asset Policy, the introduction of timely (and SRS specific) heavy and medium track refurbishment, rather than total renewal, can provide a minimum WLCC in track asset management.

1.7.8 Based on our Route meetings, it appears that Route Plans take into account the new Track Asset Policy. Refurbishment of track is a more complex process and will require new techniques to be developed and new skills learned by NR staff and those in the supply chain. This appears to have been taken into account by the Routes in that they are generally planning the increased volumes of refurbishment work in the latter years of CP5.

1.7.9 The main challenge to the delivery of plain line heavy refurbishment in CP5 is the increased volume of ballast cleaning required.

1.7.10 The Policy, modelling and bottom up plans result in significantly increased (compared with CP4) volumes of S&C maintenance and heavy refurbishment, and the CP5 outputs are heavily reliant on achieving these at the anticipated cost. In our view this will require:

- the skills and competency to consistently deliver refurbished S&C to the required high standard of initial quality necessary to achieve the desired life extension (the expected reduction in mid-life maintenance interventions is highly dependent on this);
- robust asset information systems to enable on-going management of the S&C geometry; and
- adequate and timely compaction of ballast.

1.7.11 In addition we believe there are several other aspects to consider, namely:

- procurement (where necessary) and operation of appropriate S&C tampers working in tandem;
- procurement of innovative S&C re-ballasting plant.

Robustness

1.7.12 We consider that it is very likely that the Track Policy will be robust as it has demonstrated a good knowledge of the asset, its current condition and degradation rates, the impact of traffic forecast for CP5 together with a programme of maintenance and renewals that is very likely to deliver the same track performance and safety levels that will be in place at the end of CP4.

1.7.13 Deliverability and quality of renewals, particularly S&C heavy refurbishment, are the biggest challenges.

Sustainability

1.7.14 We consider that it is reasonably likely that the Policy will be sustainable. There is some uncertainty associated with the asset life extension from heavy refurbishment of S&C and plain line on lower criticality routes, which we believe may be optimistic.

Whole System Cost

1.7.15 We consider that there is some uncertainty as to whether the Track Policy will deliver the outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets. This uncertainty primarily arises from concerns over the ability of NR to deliver the required quality and durability of renewal and refurbishment work.

1.8 Structures

General

1.8.1 NR have made significant progress with the development of their Structures Asset Policy since IIP.

1.8.2 Since IIP, NR have also prepared an additional document, Policy on a Page (PoaP) [S6], which provides detailed guidance on the management of structures assets. PoaP makes the link between the Policy, WLCC strategies and asset groups. It groups structures assets according to key similarities (material, form, failure mode) and defines intervention thresholds in terms of level of risk at critical element level.

1.8.3 Specific progress in relation to the various structure types is discussed in the individual sections below.

1.8.4 Unit rates for underbridges, overbridges, footbridges, culverts and retaining walls have been derived by NR from historic data or actual cost information (from CAF and Monitor). Some external audit of these rates has been undertaken and rates are aligned with repeatable work types and represent average costs for types of activity. The methodology to derive these rates appears to consider the aspects required to develop an accurate rate.

1.8.5 Cost data has been provided for the range of maintenance and renewal interventions used in the modelling; however, it is unclear whether the same principles (inclusion of inflation, efficiency etc.) apply to the modelled rates.

1.8.6 It is considered that whilst absolute costs are not critical for a WLCC modelling tool, the relative difference between intervention costs needs to be accurate for the model to select the lowest WLCC output strategy.

1.8.7 We have not been able to trace all costs used in the structures modelling back to the data presented in ‘Structures Unit Rates and Assumptions’ [Ref. SBPT3074]. Therefore, we have concerns as to the accuracy and reliability of the intervention costs used in the modelling.

Underbridges and Overbridges

Policy

1.8.8 NR's proposed CP5 expenditure for bridges is £1,502m, about 66% of the total Structures expenditure of £2,270m.

1.8.9 The Asset Policy is fundamentally sound and is built on risk based principles. For underbridges and overbridges (bridges) it sets minimum condition thresholds for the principal load bearing elements (PLBE) of a structure.

1.8.10 We note that NR have typically permitted 6% of bridges to be ‘below’ the minimum condition PLBE thresholds. We are unclear as to the detailed rationale for this.

1.8.11 The focus for the CP5 bridges Policy is at element level in contrast to current policy which operates at structure level. The Policy defines minimum condition PLBE thresholds for structural elements, and NR's analysis of its structures database shows about 9,666 (33%) of bridges contain elements below this minimum threshold.

1.8.12 NR’s first priority for bridge activity is directed at elements in a condition below the minimum condition PLBE thresholds. We agree that this is the correct approach. In addition to this work, NR have several programmes of work to address capability shortfalls, hidden critical elements etc. We are unclear about the degree of overlap and prioritisation between each of these and also the major enhancement programmes planned for CP5.

1.8.13 On the basis of condition data that we have seen (central and Route level) we have little doubt that there is a substantial amount of repair and renewal work to be carried out, primarily on underbridges; however, there is significant uncertainty about the makeup of this work. This relates to the fact that to apply the Policy, NR asset engineers will have to evaluate each element below the minimum PLBE threshold to determine the type and scale of intervention required.

1.8.14 NR proposes that 'Scenario 2 – Phase in Policy over CP5-CP6' should be adopted. We do not agree with this selection in relation to bridges as it potentially means that there could be bridges with individual PLBE scores below the minimum condition threshold for the next 10 years. We are concerned that NR do not appear to be seeking resolve this issue more urgently.

Robustness

1.8.15 We conclude that from an overall perspective it is reasonably likely that the CP5 policy for underbridges is robust.

1.8.16 There is a clear linkage to asset outputs and the Policy is based on reasonable inventory and condition information and has an explicit risk based intervention approach.

1.8.17 Evaluation and prioritisation of the required interventions to comply with the Policy is incomplete and represents on-going work.

Sustainability

1.8.18 The Policy implies a step change improvement in overall bridge condition in CP5/6, which would then be sustained over future Control Periods. There is some uncertainty about the definitions of CP4 exit and the targets and measures for CP5, which relates directly to the sustainability of the policy for bridges. In addition, there is some uncertainty about the long term condition requirements.

Whole System Cost

1.8.19 The Tier 2 WLCC model was developed by NR to identify long term lowest WLCC strategies for bridge interventions at a population level. This approach is good practice; however, such tools are more helpful where the owner has a reasonably steady state bridge population which is in satisfactory condition, and are less applicable in NR's immediate position. Where an element is already below an intervention threshold, more detail is required to decide on an appropriate intervention.

1.8.20 We have concerns about the unit costs used in the WLCC model.

1.8.21 There is some uncertainty that the policies based on the modelling will deliver lowest WLCC outputs.

Major Structures

Policy

1.8.22 NR's proposed CP5 expenditure for Major Structures is £102m, about 4% of the total Structures expenditure of £2,270m.

1.8.23 The number of designated Major Structures has been reduced from 283 at IIP to 34 for CP5. We are unclear how the 'retired' Major Structures will be managed.

1.8.24 NR have not proposed any Measures for Major Structures. This is a significant omission for assets which are vital for the performance of the rail network and should be corrected, as it creates a high level of uncertainty.

1.8.25 The Policy for Major Structures currently appears to simply be to prepare Asset Management Plans (AMP) for each structure prior to the start of CP5; no AMPs were included with the SBP submission – we are consequently uncertain about the robustness of the Policy for Major Structures.

Sustainability

1.8.26 NR intend to apply a risk based approach to the Policy for Major Structures. We are unclear how this will be applied and have concerns that NR may be prepared to allow the overall condition of Major Structures to deteriorate. We consider this would be a retrograde approach to assets which are vital to the long-term performance of the network. We are consequently uncertain about the sustainability of the Policy for Major Structures.

Whole System Cost

1.8.27 NR have not supplied any explicit WLCC analyses for Major Structures, hence no lifecycle options have been presented for these assets. It is therefore uncertain as to whether the Policy will deliver the outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.

Tunnels

Policy

1.8.28 NR's proposed CP5 expenditure for Tunnels is £177m, about 8% of the total Structures expenditure of £2,270m.

1.8.29 The key Policy target for tunnels is to reduce the number of poor condition sections over CP5; however, we are confused by this target in that according to the condition data for tunnels, this target has already been achieved by a significant margin.

1.8.30 The other tunnels Policy target is to complete the hidden shaft identification programme by 2020. Hidden shafts are a serious hazard for tunnels assets; we have not seen evidence to explain why a completion date of 2020 is considered to be acceptable. Therefore we are somewhat uncertain as to whether the targets proposed by NR for tunnels are reasonable.

Robustness

1.8.31 For tunnels, NR hold reasonable inventory and condition data. The Policy for tunnels interventions appears to be mainly condition based. We are unclear about the outputs which NR intend to deliver for tunnels; whether NR aim to maintain or improve tunnel condition and reduce risk over CP5. Accordingly there is some uncertainty about the robustness of the Tunnel Policy.

Sustainability

1.8.32 A pro-active approach to interventions over recent years has delivered assets in generally fair or good condition, and which the Policy would continue to apply. For these reasons we consider there is low uncertainty about the sustainability of the Tunnel Policy.

Whole system Cost

1.8.33 NR have not supplied any explicit WLCC analyses for tunnels, hence no lifecycle options have been presented for these assets. It is therefore uncertain as to whether the Policy will deliver the outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.

Other Assets

Retaining Walls, Footbridges and Culverts

1.8.34 NR's proposed CP5 expenditure for retaining Walls, footbridges and culverts is £229m, about 10% of the total structures expenditure of £2,270m. This compares with £80m in CP4 (including coastal estuarine and river defences assets). It is unclear which assets have increased spend in CP5 as no breakdown for CP4 has been provided.

1.8.35 For this group of structures assets, the condition rating is currently relatively simplistic. NR have plans to improve asset knowledge during CP5. The targets are poorly defined and it is unclear if these have been used in top-down modelling. We are consequently uncertain about the robustness of the Policy for this asset group, and in the absence of any forecast condition we consider that sustainability is uncertain.

1.8.36 NR have not supplied any specific WLCC analyses for retaining walls, footbridges and culverts and hence no lifecycle options have been presented for these assets. It is therefore highly uncertain as to whether the Policy will deliver the outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.

Coastal Estuarine and River Defences

1.8.37 NR's proposed CP5 expenditure for coastal estuarine and river defences (CERD) is £43m, about 2% of the total Structures expenditure of £2,270m.

1.8.38 NR have provided very little information relating to CERD assets. We have not seen a clear list of these structures or any condition information. A policy objective to prepare asset management plans for CERD assets has been set; however, there are no particular targets for CERDs. There is no clear line of sight and therefore we have high uncertainty that the policy for CERDs is robust and / or sustainable.

1.8.39 NR have not supplied any explicit WLCC analyses for CERD and no lifecycle options have been presented for these assets. It is therefore highly uncertain as to whether the Policy will deliver the outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.

Structures Other

1.8.40 NR's proposed CP5 expenditure for 'Structures Other' is £218m in CP5 about 10% of the total Structures expenditure of £2,270m. Historic spend data has been provided for CP4 (£536m plus £168m 'enhanced spend'). No explanation of derivation is included in the SBP submission hence we have high uncertainty in respect of CP5 and CP6-CP11 volumes and costs.

1.8.41 'Structures Other' comprises a range of 'Policy objectives' set to reduce risk and comply with statutory obligations, including, planned preventative maintenance; scour protection; spandrel wall strengthening; hidden shafts; road vehicle incursion (and for neighbouring sites); pigeon proofing; and route specific schemes such as compliance with working at height regulations and contribution to Thameslink.

1.8.42 The tests of robustness, sustainability and lowest possible whole system cost are not applicable to these items.

1.9 Earthworks

Policy

1.9.1 The Earthworks Asset Policy [Ref. SBPT3015a] explains NR's proposed management approach for embankments, soil cuttings and rock cuttings.

1.9.2 In developing their CP5 asset policy, NR have adopted a 'risk based approach' to the identification of sites for remedial work. This is a significant step forward from the CP4 polices.

1.9.3 NR have explicitly recognised the important linkage between earthworks failures and the need to improve drainage and have included this in the Earthworks Policy.

1.9.4 The policy implicitly assumes that interventions should be primarily driven by 'safety' issues rather than say 'track performance'. This is very positive.

1.9.5 NR note that the historic failure data does not show a clear reducing trend that might have been expected bearing in mind the renewals work to poor condition sites which has taken place. NR note that 80% of failures are related to high rainfall.

1.9.6 NR continue to improve their asset knowledge. Specifically, they have formally adopted 'asset five chain lengths' to improve clarity and have undertaken a validation exercise to identify earthworks previously omitted from the Earthworks Database. NR indicate that only about 1% of the national database of assets remains to be examined. We note that there is some variability in asset data between Routes. We consider that at a National Level there is low uncertainty associated with the overall NR earthworks inventory.

1.9.7 NR have developed the SCAnNeR (Strategic Cost Analysis for Network Rail) model. It is different to the majority of the other NR Tier 1 models in that it is also a 'Tier 2' strategy evaluation tool. The tool and model within it have been used to determine the optimum policy by varying intervention strategy combinations considering the output of the asset population as a whole. From this, costs and volumes for the SBP are then determined for the preferred intervention strategy.

1.9.8 NR's analysis indicates that the lowest WLCC combination of interventions will be achieved by significantly increasing the volume of pro-active 'maintenance' and 'lighter' 'refurbishment' interventions at the expense of more 'traditional' 'heavier' 'renew' interventions. This is a significant change of approach from the current and historic earthworks policies.

1.9.9 We fully support the principle of undertaking more pro-active 'maintenance' and 'lighter' 'refurbishment' interventions to reduce risk in the short-term as suggested by the Asset Policy.

1.9.10 The exact improvement in condition profile / risk reduction in terms of five chain lengths in each condition category is not stated in the SBP submission, and thus we are unclear as to exactly what the proposed improvement in condition profile / risk reduction will be in CP5.

1.9.11 We note that one key implication of applying a constraint of improving condition in CP5 whilst maintaining overall 'average' condition leads to Routes with 'poor' start condition earthworks improving and Routes with 'better' start condition earthworks being allowed to deteriorate.

1.9.12 A key area of uncertainty relates to the degree to which the Routes will be able to effectively target 'the right slopes' for the proposed maintenance and refurbishment activities. This will impact on both the performance improvement that can be achieved and the cost of achieving that improvement.

Robustness

1.9.13 The CP5 Policy has a clear linkage to asset outputs (e.g. Risk Index), is based on reasonable inventory and condition information and has an explicit risk based intervention approach. Accordingly we consider it reasonably likely that the Policy will be robust and will be capable of delivering a reduction in asset risk in the short-term.

Sustainability

1.9.14 Whilst recognising that NR's detailed analysis would indicate that the proposed combination represents best whole life value, we have a number of concerns and therefore consider that there is some uncertainty as to whether the Policy will be sustainable in the long-term.

Whole System Cost

1.9.15 It is noted that there is much less historic cost data available for 'maintenance' and 'refurbishment' interventions than the 'renew' interventions. This is primarily because 'maintain' and 'refurbish' are 'new' activities not previously regularly used by NR on their earthworks. Accordingly there is more uncertainty associated with the unit cost of these activities.

1.9.16 Our concerns about the long-term effectiveness of the proposed 'lighter' pro-active intervention activities at maintaining asset condition, together with the uncertainty of the cost of these 'lighter' interventions means that we consider it uncertain whether the proposed policy will deliver the required outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.

Mining

1.9.17 Since IIP, NR have prepared a specific Mining Policy [Ref. SBPT 3015b] which explains their approach to mining, waste disposal and landfill sites that may pose a hazard to railway operation.

1.9.18 The NR mining policy stage gate process is a reasonable way of managing the risk of potential collapse of historic shallow mineworkings. However, we do not consider that there is sufficient information to assess whether the Mining Policy is robust, sustainable or represents lowest possible whole system cost over the lifetime of the asset.

1.10 Buildings

1.10.1 Within the policy the NR building portfolio is split into six groupings based on the type of site. These types are:

- Franchised stations (2,525 locations) – passenger stations which are operated by a Train Operating Company (TOC) under a lease agreement and governed by Station Access Conditions;
- Managed stations (17 locations) – passenger stations which are directly managed by NR;
- Light maintenance depots (LMDs) (71 locations) – depot facilities which are leased to a TOC for the purposes of maintaining or servicing rolling stock;
- Maintenance delivery unit (MDU) (489 locations) – buildings used by the NR in-house maintenance teams;
- National delivery service depots (NDS) (32 locations) – locations which are used by NR for the strategic storage of materials; and
- Lineside buildings (approximately 14,000 locations) – buildings used for a variety of purposes located adjacent to the track, typically signal boxes (classified as critical lineside buildings), relay rooms, buildings associated with GSM-R, and staff welfare accommodation.

1.10.2 NR's proposed Buildings expenditure for CP5 is £1,328m, of which £214m is for managed stations, £753m is for franchised stations, £89m is for LMDs, £128m is for lineside buildings, £72m is for MDU buildings, £16m is for NDS depots and £56m is for depot plant.

Policy

1.10.3 The Buildings Asset Policy is divided into two parts, one covering building fabric and the other mechanical and electrical (M&E) elements. The fabric policy is a relatively mature document which has been in development for some time. The M&E policy is less well developed and, as we are advised, has not been fully implemented.

1.10.4 The Policy considers and provides guidance on each of the building sub-types. The sophistication of the Policy is significantly related to the current level of asset knowledge linked to the relative levels of spend. Where asset knowledge is poor, there is a reliance on the rolling forward of CP4 spend. For franchised stations, which represent the majority of the planned expenditure, NR have good asset knowledge and have used independently developed degradation modelling to determine intervention levels and frequencies.

1.10.5 Whilst we acknowledge the work which has gone into the development of the degradation curves we still have some issues with them. These concerns remain from the time of the IIP and relate to the way in which the volumes of renewal work are derived in the modelling, leading to higher volumes than would be necessary to maintain asset condition. This supports the opinion that the Policy is robust and likely to provide the required performance for the asset.

1.10.6 Whilst targets are clearly defined in terms of the short or long term, the linkage between the planned activities and the Policy output requirements is limited for some building types.

1.10.7 The dominant building type is the franchised station which accounts for over half of the planned levels of spend. The Policy in this case is based on the outputs from the Tier 2 WLCC model translated into volumes in Tier 1. The degradation / intervention regimes produced by the Tier 2 model are designed to maintain asset condition. Forecasts produced by NR demonstrate that over CP5 the critical assets covered by the modelling will largely maintain their overall condition in terms of percentage asset remaining life (PARL).

1.10.8 NR consider that the limited number of managed stations means that they are able to directly monitor the rates of degradation and intervene as necessary to maintain condition. Thus, there is a reliance on a bottom-up approach to the generation of activity volumes. We understand however that NR undertook a back-check on the volumes in the Tier 1 model to validate sustainability.

1.10.9 The findings of a NR surveyed sample of the lineside buildings portfolio have been evaluated in order to determine activity and develop the Policy. This has then been extrapolated across the national portfolio. This approach would appear to be reasonable given the lack of asset data; however, the impact on the condition of this regime cannot be determined from available information.

Robustness

1.10.10 The measures of robustness for buildings are defined by the number of 2 and 24 hour reactive faults per annum. The level for these faults remains the same as for CP4. Whilst these measures are clearly defined, we consider that there does not appear to be a direct linkage between planned activities and the delivery of the target levels of faulting. There is no evidence of a line of sight supporting the delivery of the proposed faulting levels.

1.10.11 NR are also seeking to maintain the current levels of PARL for the building portfolio. There is evidence within the Policy to link this to the planned actions for certain asset groups but not for others.

1.10.12 As a result of the foregoing we remain unconvinced that there is a clear line of sight between the planned activities and the achievement of these stated measures of robustness.

Sustainability

1.10.13 The measure of sustainability is linked to the longer term delivery of PARL. The concerns expressed earlier regarding the linkage between activity and delivery of the outputs mean that we have moderate uncertainty regarding whether the required outputs will be delivered. In the case of managed stations we have a greater degree of uncertainty.

Whole System Cost

1.10.14 The optimisation of WLCC is based on the assumptions associated with the degradation model. As described above we have some concerns with the degradation model from our WLCC assessment which lead us to believe that the planned levels of volumes are in excess of those required to maintain asset condition.

1.11 Drainage

Policy

1.11.1 We last reviewed the Drainage Policy in December 2011. Since that time NR have continued to develop their asset knowledge. This has included a series of national walkover surveys of the drainage assets for which there was no asset data. This work has considerably improved the level of drainage asset inventory knowledge. However, there remains some uncertainty regarding the quality of the asset inventory.

1.11.2 Whilst there has been progress on the assembly of the drainage asset inventory we remain highly uncertain regarding the data held with regard to the condition of these assets.

1.11.3 Within the Policy a maintenance optimisation plan is proposed. We are highly uncertain what the planned activities during CP5 will deliver in terms of its potential impact on the effectiveness of the drainage inspections and surveys.

1.11.4 We welcome the adopted principle of managing the route drainage asset as a single system with improved liaison with the track and earthworks teams. The clear division of responsibility is also commended.

1.11.5 Whilst the foregoing are encouraging steps, we have not seen details of the proposed Drainage Management Plans. As such it is unclear whether each Route will be producing Drainage Management Plans in CP5 and what they will contain. We also note that the Routes seem to be at very different maturity stages with their drainage asset management.

Robustness

1.11.6 Due to uncertainty associated with inventory and condition, together with specific outputs, we consider it is still uncertain whether the Drainage Asset Policy is robust.

Sustainability

1.11.7 Due to uncertainty associated with whole life costing, together with specific outputs, we consider that it is still highly uncertain whether the Drainage Asset Policy is sustainable.

Whole System Cost

1.11.8 NR have not yet undertaken a quantitative WLCC analysis to identify lowest WLCC interventions. We note that this is part of NR's planned development work.

1.11.9 Due to uncertainty associated with various aspects of the Policy, in particular the linkage between cost / outputs and WLCC, we consider that it is still highly uncertain whether the current policy represents lowest whole life, whole system cost.

1.12 Off Track

Policy

1.12.1 The Off Track Policy covers the two assets of lineside vegetation and boundary control (fencing).

1.12.2 The Policy defines how the vegetation must be proactively managed to prevent it having a negative influence on railway performance by physically obstructing the efficient management of other infrastructure assets and the running of trains.

1.12.3 The principal role of fencing is to prevent encroachment onto the operating railway by trespassers and animals.

1.12.4 NR have undertaken considerable work to understand the issues associated with the off track assets to measure the quantum of vegetation assets, and classify lineside fencing into various categories of condition.

Vegetation Management

1.12.5 Vegetation management is centred on an inspection regime and appropriate mitigation to both cut back growth and, where possible, prevent its return. NR consider that much of the required management of trees and shrubs along the lineside is as a result of previous management regimes not having been followed up and the vegetation being allowed to recover.

1.12.6 NR have identified only two options for the strategic approach to vegetation management. Option 1 is to adopt a planned preventative approach; Option 2 is to adopt a reactive approach.

1.12.7 Of the two options presented NR have selected Option 1 which we consider to preferable.

Boundary Measures

1.12.8 The inspection and some maintenance of the boundaries is undertaken by NR staff; however, the majority of the delivery responsibility falls on suppliers for whom this work is not rail industry specific.

1.12.9 For boundary measures three investment options have been considered by NR:

- Option 1 - repair all poor condition, and renew all very poor condition fences by the end of CP5 and the introduction of a steady state renewal programme.
- Option 2 - as Option 1, with completion of the renewals extended to the end of CP6.
- Option 3 - steady state renewal delayed until the start of CP6.

1.12.10 For England and Wales NR have selected Option 1 as the basis of their approach. For Scotland Option 2 is to be employed. This is justified on the basis of there being more Class III boundary measures in Scotland.

Robustness

1.12.11 Based on the Policy, and covering both aspects of the off track assets, we have little concern that the Policy will deliver robustness for both boundary measures and vegetation management as a result of the volumes included in the plan.

Sustainability

1.12.12 With the planned movement from a reactive to a pro-active approach to the assets means that we are satisfied that the adopted NR approach is sustainable in the long term.

Whole System Cost

1.12.13 We consider the volumes which will be required to comply with the Policy are significant. Thus, whilst we consider that the Policy will deliver a robust and sustainable asset condition we are of the view that the overall costs which are included in the plan may be above the levels which are necessary to deliver the Policy objectives.

1.13 Fleet

Policy

1.13.1 The fleet asset represents a diverse range of plant that in part supports the delivery of maintenance and renewal activities. Our review of the fleet asset has focussed on the intervention and materials delivery fleets as these are the more critical in terms of delivery of the maintenance and renewals works on the wider NR assets, including track.

1.13.2 NR have broken their owned fleet of into five functional groupings as follows:

- Incident Response;
- Monitoring / Recording / Testing;
- General Maintenance / Support;
- Maintaining / Renewing; and
- Planned Treatment.

1.13.3 The overall fleet assets required to deliver the defined CP5 outputs will be made up of NR owned and supply chain owned assets. It is recognised that there will be competing demands at peak times for limited resources to deliver the full programme of infrastructure maintenance, renewals and enhancements as set out in the SBP. In addition, it is considered likely that several suppliers will have other railway infrastructure fleet demands from contracted work with other rail infrastructure owners such as HS1 and TfL. Nevertheless NR have attempted to define their overall requirements in the appendices to the Fleet Asset Policy [Ref. SBPT3018] from which it draws conclusions on the ability of its supply chain to provide the balance of fleet resources to deliver its CP5 Business Plan.

1.13.4 We have summarised the alignment of the Fleet Asset Policy [SBPT3018] to the NR business plan as shown in Table 1-1.

Table 1-1: Fleet Business Plan Summary

Type of Plant	Aligned to Business Plan
Seasonal and Incident Response	Yes
Intervention Fleets (these vehicles are described in the main policy document and also referred to in Appendix 3, pages 8 and 9)	Broadly, but not to sufficient detail to demonstrate delivery of the SBP
Materials Delivery Fleets	Not to sufficient detail to demonstrate delivery of the SBP
Infrastructure monitoring fleet	Yes
On Track Plant	Yes
Locomotives	Yes
Seasonal Treatment Train	Yes
Road Vehicles	Yes

1.13.5 The principal issues associated with the Policy relate to how much plant will be available to deliver the planned volumes in the SBP.

1.13.6 NR Infrastructure Projects state in Appendix 3 to the Policy that there is a potential shortfall in:

- S&C tilting wagons and the associated turnaround facility throughput;
- Medium Output Ballast Cleaners (MOBCs) and other Ballasting plant and a significant portion of the current fleet will become life expired within CP5;
- Stoneblowers;
- Grinders; and
- MPVs.

1.13.7 It is not clear if the foregoing list has taken account of the large programme of work included in the enhancement programme, including for example, Crossrail (on NR infrastructure); Thameslink; Northern Hub; etc.

1.13.8 We note that the CP5 Track Asset Policy [Ref. SBPT3010] with its mid-life ballast replacement for plain line and S&C, increases the demand for tampers and haulage. NR's capacity study suggests that there is adequate capacity in the network as long as a healthy balance between weekend and midweek delivery of the programme is achieved.

1.13.9 We consider that a predominantly weekend operation will require further investment on tampers, wagons and locomotives and will result in midweek under-utilisation.

1.13.10 We have been advised by NR that producing an optimised spread of work across week nights and weekends is key to the delivery of SBP volumes and efficiency. We agree with this approach.

1.13.11 Whilst there are plans in the Fleet Policy to procure new support machinery for the increase in plain line reballasting, there are none to develop and procure similar support machinery for switches and crossings to compliment the three ballast vacuum machines listed in the Policy.

1.13.12 We consider that this over-arching Policy may be applicable to certain fleet vehicles. However, we do not consider it to be appropriate to certain key items associated with the delivery of track maintenance and renewal volumes where the financial cost implications of the failure of a machine during operations far outweigh the cost of appropriate maintenance.

Robustness

1.13.13 For the NR owned fleet, the Policy appears robust and is an improvement on that produced in 2011 for the IIP.

1.13.14 We question whether NR are confident that they can obtain the specification of new machines that will deliver the sustainability targets of the Track Policy, through the retendering of tamping contracts during CP5.

1.13.15 We have concerns that NR may not have done enough work to date, such that they can be confident that the overall bespoke fleet (plant) resources that are required to deliver the SBP outputs for asset management, including enhancements, are available at the cost levels required to deliver the SBP.

1.13.16 We are moderately uncertain as to whether the NR policy to purchase road vehicles and renewal on a four year cycle rather than lease is optimal.

Sustainability

1.13.17 Since fleet assets vary in scope and cost in their support to the principal deliverables of the SBP, it is difficult to respond to the ORR sustainability question for this Policy. As such we are not able to come to a view on the sustainability of the Fleet Policy.

Whole System Cost

1.13.18 NR have not undertaken any WLCC modelling for fleet. Accordingly there is no WLCC report for fleet.

1.13.19 We consider that delivering a minimum whole life cycle cost for the many and varied types of the mechanised wheeled fleet may not be optimal in terms of delivering the high levels of availability and reliability required to deliver the SBP.

2 Introduction

2.1.1 This report presents the findings from a review of the NR Asset Policies and supporting WLCC models as presented in the Strategic Business Plan (January 2013).

2.1.2 This document forms part of a set of reports that present the Arup review of the PR13 Maintenance and Renewal (M&R) elements of the Network Rail Strategic Business Plan (SBP). This review is undertaken in their role as the Office of Rail Regulation's Part A Independent Reporter and was commissioned under Mandate AO/030 (2012). The overall structure of the suite of reports is shown in Figure 2-1.

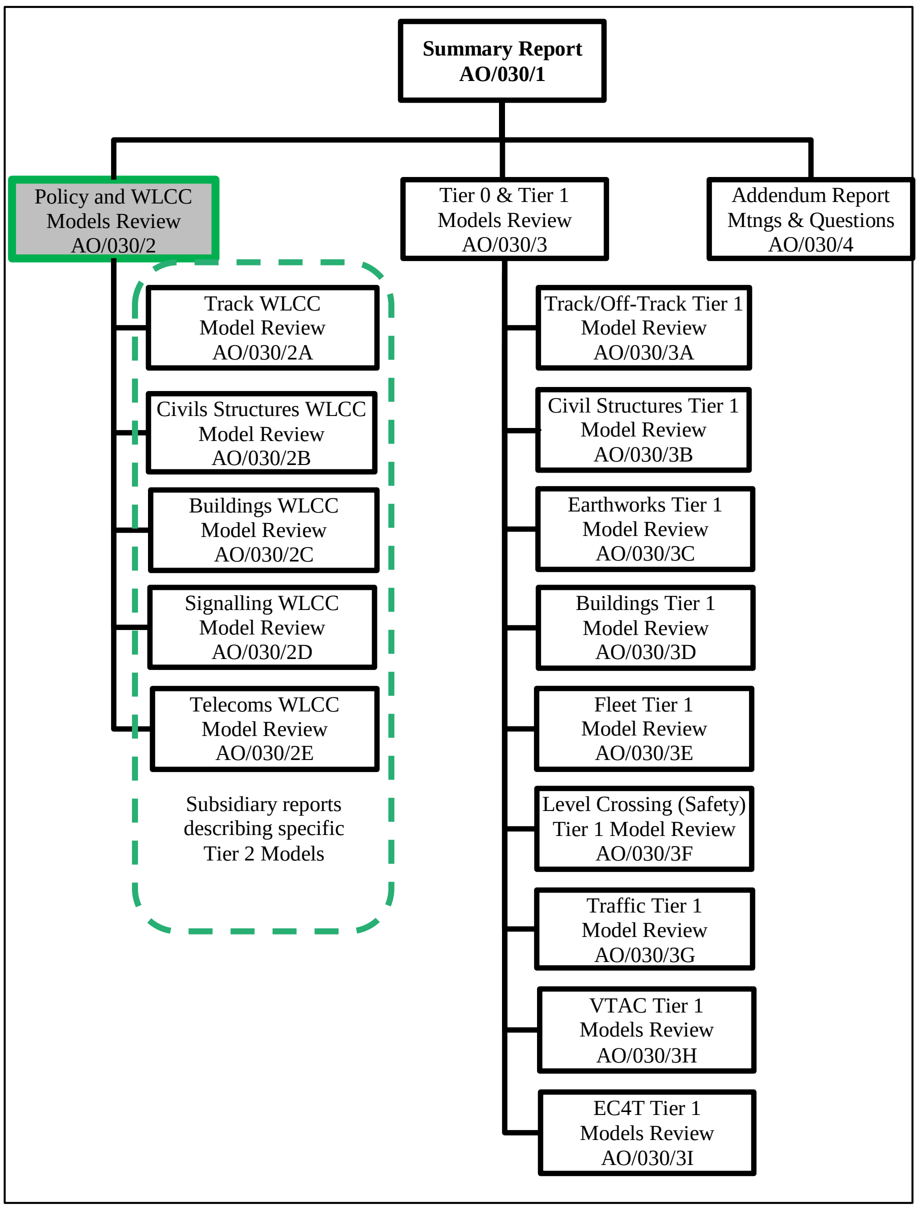

Figure 2-1: Structure of Reports Delivered under Mandate AO/030

3 Scope and Approach to Review

3.1 Purpose

3.1.1 The purpose of Mandate AO/030 is to support ORR in assessing the degree to which the NR Asset Policies and the SBP give confidence that robust and sustainable output will be delivered by NR in the next Control Period (CP5).

3.1.2 The review of the SBP documents builds on the findings of the Mandate AO/017: Initial Industry Plan (IIP) 2011 Review, presented in our Report: *Summary Report – Observations and Conclusions* (Arup 2011), and includes an assessment of the extent to which the recommendations made in that report have been addressed.

3.1.3 The NR Asset Policies have been assessed against the criteria of linkage to targets, robustness, sustainability and lowest whole life, whole system cost and the further indicator of good asset stewardship.

3.1.4 The review includes understanding how NR have used the outputs of Tier 2 - WLCC modelling, in development of Policy. Separate, related reports have been prepared that review the models and describe the approach, input data and best practice within these decision support tools.

3.2 Scope

3.2.1 The agreed scope under the Mandate AO/030 for the Part A Reporter (Arup) comprised a review of the following asset groups:

- Track;
- Civils (Structures and Earthworks);
- Buildings;
- Drainage;
- Off track;
- Fleet.

In parallel, the Part B Reporter (AMCL) were appointed under Mandate BA/025 to review:

- Electrical Power;
- Signalling;
- Level Crossings; and
- Telecoms.

3.2.2 The scope of our work included review of:

- Asset Policy documents;
- Strategic planning tools;

- WLCC analysis tools;
- Route Asset Management Plan (RAMPs) documentation; and
- SBP documentation including costs, volumes and outputs tables.

3.2.3 We have also reviewed WLCC models for signalling and telecoms asset groups. The reviews of the models were provided to AMCL to assist their review of Policy for these assets.

3.2.4 In progressing the assessment we have considered:

- Compliance with the Network Licence, particularly Section 1 relating to Network Management; and
- Our tests of robustness, sustainability and minimum whole lifecycle, whole system cost and further criteria for assessing asset policy as shared with NR.

3.3 Approach

3.3.1 We have based our assessment on the SBP submission provided by NR on 7th and 8th January 2013.

3.3.2 The SBP submission, provided on 7th/8th January 2013, comprised over 440 individual documents. In the time available we have not been able to review all of these, so we have had to prioritise our effort and focus on documents that appear to be pertinent to our review. This may mean that we have not fully appreciated some aspects of the SBP submission. It has been assumed that any such factual errors will have been identified by NR during their review of our Draft reports.

3.3.3 In our assessment we have considered the additional explanation and clarification provided by NR in the Central M&R Challenge Sessions and the Asset Specific Route Meetings. Similarly we have considered the written answers provided by NR to specific questions raised in the M&R Question Logs. In some instances as well as a concise answer or as part of an answer to a question, NR have provided additional material such as reports, technical notes, spreadsheets, models etc. We have treated this material as set out in the following paragraph.

3.3.4 A significant volume of additional material has been provided by NR after the 8th January 2013 to explain, supplement or amend details in the SBP submission. This amounts to over 390 individual documents such as reports, technical notes, spreadsheets, models etc. Due to time constraints we have generally not been able to consider this additional material supplied after 7th/8th January 2013 in our assessment. We have explicitly referenced any additional material we have used. This approach has been agreed with ORR.

3.3.5 A desk-top based review of policy documentation and models was supplemented by NR presentations and workshops through a period of progressive assurance between IIP and SBP submissions.

3.3.6 In addition, a number of meetings with NR asset specialists responsible for policy development and associated WLLC modelling and Route asset engineers have also occurred. These are documented in our Addendum Report Meetings and Questions [Ref. AO/030/04 Arup, 2013].

3.4 Report Structure

3.4.1 The remainder of this report comprises a section providing our comments on Policy development, followed by a series of sections reporting on the findings associated with each of the disciplines reviewed:

- Track (Section 5);
- Structures, including bridges and tunnels (Section 6);
- Earthworks (Section 7);
- Buildings (including stations, lineside buildings and depots) (Section 8);
- Drainage (Section 9);
- Off track (Section 10); and
- Fleet (Section 11).

3.4.2 In each of the asset specific sections our review and discussion of the policy has been aligned to an outline set of criteria provided by the ORR in the Mandate (Appendix A). Pertinent aspects of each of the asset policies are discussed under the following headings:

- Performance requirements / outputs;
- Line of sight;
- Asset knowledge;
- Asset behaviour and criticality;
- Asset degradation;
- Renewal and maintenance interventions;
- Asset cost data;
- Policy selection and preferred lifecycle option;
- Overall planning process;
- Systems approach;
- Risk;
- Deliverability;
- Continuous improvement and
- Robustness, sustainability and lowest whole life / whole system cost.

WLCC Model Reports

3.4.3 For the critical assets, WLCC models have been presented to support the policy development and validation (Section 3.7). We have reviewed the WLCC models and supporting documentation and describe the outcomes of these reviews in separate reports as shown in Figure 2-1. Each report discusses the key aspects of the WLCC models under the following headings of:

- Coverage of WLCC model;

- Input data;
- Robustness of cost modelling;
- Assessment of extent to which WLCC model outputs are used in policy development;
- Scenarios; and
- Best practice.

Observations and Conclusions

3.4.4 Within the report observations, comments or inconsistencies are highlighted by the use of green boxes like this.

4 Policy Development Process

4.1 Introduction

4.1.1 The aim of this section is to summarise our understanding as to how the NR Asset Policies have generally been developed, how they fit into the overall Asset Management System and how they are related to models and outputs. It provides a context for the subsequent sections that review and comment on the individual Asset Policies.

4.2 Asset Management System

4.2.1 As part of the SBP submission, NR have published a document describing their overall Asset Management System [Ref. SBPT3003]. This document outlines how the elements of NR's asset management system come together and it complements the Asset Management Policy [Ref. SBPT3001] and Asset Management Strategy [Ref. SBPT3002] published in February 2011.

4.2.2 The NR Asset Management System Document [Ref. SPBT3003] is relatively new (published December 2012) and has not yet been embedded in the business. Nevertheless, we consider that the principle of explicitly defining how all the asset management elements come together and defining the core processes is very significant step forward which aligns with 'good industry practice'.

4.3 Asset Management Framework

4.3.1 NR published an overall high-level Asset Management Framework in February 2011 [Ref. SBPT3001]. The framework defines the cycle of NR's asset management decisions and activities in a Plan-Do-Review sequence. This is shown in Figure 4-1.

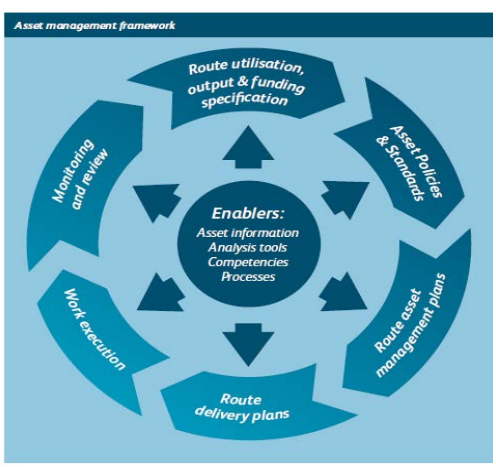

Figure 4-1: Network Rail Asset Management Framework [Ref. SBPT3001]

4.3.2 The Asset Management Framework is divided into six stages from high level objectives, through asset management planning to on-the-ground work delivery and, through monitoring and review, to return feedback and learning. NR [Ref. SBPT3003] groups and describes the six stages into three phases as follows:

"Phase 1: 'Plan' – The Strategic Planning Framework

This encompasses Stages 1-3 and involves defining high-level strategies and objectives, and how these are taken through to the development and publication of the Route Asset Management Plans (RAMP). This gives clear line of sight between the high level objectives and the activities, measures and intended outcomes described in the Ramps. This Phase has a large number of inputs including Government Policy and funding, Strategic objectives, Required Service levels, Funding, Planning Scenarios, Portfolio Condition outputs.

Phase 2: 'Do' - Managing the Asset

Incorporating Stages 4 and 5, this Phase is the translation of the RAMPs into actual activities on the ground. This includes work delivery planning, acquisition, operation, maintenance, and ultimately disposal of assets.

Phase 3: 'Review' - Reviewing and Learning

Review and monitoring occur at any stage of the overall asset management process. However, our approach firmly establishes an annualised formal learning process, leading to an updated, live Asset Management Improvement Programme and formal checks whether the AMS is sufficient. Phase 3 consists solely of the final Stage 6. It ensures sufficient assurance, feedback, observations and performance information are gathered. These "lessons learnt" drive improvement to the AMS and, from this, refresh the Asset Management Strategy and the annual asset management objectives"

4.4 Asset Management Policy and Strategy

4.4.1 Figure 4-2 shows the relationship between the NR asset management documents.

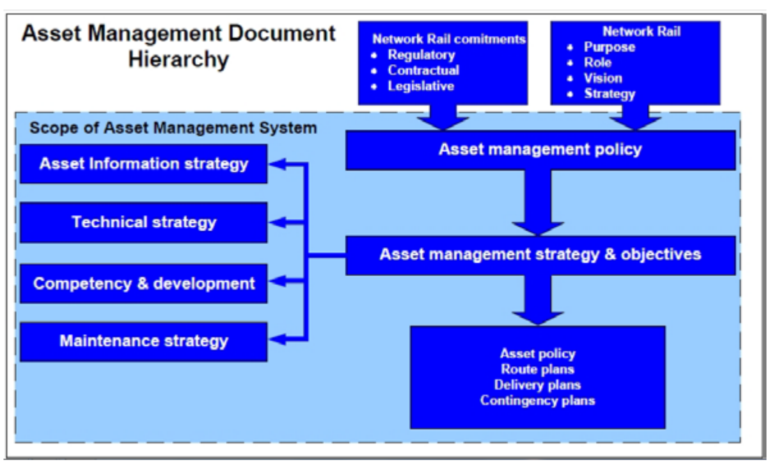

Figure 4-2: Network Rail Asset Management Document Hierarchy [Ref. SBPT3003]

4.5 Asset Policies

4.5.1 NR Asset Management System (AMS) [SBPT3003] defines the function of 'Asset Policies' as:

"A suite of documents that define how the asset groups are to be managed to meet the asset management objectives. They specify the major inspection, maintenance and renewal interventions for each asset, and specifications for new / replacement assets"

4.5.2 The Asset Management System document [Ref. SBPT3003] then uses a series of simple flow charts to explain the six stages of the AMS. Stage 2 'Asset Policies & Standards' is pertinent to this review and is shown in Figure 4-3 below. Key inputs to the development of asset policies are shown as:

- Service Levels & Funding (Asset Output Measures); and
- Decision Support Tools (Tier 2 asset WLCC models).

4.5.3 These key inputs and their relationship with the Asset Policies are described below.

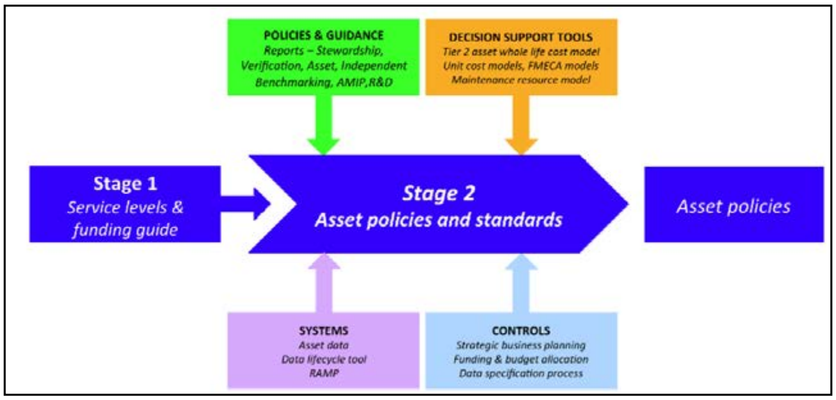

Figure 4-3: Stage 2 Inputs, Outputs and Enablers [Ref. SBPT3003]

4.5.4 The NR Asset Management Strategy [SPBT3002] sets out a standard '10 section' / '10 stage' structure for the Asset Policies which they have consistently adopted for all the Asset Policies to promote cross-asset consistency. This is very positive and represents 'best industry practice'.

4.5.5 The '10 stage' Asset Policy structure is shown in Figure 4-4.

Section	Title	Content
1.	Asset Description	Summarises the scope, composition and utilisation of the asset base and its interfaces with other asset disciplines.
2.	Historical Analysis	Describes the historical trends within an asset group including age profile, utilisation, condition and performance.
3.	Asset Criticality	Identifies the most critical asset sub-groups in terms of expenditure and impact on outputs, and prioritising later analysis.
4.	Route Criticality	Defines the approach to segmenting the network and the framework for prioritising decisions based on the impact of infrastructure failures on service outputs.
5.	Asset Degradation	Catalogues the degradation mechanism(s), modes of failure or degraded operation and the consequences in terms safety, costs and performance.
6.	Intervention Options	Specifies possible intervention options, their effectiveness, costs and associated dependencies.
7.	Planning & Funding Scenarios	Defines the scenarios required to evaluate alternative output / funding options and identifying the trade-offs between activity, expenditure and outputs needed in model development and policy definition.
8.	Model Development	Describes the modelling tools and their capability to analyse Whole Life Cycle Cost and forecast activities, expenditures and outputs.
9.	Investment Options	Presents the results from the application of the models to the specified scenarios.
10.	Policy Selection	Justifies the selection of the preferred policy option and provides further detail on the selected policy.

Figure 4-4: Outline Structure of Network Rail Asset Policy Documents [Ref. SBPT3002]

4.6 Asset Output Measures

4.6.1 In their 'Asset Output Measures Summary' document [SBPT232], NR have identified asset specific output measures for the seven major asset disciplines (Figure 4-5). NR have selected these measures to align with the ORR 'robustness' and 'sustainability' tests[1].

4.6.2 NR note that their proposed 'robustness measures' provide the highest level indicators against which they are proposing to monitor performance during CP5 and in the long term. They see these measures as supplementing or replacing their Asset Stewardship Indicator (ASI) that was used in CP3 (and with modifications) in CP4.

4.6.3 Sections 7- 10 of the Asset Policies generally reference these or similar output measures or targets to be achieved through implementation of the Asset Policy.

4.6.4 The NR preferred robustness measure is *'failures causing train delays greater than ten minutes'*. For buildings and civils where asset failures are 'infrequent', NR have proposed robustness measures related to faults requiring intervention or assets in a poor condition state.

[1] 'Requirements for Network Rail's January 2013 Strategic Business Plan' issued by ORR on 15 March 2012.

	Robustness Measure	Sustainability Measure
Track	Failure causing delays > 10 minutes	Used / remaining life
Signalling	Failure causing delays > 10 minutes	Used / remaining life
Telecoms	Failure causing delays > 10 minutes	Used / remaining life
Electrification & Plant	Failure causing delays > 10 minutes	Used / remaining life
Buildings	Reactive faults (for repair within 24 hours)	Used / remaining life
Structures	Number of open work items with risk score greater than 20	Condition score for Principal Load Bearing Elements (bridges)
Earthworks	Earthworks drainage in poor condition	Earthworks Risk Index

Figure 4-5: Asset Output Measures Summary [Ref. SBPT232]

4.6.5 NR targets for the end of CP4 and 'best estimates' of the forecast for the end of CP5 are shown in Figure 4-6.

Robustness measures	CP4	CP5
Track		
Failures > 10 mins (p.a.)	10,019	10,113
Signalling		
Failures > 10 mins (p.a.)	13,614	13,614
Telecoms		
Failures > 10 mins (p.a.)	644	644
Electrification & Plant		
Failures > 10 mins (p.a.)	706	778
Buildings		
2 and 24 hour reactive faults (p.a.)	5,743	5,743
Structures		
Open risk items with risk score >20 (p.a.)	300	225
Earthworks		
Robustness	Under development	

Figure 4-6: Asset Output 'Robustness' Measures CP4 / CP5 [Ref. SBPT232]

4.6.6 For sustainability the NR preferred measure is *'asset used / remaining life'*. The intention is that such a measure is relatively straightforward to forecast over several control periods and is a good indicator of whether the maintenance and renewal regime will sustain asset condition and performance in the long term. For structures, a measure of PLBE condition has been selected and a risk index adapted for earthworks. NR targets for the end of CP4 and 'best estimates' of the forecast for the end of CP5 are shown in Figure 4-7 below.

Asset	Sustainability measure	CP4	CP5	CP6	CP7	CP8	CP9	CP10	CP11
Track	Used life	53%	52%	51%	51%	53%	55%	57%	58%
Signalling	Remaining years of life	13.3	14.8	17.5	21.0	20.5	19.4	18.6	17.7
Telecoms	Remaining years of life	64%	44%	34%	48%	68%	53%	34%	38%
E&P	Remaining years of life	61%	57%	55%	54%	53%	54%	53%	51%
Buildings	Percentage Asset Remaining Life	42%	43%	45%	49%	53%	54%	57%	58%
Structures	Condition score for PLBEs (bridges)	7.7	5.9	4.1	4.3	4.4	4.6	4.6	4.5
Earthworks	Earthworks Risk Index	100	99.6	99.7	99.7	99.7	99.7	99.7	99.6

Figure 4-7: Asset Output 'Sustainability' Measures CP4 / CP5 [Ref. SBPT232]

4.6.7 The principle of explicitly starting to define clear asset output measures is very positive and represents 'best industry practice'.

4.7 Whole Life Cycle Cost Models

4.7.1 NR have developed a hierarchy of modelling tools to facilitate planning and forecasting. The key tools are broadly structured into three 'tiers', namely:

- Tier 0 - single 'presentation layer database'
- Tier 1 - asset specific models that derive 'costs, volumes and outputs …'
- Tier 2 - WLCC tools.

4.7.2 NR explains in their AMS [Ref. SPBT3003] that the Tier 2 WLCC models have been used to analyse differing cost, performance and risk requirements to establish the best WLCC for the required programmes of maintenance, inspections and renewals.

4.7.3 Specifically NR have used the Tier 2 WLCC Models to test constraints on the Policies, such as resource, budget, political, etc. and to determine the most cost effective solution that can be achieved. Other factors considered include:

- The consequences for an asset if a renewal / refurbishment project is deferred; and
- The relative importance of different asset types and their associated risks.

4.7.4 The principle of explicitly using WLCC modelling tools to analyse differing cost, performance and risk requirements and optimise Asset Policies is very positive and represents 'best industry practice'.

4.8 Efficiencies

4.8.1 The NR SBP submission includes an 'Efficiency Summary' [Ref. SBPT220]. This categorises efficiencies as:

- Scope efficiencies[2]; and
- Delivery efficiencies[3].

4.8.2 Scope efficiencies are further sub-divided into:

- Refined asset Policies or Embedded efficiencies; and
- Asset Information efficiencies.

4.8.3 NR have set out any local Route specific efficiencies in the individual Route Plans.

4.8.4 NR have presented their SBP M&R costs in terms of 'pre-efficient' and 'post-efficient' values [Ref. SBPT3338].

4.8.5 A detailed review of efficiencies is being undertaken as part of a separate mandate[4] and is not reproduced here. However, qualitative comment on the NR assumed 'embedded efficiencies' is made below and in the individual asset sections of this report.

Renewals 'Embedded Efficiencies'

4.8.6 The 'Efficiency Summary' [SBPT220] notes that scope efficiencies due to refined asset policies ('embedded efficiencies') sit within the pre-efficient numbers. NR have estimated that their CP5 Renewal pre-efficient expenditure includes a 4% embedded efficiency associated with the application of CP5 asset policies compared with the scope that would have resulted from the application of their current (CP4) policies. A breakdown of NR's estimated 'embedded efficiencies' is shown in Figure 4-8 below.

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[2] *Scope efficiencies – sustainable reductions in scope to deliver required outputs through improved asset information, refined asset policies (including those improvements which are already embedded in our CP5 policies and therefore reflected in the pre-efficient spend projections) and other more project-based value engineering*

[3] *Delivery efficiencies – a lower cost of delivering a unit of activity.*

[4] Mandate AO/035 'PR13 review of Network Rail's CP5 efficiency projections and supporting evidence'

Asset	CP5 pre-efficient renewal expenditure £m	Embedded efficiencies £m	%
Track	3,954	–	0%
Signalling	3,943	380	10%
Civils	2,904	–	0%
Buildings	1,328	66	5%
Electrical power & fixed plant	1,071	107	10%
Telecoms	439	22	5%
Renewal Total	13,640	575	4%
OMR	23,485	575	2%

Figure 4-8: Network Rail's Estimated Embedded Efficiencies [Ref. SBPT220, Table2]

Maintenance Efficiencies

4.8.7 Asset Management Maintenance Costs are pertinent to track and civils assets.

4.8.8 For civils, the maintenance costs [Ref. SBPT3039] relate primarily to the Civil Engineering Framework Agreement (CEFA) examination and assessment contract. NR note that for CP5 the accounting of the CEFA costs will change from CP4. In CP4 the cost of 'around £82-84 million' [Ref. SBPT220] was split £49 million against renewals and £35 million against Opex. In CP5 all CEFA costs will be recognised as Opex costs.

4.9 Maintenance Strategy

4.9.1 NR have provided a document entitled 'Infrastructure Maintenance Strategy' [Ref. SBPT3169]. The stated aim of the document is:

"This document describes Network Rail Maintenance's strategy for identification of Maintenance Requirements and the provision of a sufficient and competent Maintenance workforce. This document should be read in conjunction with the document "Optimising Maintenance Regimes", which describes Network Rail's processes for determining detailed Asset Maintenance Requirements"

4.9.2 The NR SBP submission includes a document 'Optimising Maintenance Regimes' [SBPT3004]. The stated purpose of the document is:

"This document is intended to describe the processes applied to develop an efficient and effective operating model for Infrastructure Maintenance in Network Rail. It is intended to form a part of the suite of documents that underpin the Company's strategy and policies for the period from 2013 to 2019, which will include the 2014 to 2019 Price Control Period. The document does not create mandatory requirements, as any such requirements are specified via the Company's standards framework, but seeks to describe good practice."

4.9.3 The principles described in the document are noted as being applied to *"all maintenance included within the maintenance funding provided in the control period pricing reviews"*.

4.9.4 It is noted that by ‘maintenance’ NR are referring to activities “*included within the maintenance funding provided in the control period pricing reviews*”.

4.9.5 Aspects pertinent to this report relate to the track and civils assets.

Maintenance Regime Development

4.9.6 The NR ‘Optimising Maintenance Regimes’ (OMR) document [SBPT3004] considers five stages in the development of optimum maintenance regimes for their infrastructure assets, namely:

- Stage 1 – Historic regimes – intuitive consideration of Parameters of Risk;
- Stage 2 – National regimes based on RCM techniques;
- Stage 3 – Local regimes;
- Stage 4 – Regimes fully supported by data; and
- Stage 5 – Complex risk-based regimes.

4.9.7 NR recognise that increasing levels of asset information are required as the analysis techniques become more complex.

5 Track Asset Policy

5.1 Performance Requirements / Outputs

Overview

5.1.1 The principles of the Track Asset Policy have been in existence since 2010 when NR introduced the revised CP4 Policy with a new track organisation. The CP5 SBP policy further develops this work, in particular introduces the concept of WLCC based decision making.

5.1.2 The overall aim of the Policy is to maintain the targeted end-CP4 overall track condition through CP5 whilst improving the high criticality / high traffic routes. The other main focus of the Policy is to improve the condition of S&C.

5.1.3 The track asset system is split between plain line and S&C and then broken down into the following asset type/components (as shown on Figure 5-1):

- Rail;
- Sleepers/bearers;
- Fastenings/Pads;
- Ballast;
- Formation; and
- Drainage.

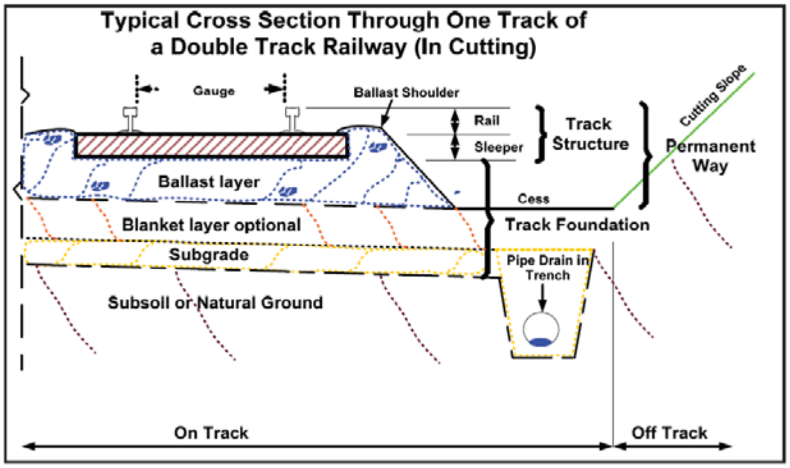


Figure 5-1: Cross Section of the Track System [Ref. SBPT3010, Figure 1.3]

5.1.4 The principal interface for track is the rail vehicle. As stated in the Policy, track also interfaces with other infrastructure assets, including signalling, electrification, plant, civil engineering and off-track [Ref. SBPT3010, Pages 24-28].

5.1.5 The NR track engineering standards define seven categories of track as a function of speed and tonnage. Dynamic forces on the track are related to the speed and tonnage imposed from all traffic forecast for CP5, travelling over a particular section of the route at the time when a total renewal is to take place or a new line is to be constructed. The track construction standard specifies different types of track system (rail section, sleeper type and ballast depth) appropriate to withstand those forces. The track categories are broadly aligned with the five Criticality Bands as shown in the Policy [Ref. SBPT3010, Section 4.4.3].

5.1.6 NR manage the whole UK network using a range of geographical business units as per Figure 5-2.

Whole Network	
England & Wales	Scotland
10 Operational Routes	
305 Strategic Route Sections	
c. 30,000 km of track	

Figure 5-2: Track Organisational Structure [Ref. SBPT3010]

5.1.7 The Strategic Route Sections (SRS) are discrete sections of the network having largely consistent traffic levels and infrastructure type throughout their length. For the 305 SRSs, Network Rail has analysed historical data for the last five years where performance has not been met. This historical data has then been linked to the Schedule 8 payments incurred to produce a ranking of Route Criticality. Based on this a ranking of the mean delay cost per incident has been derived from which NR have defined five separate bands of Route Criticality.

Current Performance

5.1.8 Figure 5-3 below, from the Policy shows delay minutes due to track faults. For track related temporary speed restrictions (TSR) and Point Failures it shows an improving trend. However in 2011/12, delay minutes associated with broken rails and track faults rose; NR state that there were fewer faults causing delay, but delays were longer.

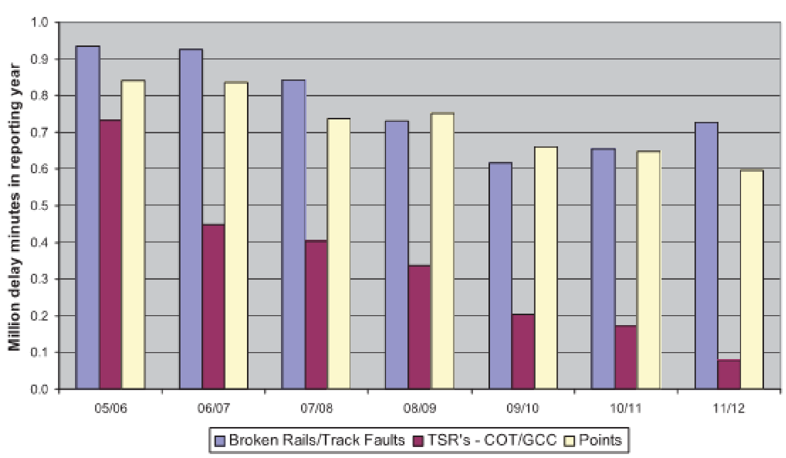


Figure 5-3: Delay Minutes Due to Track Faults [Ref. SBPT3010, Figure 2.21]

5.1.9 In the three years 2009/10 to 2011/12 track geometry quality deteriorated, as shown in Figure 5-4, below. NR have implemented a positive action plan in order to achieve their end of CP4 performance targets. These actions include increased tamping and stoneblowing shifts and the establishment of Route Track Geometry Engineers. As a result, Routes have generally reported a reversal in this negative track quality trend.

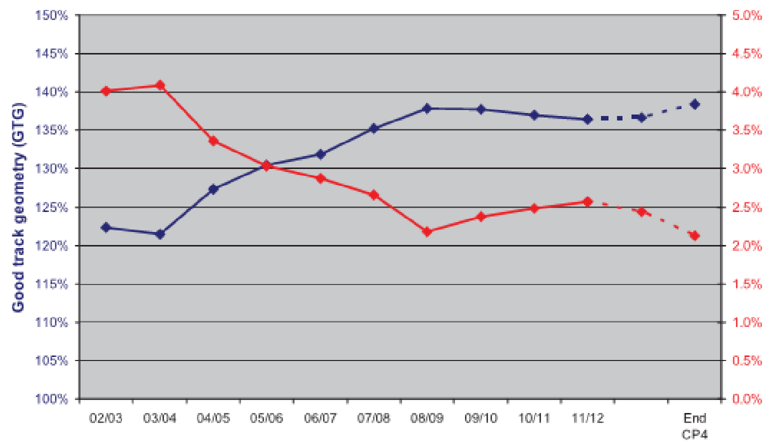


Figure 5-4: Good and Poor Track Geometry: Recent History and Targets [Ref. SBPT3010, Figure 2.15]

5.1.10 After a prolonged and significant reduction in the number of actionable geometry defects from 2002/3 to 2008/9 there was a slight reversal in this trend in the first 3 years of CP4, as shown in Figure 5.5.

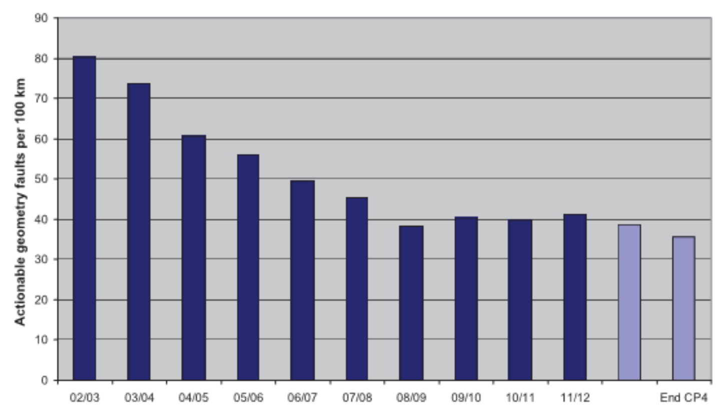


Figure 5-5: Intervention and Immediate Action Faults [Ref. SBPT3010, Figure 2.16]

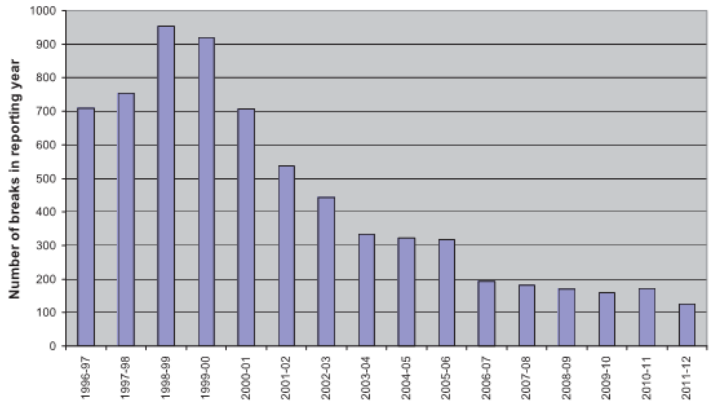


Figure 5-6: Rail Breaks from 1995/96 - 2011/12 [Ref. SBPT3010, Figure 2.17]

5.1.11 Figure 5.6 from the Track Policy shows the significant reduction in broken rails that has been achieved since 1998/99. It has been reported, and evidenced at Route meetings, that the 2012/13 broken rail target will not be achieved; however the increase in occurrences is small in comparison to the overall improvement in the last decade.

5.2 Line of Sight

5.2.1 NR states in its Track Asset Policy [SBPT3010] that its baseline objective for CP5 is to "maintain the end of CP4 condition", thereby continuing to achieve the key track asset performance indicators as defined in the ORR Asset Stewardship Indices.

5.2.2 The NR Asset Stewardship Index measures the following track KPIs:

- broken rails;
- rail defects;
- track geometry quality;
- temporary speed restrictions; and
- track geometry faults.

5.2.3 The Track Policy [Ref. SBPT3010, Section 10.10] contains proposed KPI's for CP5; these are shown in Figure 5.7 below. The measures are similar to those currently used, with the addition of two long-term sustainability indicators: Effective Used Service Life and Ballast Fouling Index. We understand that these measures will be broken down by Asset Criticality.

Metric	Description
Good Track Geometry (GTG)	A measure of the proportion of track that is recorded as being in the 'good' and 'satisfactory' track quality bands. A higher GTG implies a better overall condition of the track asset and a better ride experienced by passengers in trains on that track.
Poor Track Geometry (PTG)	A measure of the proportion of track that is recorded as being in the 'very poor' and 'super-red' track quality bands. A higher PTG implies a worse safety and performance risk and more reactive maintenance.
Serious rail defects	Serious rail defects require a speed restriction or line blockage until they have been removed.
Service affecting failures	The number of service affecting failures (i.e. failures causing more than 10 minutes train delay) arising from track infrastructure faults (track + points failures)
Effective used service life	A proxy for asset condition of the rail, sleepers and S&C. It can be predicted by our modelling and performance can be monitored against this.
Ballast fouling index	Ballast fouling index is a measure based on the calculated filling of void space between the ballast particles with fine material, which inhibits free drainage and reduces the effectiveness of geometry maintenance. The fine material is generated mainly by ballast degradation due to wear from traffic and tamping, with an allowance for other factors such as spillage from trains, and local environmental contributions

Figure 5-7: Proposed Key Performance Indicators [Ref. SBPT3010, Table 10.3]

5.2.4 We have concerns with how ballast fouling will be baselined at the start of CP5 and then measured and would wish to see how NR propose to implement this. Nevertheless, we agree that the measures are appropriate.

5.2.5 The output requirements for the rail industry are specified in the DfT's High Level Output Statement (HLOS) (Section 4).

5.2.6 In order to achieve the public performance measure (PPM) and improve safety a set of specific output requirements for track thorough CP5 have been defined by NR, these are:

- Maintain the targeted end-CP4 overall track condition through CP5, improving the high criticality / high traffic routes;
- Maintain the targeted end-CP4 number of service affecting failures, averaged over CP5;
- Maintain the targeted end-CP4 train delays and costs, consistent with a 92.5% PPM target; and
- Improve the condition of S&C geometry and switch gauge.

5.2.7 The aim is further defined in the Track Asset Policy [Ref. SBPY3010, Chapter 9 page 249] as:

"The above objectives are to be achieved within the context of route criticality. Higher criticality routes are targeted to be in better condition, with associated better reliability, than lower criticality routes, because there is less access for maintenance (due to much higher traffic densities, sometimes for 24 hours a day), and the cost of

each track failure is much higher (a factor of more than 8 between Band 1 and Band 5 routes).

Therefore, the aim in CP5, carrying on the policy in CP4, is to improve the condition of routes in Criticality Bands 1 and 2 and maintain the condition in the other Bands to a level that does not degrade overall performance.

In effect, this means that track in the higher bands is more likely to be renewed, while lower criticality track will be more likely to be refurbished in order to prolong its life. As will be seen later, the result in terms of overall performance (i.e. failure rates) is similar in each criticality band, because the expected traffic increases in Bands 1 and 2 offset the considerable improvements in track condition."

5.2.8 The Policy implies that the quality of the track on Route Criticality 4 & 5 may decline. This use of the remaining asset life of lower criticality bands of track is not unreasonable provided that safety performance is managed.

5.2.9 Performance is measured by the achievement of the HLOS PPM target. Track's contribution to meeting this target will be to maintain or reduce the number of service affecting failures or train delays caused by track faults, speed restrictions, broken rails etc.

5.2.10 The output from the WLCC model links to train delay, safety, rail defects and track defects and track quality. Figure 5-8 below, is an example output from a Tier 2 model case study.

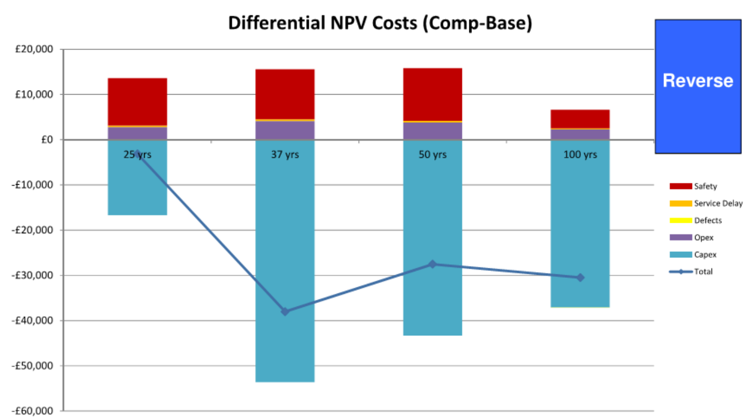


Figure 5-8: Example of WLCC Track Model Output [Ref. SBPT3030-1, extract]

5.2.11 We are satisfied that there is a linkage between the HLOS targets and the Policy objectives and consider it very likely that their attainment will meet the contribution required from track to achieve the HLOS output requirements.

5.2.12 For track the measures and targets are as shown in Figures 5-9 and 5-10.

Robustness measures	CP4	CP5
Track		
Failures > 10 mins	9,364	9,451
Signalling		
Failures > 10 mins	12,053	12,053
Telecoms		
Failures > 10 mins	519	519
Electrification and Plant		
Failures > 10 mins	671	736
Buildings		
2 and 24 hour reactive faults	5,268	5,268
Structures		
Open risk items with risk score >20	291	218
Earthworks		
Robustness	Under development	

Figure 5-9: Track Robustness Measure for England & Wales [Ref. SBPT101, Page 69]

Asset	Sustainability measure	CP4	CP5	CP6	CP7	CP8	CP9	CP10	CP11
Track	Used life (%)	52%	51%	50%	50%	53%	55%	56%	57%
Signalling	Remaining life (years)	13.3	15.0	17.8	21.1	21.0	20.0	18.4	17.8
Telecoms	Remaining life (%)	72%	46%	36%	44%	69%	53%	36%	37%
E&P	Remaining life (%)	61%	57%	55%	54%	53%	53%	53%	51%
Buildings	Remaining life (%)	41%	42%	45%	49%	53%	55%	58%	58%
Structures	Condition score for principal load bearing elements (bridges)	7.4	5.8	4.2	4.3	4.5	4.6	4.6	4.5
Earthworks (GB total)	Earthworks Risk Index	100	99.6	99.7	99.7	99.7	99.7	99.7	99.6

Figure 5-10: Track Sustainability Measure for England & Wales [Ref. SBPT101, page 69]

5.3 Asset Knowledge

5.3.1 There are several different plain line (PL) and S&C track system designs in use, each with different whole system and component asset lives. Section 2 of the Policy contains details of asset characteristics and analysis of historical data. Section 5 of the Policy covers the key degradation mechanisms and failure modes.

5.3.2 The data used to inform the Policy for track is largely drawn from records held in GEOGIS (for inventory and condition) and Ellipse (for activity planning). Other sources include rail defects from the Rail Defect Management System (RDMS), fault records, TRUST and geometry recording data from a track quality database of all 220-yard (200m) SD measurements obtained from the track recording cars. It is recognised that there are some areas with less robust age and condition data. These include ballast, formation, drainage and some S&C components.

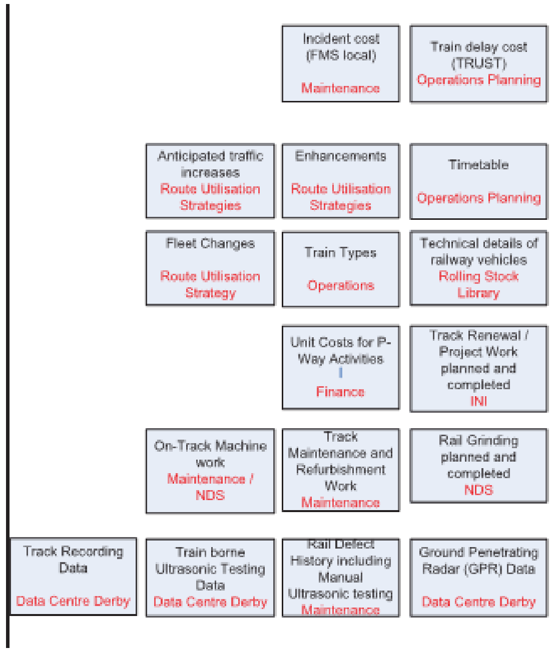


Figure 5-11: Data Sources [Ref. SBPT3010, Figure 8.1(extract)]

5.3.3 Although there are shortcomings in asset data, particularly from GEOGIS, we are satisfied that NR have used best available current knowledge. NR are currently in the process of improving asset data collection, storage and presentation as part of the ORBIS project, the LADS system being a tool particularly applicable to track.

5.3.4 Further details of the data preparation undertaken by NR can be found in our Strategic Business Plan (SBP) Report - Review of ICM Track Tier 1 VTISM and Cost & Volume Model.

5.3.5 The GEOGIS field relating to age of ballast is particularly poor, *"up to 60% of ballast installation dates are missing"* and imperfect [Ref. Tier 1 Uncertainty, Section 2.1.1]. This data has been in-filled based on sleeper and rail installation dates.

5.3.6 We would expect to see that once the current work to improve the understanding of the network's ballast/formation condition using High Definition Ground Penetrating Radar (HD GPR) is suitably advanced, the ballast deterioration models will be re-configured to use measured condition rather than just installation date. The HD GPR data has been seen to be being used by some Routes to identify underlying formation and ballast condition and hence been used to formulate remedial treatments.

5.3.7 The Track Asset Policy and its supporting models use rates of degradation for the key components and also consider future traffic growth. The models have been designed to mirror the key maintenance and renewal interventions necessary to maintain the track in its respective criticality band and track category to the required levels of geometry to be both compliant with standards and necessary to achieve performance goals. Minimum intervals are set for these criteria to be met, outside of which either heavy refurbishment or total renewal interventions are required.

5.3.8 Initially NR's Tier 2 model permitted only one heavy refurbishment in the 100 years of modelled track life. This has now been relaxed and an option for a second heavy refurbishment after the first renewal is permitted. We support this change as it is reasonable and can only lead to even lower life cycle costs. Any savings will only be realised in CP6 and beyond; however, we noted that in the Tier 2 model case studies that this option was not used and should be for future modelling runs.

5.3.9 A key element of the models is the predicted life of the ballast bed, which is the main driver for a renewal or heavy refurbishment intervention. The modelled condition of the ballast bed is also a key driver of track geometry quality, which triggers maintenance interventions.

5.3.10 The current Tier 2 model has been updated to allow for the deterioration of track geometry due to poor drainage and subsequent decline of formation stiffness to be considered. However, NR have not used this new modelling capability in the SBP submission, due to a lack of calibration. The fact that the model has not been switched on is not considered to be critical since emerging formation failures will appear in deteriorating track geometry.

5.3.11 A generally good understanding of the behaviour of the track system is demonstrated in the Policy. Improvements have been made to the Policy since the version published in 2011 and the Tier 2 model has been enhanced to account for the important role of drainage and track formation, even though the data is fairly basic. In the model, the influence on track geometry by the engineering property of the formation is linked to a five point state of the drainage. Where no drainage is present, the condition of the formation and any influence its condition may have on ballast behaviour and track geometry is ignored.

5.3.12 The Track Asset Policy states *"stiffness of the underlying formation and the strength of any underlying earthworks can also have a significant impact on the local rate of settlement of the track."* We strongly agree with this statement and are surprised that NR continues to defer from introducing into its track engineering standards a range of acceptable values for the modulus of elasticity of the track formation. We believe that a start, which need not wait until CP5, could be made by measuring this modulus on current total ballast excavation track renewals, especially under switches and crossings which are most in need of a good uniform foundation.

5.4 Asset Behaviour, Degradation and Criticality

5.4.1 NR consider Asset Criticality and Route Criticality separately.

Asset Criticality

5.4.2 Section 3 of the Track Asset Policy defines Asset Criticality for the track system components by looking at the historical performance data together with the RSSB safety risk model and determines which has been the critical component that contributed to safety risk, delay minutes and renewal and maintenance cost. The outcome of this analysis can be seen in Figure 5-12, Figure 5-13 and Figure 5-14 below:

Asset	Failure mode	Contribution to safety risk from track
Rail	Buckled rail	38%
	Broken rail	6%
	Fishplates	2%
Sleepers	Gauge spread	2%
Ballast	Track twist	37%
	Cyclic top	0%
S&C	All	14%
Other	All	1%

Figure 5-12: Track Asset System Component Contributions to Safety [Ref. SBPT3010, Table 3.1]

Asset	Component	Contribution to delay costs
Plain line	Rail	35%
	Sleeper	0%
	Rail pads	0%
	Ballast	13%
	Formation	3%
	Total PL	51%
S&C	Half-sets	22%
	Crossings	4%
	Other rail	0%
	Bearers	1%
	Ballast	11%
	Formation	3%
	Total S&C	41%
Unattributed		8%

Figure 5.13: Track Asset System Component Contributions to Delay [Ref. SBPT3010, Table 3.2]

Asset	Component	Contribution to renewal costs	Contribution to maintenance costs
Plain line	Rail	28%	25%
	Sleeper	22%	11%
	Ballast	21%	17%
	Formation	1%	1%
	Total PL	71%	54%
S&C	Half-sets	4%	6%
	Crossings	4%	8%
	Other rail	0%	1%
	Bearers	9%	4%
	Ballast	8%	9%
	Formation	1%	0%
	Total S&C	27%	27%
Remainder		2%	19%

Figure 5-14: Plain Line and S&C Contribution to Renewal and Maintenance Cost [Ref. SBPT3010, Table 3.3]

5.4.3 The final assignment of criticality is summarised in Figure 5-15 below which shows the assets that have been assigned a high criticality by NR, based on the information given in the tables above.

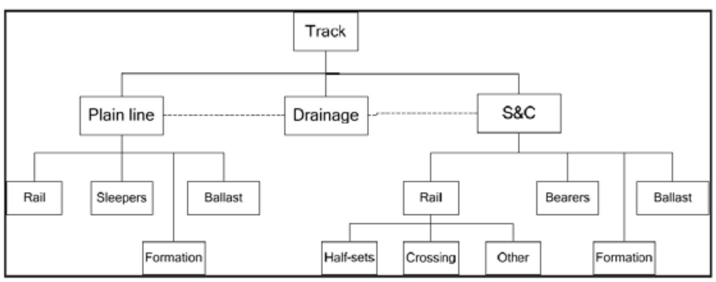


Figure 5-15: Identification of High Criticality Track Assets [Ref. SBPT3010, Figure 3.1]

5.4.4 We consider that the NR view of asset criticality is appropriate, but consider that the figure above could be improved to reflect component contribution.

5.4.5 NR view S&C defects, followed by rail buckles, as their highest derailment risks.

5.4.6 NR have used contemporary track degradation research material from the UK and Europe to support their Policy. NR's knowledge of rail and track geometry degradation is considered to be good and is used in both the Tier 1 and the Tier 2 track models.

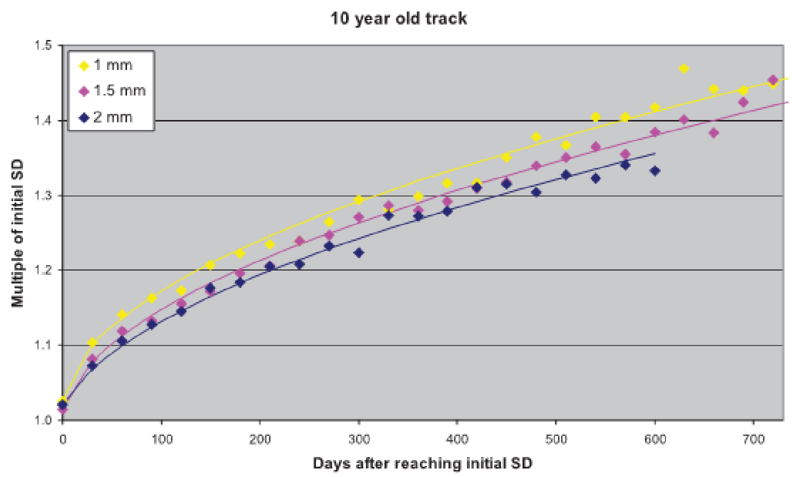


Figure 5-16: Average Measured Track Geometry Degradation [Ref. SBPT3010, Figure 5.17]

5.4.7 It is recognised that degradation of the components in plain line is better understood than those in S&C. For the latter NR have commenced a workstream to improve data capture and analysis within its Tier 2 modelling work. This is a very important area of further work, because, as the Policy states, "*S&C is more unreliable than plain line*". Furthermore, the Policy also states that "there is room for improvement in this area". On page 109 it states "*...geometry deterioration is about 60% higher on S&C and the plain line 50 yards either side of it (on the through rail) compared to equivalent un-associated plain line...*"

5.4.8 This is further evidenced with data on the initial quality of S&C renewals. Figure 6.26 on page 170 (see Figure 5-17) shows that the percentage of S&C renewals achieving NR's construction standard, which is a track geometry measure, is 65%. The data used to calculate track geometry degradation in the models includes new track represented on this graph. Were NR to fully meet their track geometry standards for new work, this would start to flatten the geometry degradation curves leading to lower WLCC.

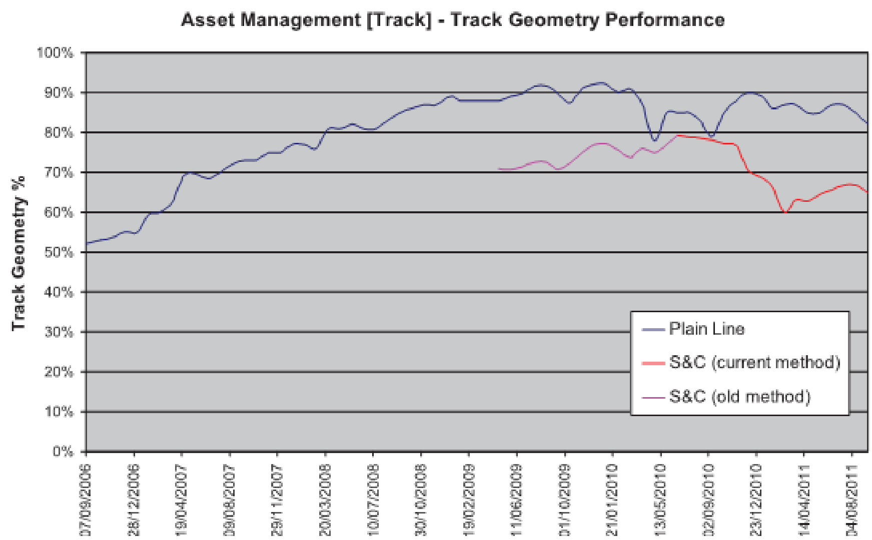


Figure 5-17: Percentage of Track Renewals Meeting the Network Rail Track Construction Standard [Ref. SBPT3010, Figure 6.26]

5.4.9 It is widely recognised in the field of track engineering that the initial quality of track at the time of installation has an influence on both the rate of degradation and the future cost of maintenance. Using the measure of vertical standard deviations (SD) over a 35 metre wavelength, if a section of track has a linear rate of geometry degradation, and an upper limit at which it is known to require correction, then a lower initial value will lengthen the interval before the first intervention becomes necessary. A further improvement can be made if the rate of geometry degradation can be reduced. This can be achieved by ensuring an optimum design and construction of the track formation and the ballast bed.

5.4.10 Alongside track geometry, the next critical asset about which data is robust is rail. Since the consequence of a broken rail is so severe a significant amount of work has been done to develop systems to detect defects both on the rail surface and within the rail steel. By relating this data to annual tonnage both degradation and expected rail life are calculated.

5.4.11 Degradation of the other track system components is supported from the Ellipse maintenance planning system and is based on information relating to the age of components being renewed. Where possible, the service life of components is linked to tonnage; however, on lines with small traffic volumes, items such as steel fastenings and timber sleepers may have a life limited by time, due to erosion and decay.

5.4.12 The supporting data for PL is of a higher quality than that for S&C.

5.4.13 NR are a key member of the Vehicle/Track Systems Interface Committee (V/T SIC) which was created following the Hatfield accident in 2000 to better understand the engineering interface between vehicle wheel and rail and the interaction between the vehicle and track. It is through this committee, under the auspices of the RSSB, that mathematical models have been developed that NR are using for PR13 to look at rail life and its maintenance.

5.4.14 For PL, the Tier 2 model uses some of the above models, implemented in VTISM, for ballast/geometry deterioration and intervention models, and the rail defects generation model. These are supplemented by degradation models for pad deterioration, sleeper condition, and formation and drainage deterioration.

5.4.15 The above models have also been adapted for S&C, but NR have said that these are not as good as for PL and further work is required.

5.4.16 The degradation information and relationships has been obtained from multiple sources, including that used within other NR models and some obtained during the writing of the policy and development of the Tier 2 model. The models and supporting data used are shown in Figure 5-18:

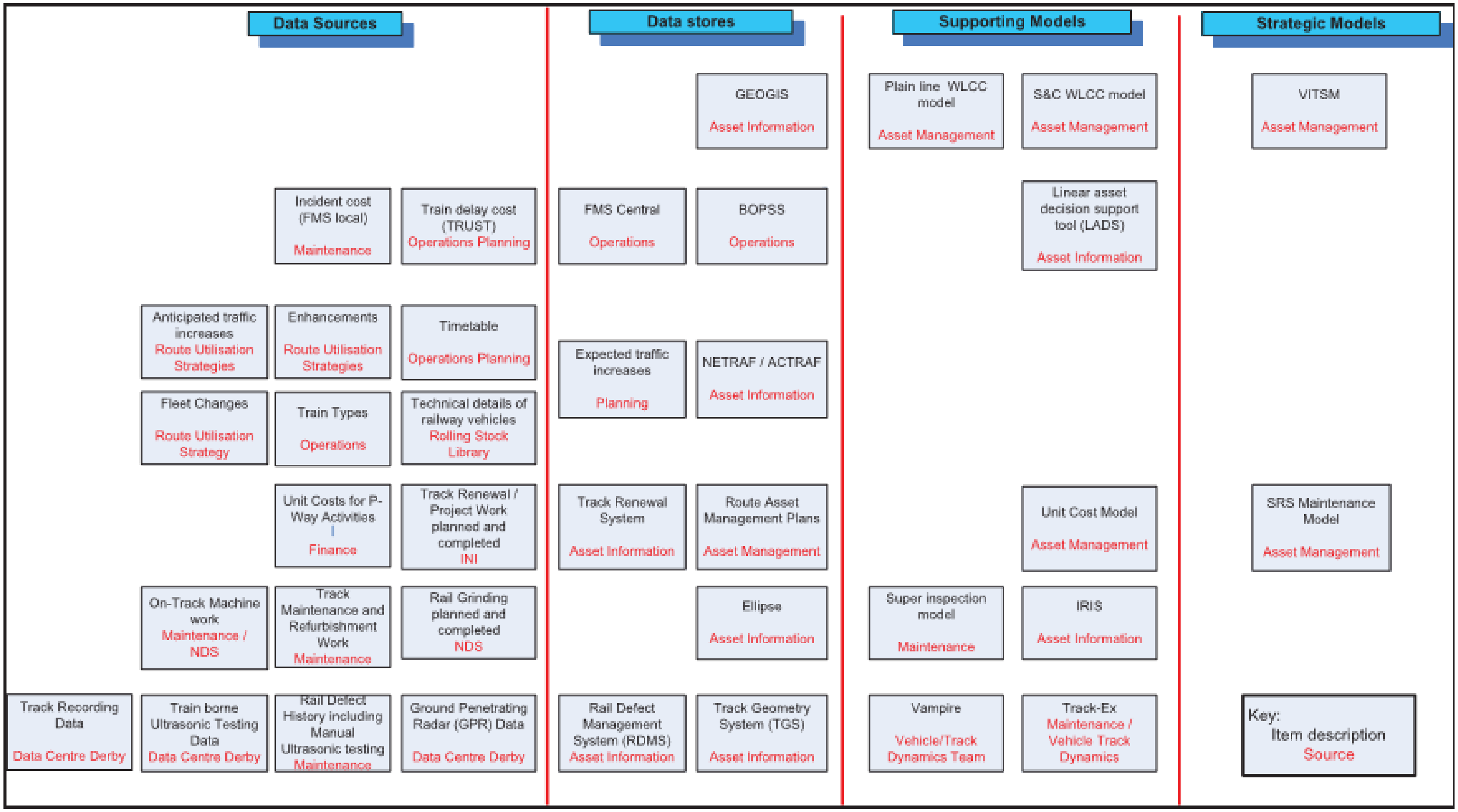


Figure 5-18: Track Models and Supporting Data [Ref. SBPT3010, Figure 8.1]

5.4.17 Validation and verification has been undertaken, however there are areas that require future work to validate the engineering judgement used.

5.4.18 The rate of track geometry degradation is arguably the single critical element that determines the interval between maintenance interventions, including total renewal. This is also the key parameter in the model and is incorporated in two ways; the rate at which the ballast bed voids are filled and the rate at which for particular circumstances the geometry deteriorates. Rail life is also critical; however, rails can be replaced before their condition threatens performance in isolation of other major track system components.

5.4.19 There are eight modes of degradation included in the Plain Line model, with data coming from a number of different sources. These are summarised in Table 5-1.

Table 5-1: Degradation Modes for Plain Line Track

Heading	Commentary
Geometry	This is a key degradation model since it determines when an intervention or heavy refurbishment is triggered. The model replicates the geometry models used within the TSPA and VTISM Tier 1 models. Maximum and target track quality thresholds are defined in NR's track standard NR/SP/TRK/001. The model is able to account for increased geometry deterioration as a result of sleeper degradation and the effect of gross tonnage.
Ballast	A ballast condition factor is calculated depending on ballast void fill as a percentage. Track geometry deteriorates rapidly once the voids are full.
Sleepers	Degradation curves have been derived, largely from track engineering judgement, for six categories of PL sleeper, three in dry conditions and three in damp conditions, to replicate sleeper life and the year when respective sleepers would normally be replaced. Only concrete and timber sleepers are modelled.
Rail Pads	Rail pad life has been modelled as a direct correlation with cumulative tonnage and incorporated into the sleeper degradation model (for concrete sleepers only). It has been recognised by NR that actual pad lives can be at variance with modelled values.
Rail Defects	As a result of extensive research and data collection, NR have been able to develop a probabilistic model to simulate defect occurrences.
Geometry Faults	Geometry faults are usually detected by the track geometry measurement train and subsequently repaired, usually by manual means. These maintenance interventions are modelled based on the probability of a number of defects arising each month based on predicted geometry.
Rolling Contact Fatigue	The RCF and sidewear models, although built, have not been activated in the Tier 2 model.

Heading	Commentary
Formation and Drainage	Existing condition data for drainage and formation is poor. A layered Markov chain approach to modelling the degradation of drainage and track formation has been used. The model uses a probabilistic method to reflect clogging, silting and blockage of drainage over time. In the model, track formation deteriorates at a very slow rate until drainage degrades, once this happens the rate increases. The impact of this is on increased deterioration of track geometry and ballast fouling.

5.4.20 The failure modes for PL and S&C, down to a component level, are defined in Table 5.1 of the Track Policy [Ref. SBPT3010, Table 5.1].

5.4.21 The model for ballast bed degradation takes into account the accumulation of fines during its lifetime. This contamination can be caused by stones being crushed both as a consequence of traffic carried and by the action of tamping machines. Fines are carried to site with new ballast, spillage occurs from vehicles and wind-blown soils are added to the ballast. The addition of fines from the erosion of the undersides of concrete sleepers and from wind-blown vegetation are not included at present, although the upwards migration of soil particles from cohesive formations when wet have now been added.

5.4.22 The Track Policy states that high category track accumulates fines up to twice as fast as low category track. Based on tests carried out on the case studies, the PL model appears sufficiently robust to determine whether track should be totally renewed or heavily refurbished.

5.4.23 There are eight modes of track system or track component degradation included in the S&C model. Ballast, Geometry Faults and Rail Defects are the same as for PL. The five modes specific to S&C are described in Table 5-2.

Table 5-2: Degradation Modes Specific to S&C

Heading	Commentary
Bearers	Bearers are classed as timber or concrete and treated in three groups. These are ‘Other’ and ‘Switches’, which are both treated as for PL; and ‘Crossings’ which degrade additionally due to fatigue and are treated according to the life of the crossing.
Crossings	Crossing degradation is based on two formulae which are derived from a combination of engineering judgement and collected data. The equation chosen depends on whether the track exceeds the ‘good’ track quality thresholds are defined in Network Rail’s track standard NR/SP/TRK/001. The resulting exponential formula is heavily dependent on geometry. The model reduces the rate of wear by 50% once concrete bearers replace timber. This factor was based on engineering judgement by NR and is a reasonable assumption for crossings.

Heading	Commentary
Switches	Switch degradation follows the same methodology as for crossings. The 'good' track quality thresholds are defined in NR's track standard NR/SP/TRK/001. As before, the model reduces the rate of wear by 50% once concrete bearers replace timber.
Gauge	The development of wide gauge in timber turnouts has been modelled from experience and engineering judgement and is deemed to be a function of tonnage over time. Once the layout has been renewed with concrete bearers there is no longer a maintenance requirement.
Geometry	The S&C model has been updated to the same formula as for PL. It should be noted that SD values are based on 200 metre lengths, and not specifically over the length of S&C.

5.4.24 Details of the degradation models for track used in the WLCC model and the status of their validation is contained in the Track WLCC Model Review [Ref. AO/030/2A, Section 4.2].

5.4.25 We believe that the degradation of PL is well understood and the models have been validated, although there is further work to be done on the deterioration of rail pads.

5.4.26 We consider that S&C degradation has not been fully validated and currently relies mainly on engineering judgement. Work on better understanding the deterioration of S&C ironwork and gauge has been carried out by NR, but is not complete.

5.4.27 In our review of the Tier 2 WLCC model, we noted that the approximation that S&C geometry may be up to 60% worse than plain line has been retained. NR advised that this has been retained in the model to reflect the current insitu network situation. We do not consider that this will inhibit the improvements in S&C geometry quality to be delivered through compliance with the Track Policy and we would expect that the 60% figure would be reduced in the future.

Route Criticality

5.4.28 Route Criticality is considered in Section 4 of the Policy. Performance of the track system at any particular location can be defined as the provision of a safe and reliable journey to the passengers or goods in the operator's vehicles at the published line speed and without delay to the published journey.

5.4.29 Section 4 of the Policy explains in how NR have broken down their network into 305 route sections and for each, analysed historical data for the last five years where performance has not been met. This historical data has then been linked to the Schedule 8 payments incurred to produce a ranking of Route Criticality. Based on this ranking of the mean delay cost per incident, NR have defined five bands of Route Criticality. We consider this improved granularity over the three bands in CP4 to be a positive step forward.

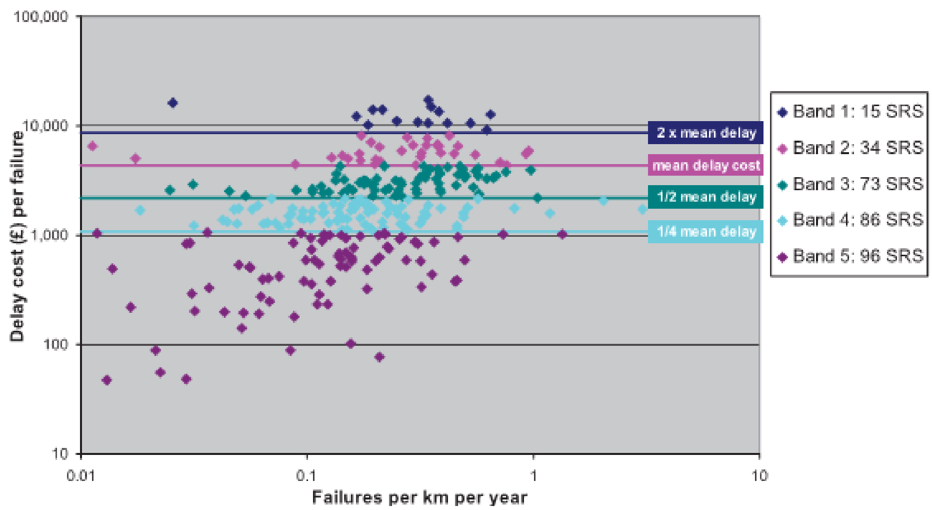


Figure 5-19: Route Criticality Based on Mean Delay Cost [Ref. Track Asset Policy Figure 4.2]

Band	Definition
Band 1	SRS with costs per incident more than two times the mean
Band 2	SRS with costs per incident between the mean and two times the mean
Band 3	SRS with costs per incident between the mean and half the mean
Band 4	SRS with costs per incident between half the mean and one quarter the mean
Band 5	SRS with costs per incident less than one quarter the mean

Figure 5-20: Definitions of Route Criticality Bands [Ref. Track Asset Policy Table 4.2]

5.4.30 The SRSs in each band are shown in Appendix 4.2 on pages 77 to 84 of the Track Asset Policy.

5.4.31 This establishment of Asset and Route Criticality for track and the consequential detailed policy statements described in Appendix 10.2 of the Track Asset Policy will enable Route Asset Managers (RAMs) responsible for track to set maintenance and renewal budgets targeted to meet the performance requirements for each SRS under their responsibility. The development of a hierarchy of five Criticality Bands for the routes on the network is commended.

5.5 Renewal and Maintenance Interventions

5.5.1 Four broad intervention scenarios are considered:

- Maintenance;
- Refurbishment (medium and heavy maintenance);
- Renewal; and
- Enhancement.

5.5.2 The prime role of the maintenance function is to undertake timely inspections of the track, to carry out routine servicing of components (i.e. lubrication) and be responsive to attend and repair faults that would otherwise have safety or performance consequences. The policy for inspection of plain line is moving from foot inspection to plain line pattern recognition (PLPR) systems that are train borne and more efficient. In order to better understand ballast and formation condition, new high definition ground penetrating radar is to be deployed. This will considerably enhance asset knowledge of the condition of these assets, the largely hidden support to the sleepers and rails.

5.5.3 There are no current plans to change the general intervention thresholds for routine maintenance servicing activities in CP5; however NR have indicated that they intend to develop plans to introduce a more proactive approach to maintenance in CP5, such as earlier repair of switch half-sets, prior to an SO53 fault (the point when wear on a switch gives rise to the risk of derailment in the facing direction).

5.5.4 NR are developing risk-based maintenance for plain line track, this is currently being trialled on some selected routes. If successful the process and training will be rolled out network wide and also be trialled on S&C.

5.5.5 Five scenarios are described in Section 9.4 of the Track Asset Policy, however only three have been fully assessed; these are listed in Table 5-3:

Table 5-3: Traffic and Investment Scenarios

Scenario	Title	Description	Assessed
1	No traffic increase, no investment	Traffic stays constant from the end of CP4	**Y**
2	No traffic increase, additional investment	Traffic stays constant from the end of CP4. Additional investment in improving asset information, training and new mechanised plant.	**Y**
3	Traffic Growth from end CP4	Traffic increase implied by HLOS accounted for	**Y**
4	Remove all jointed track	Remove all remaining jointed track by end of CP5	**N**
5	Rationalise Junctions	Remove redundant/rarely used S&C, even if in adequate condition	**N**

5.5.6 The performance targets for all scenarios are the same, the overall HLOS requirements and the associated track specific objectives to meet them.

5.5.7 By planning to achieve the HLOS targets the scenarios are consistent with the business' objectives.

5.5.8 The estimated effective increases in asset life for renewal and refurbishment are shown below. These are contained in the policy [Ref. SBPT3010, Appendix 9.1].

	Rail	Sleeper	Ballast	S&C	Comments
Complete trax	100%	100%	100%		All track renewed
Complete renewal + formation	100%	100%	100%		All track renewed
Complete HO	100%	100%	100%		All track renewed
Steel relay	100%	100%	100%		Sleeper rail renewed, moderately fouled ballast scarified
Heavy refurbishment (concrete)	10%	40%	100%		Ballast renewed, sleepers life extended through re-padding and renewed ballast
Heavy refurbishment (timber)	20%	40%	40%		Sleeper 1-3 replacement, ballast lift
Medium refurbishment (concrete)	10%	20%	10%		Sleepers re-padded, plus spot re-sleepering
Medium refurbishment (timber)	10%	20%	10%		Spot re-sleepering, track made suitable for stoneblowing
Rail renewal	100%				Both rails renewed
Single rail renewal	50%				One rail renewed
S&C renewal				100%	New S&C unit
S&C abandonment				50%	S&C removed and plain-lined on through rail, ballast replaced
S&C heavy refurbishment				50%	Ballast replaced, some component replacement, switch re-gauging
S&C medium refurbishment				20%	Component replacement, switch re-gauging

Figure 5-21: Intervention Resets Assumed in the Policy [Ref. SBPT3010, Table 9.A.1]

5.5.9 We consider that the estimated effective increase in life for ballast, associated with steel relay is too high, simply as the ballast is not renewed when steel sleepers are relayed.

5.5.10 The estimates of an effective increase in asset life for heavy refurbishment are only valid if the underlying problems causing poor track geometry are understood. As this is an area where asset condition knowledge is poor, the work currently underway to determine ballast and formation condition through HD GPR and the network drainage survey is all the more important.

5.5.11 We believe that the 50% increase in asset life for S&C Heavy Refurbishment to be a challenging target. The industry does not have a proven track record in this area. NR see the shortage of skills and experience as a risk.

5.5.12 Interventions are required before degradation of a particular element of the track system has reached a condition where the track is no longer able to deliver safe performance as defined in NR's engineering track standards. Interventions will also be planned, based on degradation models, when other factors such as gross tonnage is due to reach a level where experience has shown that component failures, leading to an unacceptable loss of performance, are likely to occur.

5.5.13 For the track model there are discrete interventions based on mathematical degradation curves for sub-assets such as rail, pad, sleeper and ballast. As the model is run over time, each of these sub-assets reaches a point in its life when an intervention is triggered. In this way a major intervention to renew the whole track system, after which each element starts a "new life" can be compared with a longer maintenance regime with frequent interventions for smaller component changes. This is fully described in Halcrow's Track Tier 2 Methodology and Verification Report [Ref. SPBT3030-3].

5.5.14 Track component service lives are related to the equivalent gross tonnage (EGT) experienced by the asset and the asset construction type. A key output of the policy is the forecast average asset used life. These used life fractions are based on historical information and reflect the full application of maintenance activities described at page 57 in Appendix 2.1 of the Track Asset Policy.

5.5.15 Future maintenance activities are modelled in the SRS Maintenance model and are described in Section 8.5 of the Policy.

5.5.16 Failure to achieve routine maintenance on critical assets can lead to asset failures. On less critical assets such as sleeper pads and drainage it results in shorter asset lives and possible impacts to linked assets, such as sleepers and rails in the case of pads; track geometry, ballast and formation in the case of drainage.

5.5.17 The prime purpose of the Tier 2 model for track is to demonstrate that the Policy, which introduces the principle of refurbishment rather than total renewal, is robust and delivers a minimum whole life cost for the track assets. The Tier 2 model allows the following range of interventions (as well as others e.g. full renewal) to be evaluated against current practice.

Plain Line

- Renewal
- Medium refurbishment
- Heavy refurbishment – concrete
- Heavy refurbishment – timber

Switches and Crossings

- Renewal

- Medium refurbishment
- Heavy refurbishment

5.5.18 The Tier 2 model was tested by NR with each Route submitting five plain line sites and 5 S&C sites to be run through the model. In addition, the model has been used to test more generally the likely whole life cycle cost implications for a number of common track asset management decisions, scenarios and options. These are:

- Heavy Refurbishment vs. Renewal;
- Heavy Refurbishment with Re-Rail vs. Renewal;
- Life Extension (Medium Refurbishment) vs. Immediate Renewal;
- Proactive vs. reactive drainage intervention regimes;
- High performance vs. satisfactory regimes; and
- Lifecycle cost implications of timely interventions scheduling (i.e. good track access).

5.5.19 The Track Tier 2 model indicates that by following the Track Asset Policy, the introduction of timely (and SRS specific) heavy and medium track refurbishment, rather than total renewal, can provide a minimum WLCC in track asset management.

5.5.20 The case study assessment described in the WLCC model [Ref: AO/030/2A] concluded that in "*most cases*" where Local Track Selection Factor (LTSF) was less than average (0.74), 50% life extension of the asset could be achieved. "*Most cases*" results in approximately 70% of sites achieving successful life extension.

5.5.21 We note that LTSF=1 is an absolute upper bound and that other parameters are considered for selection of sites for heavy refurbishment in T-SPA. In addition from discussions with NR, track of criticality 1 to 3 are less likely to be selected with a higher LTSF. However for bands 4 and 5 there is a 50% chance that a site with an LTSF>0.74 can be selected and therefore this increases the uncertainty of achieving successful refurbishment for these sites. There is also still a 30 to 40% chance that LTSF>0.74 is selected for bands 1 to 3.

5.5.22 We note that to reduce the risk of selecting sites not suitable for heavy refurbishment, NR are "back loading" the CP5 workbank. This is to pre-empt that schemes to acquire better data quality will have been implemented, which is a significant factor in identifying sites suitable for heavy refurbishment. This is evident from the bottom up SBP track volumes developed by the Routes and agreed with the HAM (Track) that have a higher proportion of renewal than refurbishment, compared to the top-down modelled volumes. NR have informed us that this is a result of the lack of good quality asset information for identifying suitable sites in the first couple of years of CP5, for which workbanks have to be specified and agreed now.

5.5.23 We consider the use of LTSF>1 in T-SPA will over estimate the sites suitable for refurbishment, particularly for plain line on route criticality 4 and 5.

5.6 Asset Cost Data

Tier 1 Model

5.6.1 Table 5-4 provides an overview of the correlation of Tier 1 model track unit rates for each route with the supporting data provided by NR.

Table 5-4: Correlation between Track Renewals and Tier 1 Model Track Unit Rates

Track Renewals Category	Level of Correlation T1 Versus Unit Cost Information
Steel relay	100%
High output (ABC)	Variance in rate for Wales of <-1%
High output (rail sleeper relay)	Variance in rate for Scotland of -4%
Complete Trax	100%
Heavy refurb (concrete, HO)	100%
Heavy refurb (concrete, MO)	100%
Heavy refurb (other)	Variance in all rates of +7%
Medium refurb (concrete)	100%
Medium refurb (other)	100%
Rail renewal	100%
Single rail	100%
S&C full renewal	Variance in all rates of <-1%
S&C heavy refurb	Variance in all rates of c.7.5%
S&C medium refurb	Variance in all rates of 7.1%
S&C abandonment	Variance in all rates of 6.4%

5.6.2 The materiality of these variances is not fully understood but clearly variances of <1% is not considered significant. Remaining variances are likely to be based on a revised viewpoint at SBP of national costs and the volume of work to be delivered to the end of CP4.

5.6.3 Unit costs are assessed under Mandate AO/034. A number of issues were identified in the derivation of track and S&C unit costs during progressive assurance including:

- The importance of using a representative 2012/13 baseline and work mix to estimate track renewals rates for CP5;
- The appropriateness of including IMT contingency within the 2012/13 baseline cost estimates;
- The accuracy of allowances made for NR staff costs and capitalised overheads; and
- On further review of the Progressive Assurance report validation of the blanket 3% uplift to all rates, prices and allowances within the 2012/13 baseline rates is also required.

5.6.4 These items are presently under review and will be updated in the final report for Mandate AO/034. However, the basis of the unit costs is clear and supporting data has been provided by Network Rail. Unitised cost coverage for track assets is high and provides a reliable basis for the calculation of renewals interventions.

5.6.5 Network Rail has advised that the Track Tier 1 maintenance model is based on current maintenance unit costs (MUC). The following table compares the MUCs presented in the Tier 1 model with our most up to date understanding of the rates.

MNT Code	Description	Tier 1 Rate (£)	Latest MUC (£)	Variance
MNT004	Plain Line Tamping	2,994	2,994	0%
MNT005	Stoneblowing Plain Line	2,583	2,583	0%
MNT006	Manual Wet Bed Removal	78	78	0%
MNT007	S&C Tamping	5,026	5,026	0%
MNT009	Mechanical Spot Re-sleepering	365	365	0%
MNT010	Replacement of S&C Bearers	228	228	0%
MNT011	S&C Arc Weld Repair	306	306	0%
MNT012	Mechanical Wet Bed Removal	187	187	0%
MNT013	Level 1 Patrolling Track Inspection	150	139	8%
MNT014	Mechanised Patrolling Track Inspection	-	47	
MNT015	Weld Repair of Defective Rail	257	257	0%
MNT016	Installation of Pre-Fabricated IRJs	1,476	1,477	0%
MNT017	Mechanical Reprofiling of Ballast	2,111	2,111	0%
MNT020	Manual Reprofiling of Ballast	2	2	0%
MNT025	Replenishment of Ballast Manual	23	23	0%
MNT026	Replenishment of Ballast Train	17	17	0%
MNT027	Maintenance of Rail Lubricators	72	72	0%
MNT029	Replacement of Pads & Insulators	6	6	0%
MNT030	Maintenance of Longitudinal Timber	142	142	0%
MNT031	Complete Treatment of S&C unit	2,443	2,443	0%
MNT032	CWR - Stressing	16	16	0%
MNT033	Jointed Track Hot Weather Preparation	24	24	0%
MNT034	Patrolling Track Inspection (Video) Plain Line	16	14	14%
MNT035	Patrolling Track Inspection (Video) S&C	12	12	0%
MNT036	Manual Correction of PL Track Geometry (CWR)	14	14	0%
MNT038	Manual Rail Grinding	11	11	0%
MNT039	Manual Spot Re-sleepering (Concrete)	273	273	0%
MNT040	Manual Spot Re-sleepering (Wood / Steel)	173	173	0%
MNT041	Manual Ultrasonic Inspection - (Plain Line)	279	279	0%
MNT042	Manual Ultrasonic Inspection - (S&C)	45	45	0%
MNT043	Manual Ultrasonic Inspection - RCF	0	0	-1%
MNT044	Rail Changing - Al-Thermic Weld - Standard Gap	173	173	0%
MNT045	Rail Changing - CWR - Renew (Defects)	74	74	0%
MNT046	Rail Changing - CWR - Renew Due to Wear	40	40	0%
MNT047	Rail Changing - Jointed Rail - Renew (Defects)	59	59	0%
MNT048	Rail Changing - Jointed Rail - Renew Due to Wear	37	37	0%
MNT049	Rail Lubricators Install / Remove	288	288	0%
MNT070	Inspections (Fencing, Vegetation, Drainage)	54	54	0%
MNT071	Inspections (Level Crossing - Access Points)	48	48	0%
MNT072	Fences and Boundary Walls	8	8	0%
MNT075	Level Crossings Management (Off Track)	341	341	0%
MNT079	Spoil & Debris Clearance Outside Station Area	166	166	0%
MNT081	Vegetation Removal of Boundary Trees	110	110	0%
MNT082	Vegetation Management by Train	534	534	0%
MNT120	S&C - renew crossing	13,645	13,645	0%
MNT121	S&C Inspection (Other)	17	17	0%
MNT122	S&C Maintenance (Other)	39	39	0%
MNT123	S&C Renew Half Set of Switches	7,610	7,610	0%
MNT124	Stoneblowing S&C	3,713	3,713	0%
MNT125	Track Inspection (Other)	39	39	0%
MNT126	Train Grinding - S&C	1,433	1,433	0%
MNT127	Transportation of Materials (To/From Site)	24	24	0%
MNT128	Lift & Replace Level Crossing for PWAY	667	667	0%
MNT170	Vegetation Management (Manual)	3	3	0%
MNT171	Vegetation Management (Mechanised)	3,884	3,884	0%
MNT172	Vegetation Management (Spray)	0	0	-1%

Figure 5-22: Comparison between MUCs and Recent Understanding of Rates

5.6.6 The key variances are in MNT codes 013 and 034. The variances in Level 1 Patrolling Track Inspection and Patrolling Track Inspection (Video) Plain Line are unknown and need further investigation. In addition the rates for plain line tamping and stoneblowing need further clarification as there is uncertainty if they are per km or per mile. The effect of such an error could be significant.

Tier 2 Model

5.6.7 The extract from the WLCC model provides a range of unit costs for the following items:

- Tamping;
- Stoneblowing;
- Spot Sleeper Replacement;
- Pad Replacement;
- Geometry Inspection;
- Heavy Refurbishment;
- Renewal w/Trax;
- Renewal High Output (HO);
- Rail Renewal;
- Additional SandBlanket;
- Additional GeoTextile;
- Catch Pit Cleaning;
- Drain Jetting;
- Off Track Drain Installation;
- On Track Drain Installation Additional;
- Weld Repair;
- Short Rail Replacement;
- Geometry Fault Repair;
- HR w Re Rail;
- Trax w Formation;
- MAC Defect Repair;
- Defect Cost Uplift; and
- Geo Fault Cost Uplift.

5.6.8 The unit cost data provided under Mandate AO/034 is not directly comparable to the unit costs in the WLCC model. No further information has been provided to substantiate the rates provided in the model or how they correlate to recently developed renewals and maintenance unit costs.

5.7 Policy Selection and Preferred Life Cycle Options

5.7.1 NR have considered a number of scenarios in their Track Asset Policy to support decisions as to which combination of maintenance, refurbishment and renewal interventions gives the lowest WLCC.

5.7.2 In 2010 NR introduced a new Policy for track and a new Route based organisational structure. The current Policy builds on that earlier work and in particular introduces the application of WLCC at the decision point when a length of track is considered ready for renewal. Previously, after assessment that renewal was necessary due to one element of the track system having reached the end of its serviceable life, the whole system would be renewed, thereby removing some components before their service life had ended.

5.7.3 This new Policy introduced a strategy to maximise the life of all of the components of the track system when one of those components had reached the end of its life cycle. As the previous practice had been largely to renew the whole system, this was seen as a development that would reduce intervention costs and generate efficiency in CP4. That Policy has been enhanced and developed for CP5, with a stronger focus on the principle of Life Cycle Cost Planning at the intervention point when a component of the track system needs to be renewed, supported by the development of the Tier 2 model.

5.7.4 Route Asset Managers, responsible for track, develop bottom up plans for maintenance and renewal based on observed and recorded asset condition received from Track Maintenance Engineers. They also receive target top down budgets for each SRS from the modelled volumes and costs. It is their responsibility to assess this information and set actual budgets for maintenance and renewals. This is a key role in the establishment of annual programmes of work as it balances on a route basis the overall requirements necessary to deliver the required track safety and ensure a quality performance. This also is a contribution to efficiency over previous practices where maintenance and renewal programmes were set independently.

5.7.5 The Track Asset Policy [Ref. SBPT3010, Appendix 6.1] provides details of the refurbishment lifecycle options that should be considered when a section of track is due for renewal. It differentiates between ‘Heavy’ and ‘Medium’ and between PL and S&C. It also considers treatments to the ballast, formation and drainage. The options are described in general terms rather than as engineering specifications, which is acceptable for a policy document. However, in due course, the general terms will need to be translated into engineering specifications against which completed works can be measured in order to assure performance and sustainability.

5.7.6 The PL section of the Policy is considered to be stronger than that for S&C.

5.7.7 There are no specific Scotland issues in the Track Asset Policy. However there has been an acceptance by the Head of Asset Management (Track), that sleeper degradation rates on some low traffic routes may be specific to Scotland.

5.7.8 The Track Asset Policy does not advocate the adoption of the principle of minimum WLCC management in every aspect of its track maintenance and renewal activities, only at the "what to do" optimisation situations for geometry and rail maintenance and track renewal. The full adoption of the principle of WLCC would introduce a stronger emphasis on the initial quality of track after renewal and require the right maintenance intervention at the right time, supported by a complete asset information system. By following these steps in the early life of track it can be expected that mid-life maintenance interventions could be reduced, leading to a lower overall cost. NR are currently improving asset information with the ORBIS project. We have been informed by NR that work is in progress to address the quality of track renewals, particularly for S&C.

5.7.9 Section 10.2 of the Track Asset Policy gives an overview of track policy, stating that CP5 will achieve the track asset output objectives by:

- *"More fully exploiting the remaining service life of track components, especially sleepers, through refurbishment;*
- *Enhancing the CP4 policy on route criticality, so that capital expenditure can be efficiently distributed around the network.;*
- *Focusing on critical assets (S&C, ballast, rail and pads) to maximise the life of the track system"*

5.7.10 NR also believe that the selected Policy of undertaking more refurbishment and less total renewal can deliver cost savings. NR believe that initiatives in the Policy will reduce the present level of safety risk in the two key areas of S&C reliability and track buckles in hot weather; however, increased traffic levels, with a corresponding reduced access for maintenance and renewal will provide some challenges.

5.8 Overall Planning Process

5.8.1 The planning process for track maintenance and renewal volumes commenced with the Head of Asset Management Track (HAM(T)) sending to each Route Asset Manager Track (RAM(T)) the Tier 1 modelled volumes and costs for their route.

5.8.2 Route plans were drawn up based on local asset knowledge and the track problem statements from Track Maintenance Engineers. These were reviewed by the RAM(T) who, by making reference to the track Policy, enhanced the initial plans. Engineers in the RAM(T)'s team conducted site inspections and met with maintenance staff. In some cases detailed consecutive 200 metre long track asset condition diagrams were produced to develop detailed SRS plans for the whole control period.

5.8.3 Bottom up Route track plans for CP5 were finalised, unit rates adjusted for local conditions, and these were submitted to HQ for review.

5.8.4 The next stage in the planning process was for the bottom up volumes proposed by the routes to be reviewed by the HAM(T). This comprised a peer review process for each Route involving the HAM(T), Professional Head of Track and a RAM(T) from another Route. The review of the Route's track M&R plan involved undertaking site inspections and reviewing instances where the Route proposed to carry out work at variance to the policy.

5.8.5 Following all ten reviews, and agreement where local circumstances sought variance from policy, Route track Maintenance & Renewal plans were agreed and defined.

5.8.6 The agreed SBP volumes for Routes were re-run in the Tier 1 model in order to confirm that the required track performance outputs would be met, including used asset lives for the track system components.

5.8.7 We observed acceptance from the Routes to the overall process, including the peer review. The Routes were also satisfied that the final volumes they have put forward have been accepted by the HAM(T).

5.8.8 Following SBP review meetings, held during January and February 2013 with the majority of Routes, it was clear that whilst the RAM(T) team had a firm understanding of the Track Policy and its application, there is still much work to be done to train and develop all Route staff involved in track asset management and the application of the Policy, as highlighted in appendix 10.1.3 of the Track Asset Policy document.

5.9 Systems Approach

5.9.1 The Policy has considered inter-dependencies of the rail infrastructure system; these are described in Appendix 10.1.10 of the Track Policy.

5.9.2 Having reviewed the described inter-dependencies we consider this approach to be acceptable.

5.10 Risk and Review

5.10.1 Risks and uncertainties are discussed in Section 10.9 of the Track Policy.

5.10.2 NR have identified the following high risks and uncertainties in the policy:

- Increased staff competency levels are required to deliver track refurbishment;
- The use of new asset information systems (ORBIS); and
- Sufficient resources to deliver refurbishment.

5.10.3 We agree that the foregoing represent high risks to the delivery of the plan. In particular we believe that there is a requirement to develop the skills and expertise of track at all levels.

5.11 Deliverability

5.11.1 Implementation issues are covered in Section 10.8 of the Policy. The key issues are listed as:

- Route Asset Management Plans;
- Refurbishment;
- Asset information; and
- Change Management.

5.11.2 Based on our Route meetings, it appears that Route Plans take into account the new Track Asset Policy.

5.11.3 Refurbishment of track is a more complex process and will require new techniques to be developed and new skills learned by NR staff and those in the supply chain. This appears to have been taken into account by the Routes in that they are generally planning the increased volumes of refurbishment work in the latter years of CP5.

5.11.4 The main challenge to the delivery of PL heavy refurbishment in CP5 is the increased volume of ballast cleaning required. NR have said that 62km of this work in CP5 cannot be resourced at the present time. We have concerns that the current fleet of medium and high output ballast cleaners have been allocated to this work with inadequate contingency to achieve the planned volumes, which may result in the 62km growing to 100km. One possible way in which these volumes could be delivered is to increase the weekly throughput by working the fleet an extra shift each week. This may have implications for the fleet maintenance plan.

5.11.5 The Policy, modelling and bottom up plans result in significantly increased (compared with CP4) volumes of S&C maintenance and heavy refurbishment, and the CP5 outputs are heavily reliant on achieving these at the anticipated cost. In our view this will require:

- the skills and competency to consistently deliver refurbished S&C to the required high standard of initial quality necessary to achieve the desired life extension (the expected reduction in mid-life maintenance interventions is highly dependent on this);
- robust asset information systems to enable on-going management of the S&C geometry; and
- adequate and timely compaction of ballast.

5.11.7 In addition we believe there are several other aspects to consider, namely:

- procurement (where necessary) and operation of appropriate S&C tampers working in tandem;
- procurement of innovative S&C re-ballasting plant.
- We have not seen a management plan which addresses the points raised above.

5.11.8 We note that NR are currently in the process of re-tendering the contracts for S&C and PL renewals.

5.12 Continuous Improvement

5.12.1 The Policy does not specifically discuss any future review or development of the Policy. In principle we find this acceptable, as the introduction of track refurbishment, which is adopted by other track owning authorities, is a welcome and proven asset management practice.

5.12.2 The Policy [Ref. SBPY3010, Section 10.9] refers to the importance of the Route Asset Management Plans (RAMPS) and Asset Information.

"The RAMPS are the foundation on which current and future delivery plans will be based. They are also the vehicle that enables delivery of the plan works to be monitored, the effectiveness of the plans against anticipated outputs assessed thus enabling feedback into future plans, policy and standards.

Asset Information is a combination of what data do we need, how to collect and analyse it, what information do we produce and how do we use this to continuously improve our management of the assets."

5.12.3 We consider that it will be good practice to undertake a review of the Policy during the course of CP5.

5.13 Targets, Robustness, Sustainability and Cost

5.13.1 We have been asked to consider the degree to which NR have demonstrated that the asset policies are robust, sustainable[5] and the degree to which the Asset Policy has been demonstrated to deliver the required outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets[6].

5.13.2 Generally the Policy is very good, it is a mature document that has been updated from CP4 and improved for CP5. If work is delivered to a quality that meets the current track engineering standards it will pass the test of robustness and sustainability. However we believe there is some uncertainty that NR can deliver the lowest WLCC, as they have admitted that currently track renewals are not consistently delivered to meet their track construction standard.

5.13.3 Improvements have been made to the Track Policy and in the Tier 2 model since IIP to account for the important role of drainage and track formation in the overall track asset system.

5.13.4 We believe that in general, the Routes have embraced the Policy.

Targets

5.13.5 In order to achieve the PPM and improve safety a set of specific output requirements for track thorough CP5 have been defined, these are:

- Maintain the targeted end-CP4 overall track condition through CP5, improving the high criticality / high traffic routes;
- Maintain the targeted end-CP4 number of service affecting failures, averaged over CP5;
- Maintain the targeted end-CP4 train delays and costs, consistent with a 92.5% PPM target; and
- Improve the condition of S&C geometry and switch gauge.

5.13.6 The Policy [Ref. SBPT3010, Section 10.10] contains the predicted output for the final Policy option. These are shown in Figure 5-23 below.

[5] ORR letter dated 1st June 2010 (document ref. 379948)
[6] ORR-#430597-v1-20111028_ORR_PR13_Policy_review_note and Mandate AO/030.

	End CP4	End CP5
Condition		
Good Track Geometry (GTG)	136.7%	136.9%
Poor Track Geometry	2.43%	2.79%
Serious defects per 100km	3.42	3.22
Performance		
Service affecting failures per km	0..324	0.327
Sustainability		
Rail used life	48%	49%
Sleeper used life	62%	61%
Ballast fouling	49%	47%
S&C used life	53%	50%

Figure 5-23: Track Output Forecast [Ref. SBPT3010, Table 10.4]

5.13.7 Across the network it is forecast that poor track geometry will deteriorate from the end of CP4 to end of CP5, with NR predicting an overall improvement in Criticality Bands 1 & 2, but with deterioration in all other bands. The largest deterioration is in Band 5.

5.13.8 As stated previously, in order to meet or better track geometry targets, we consider that NR need a robust plan to confirm that there are sufficient tampers, of the right type, for maintenance, renewals and enhancements in the UK.

Robustness

5.13.9 We consider that it is very likely that the Track Policy will be robust as it has demonstrated a good knowledge of the asset, its current condition and degradation rates, the impact of traffic forecast for CP5 together with a programme of maintenance and renewals that is very likely to deliver the same track performance and safety levels that will be in place at the end of CP4.

Sustainability

5.13.10 We consider the network volumes of track maintenance and renewals in the SBP to be those necessary to deliver the stated track performance outputs in the Policy.

5.13.11 Deliverability and quality of renewals, particularly S&C heavy refurbishment, are the biggest challenges. However we believe that there are action plans in place with strong leadership and accountability to address the majority of issues.

5.13.12 New technologies, such as LADS and HD GPR are helping to improve asset condition knowledge, particularly for ballast and formation. We have seen enthusiasm at Route level for both systems.

5.13.13 Anticipated asset life extension from heavy refurbishment of S&C and plain line, on lower criticality routes, may be optimistic as a result of our analysis of the WLCC modelling outputs.

5.13.14 We consider that it is reasonably likely that the Policy will be sustainable. There is some uncertainty associated with the asset life extension from heavy refurbishment of S&C and PL on lower criticality routes, which we believe may be optimistic.

Whole System Cost

5.13.15 For a minimum whole system cost maintenance and renewal of track should ensure that the ballast and formation is adequately drained. This is acknowledged in the Track Policy and in the creation of a drainage policy for CP5. We support these developments.

5.13.16 Work on delivering and assuring a uniform track formation stiffness may be critical to achieving this measure when track is renewed. We do not consider sufficient importance has been given to track formation in their asset policies.

5.13.17 We consider that there is some uncertainty as to whether the Track Policy will deliver the outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets. This uncertainty primarily arises from concerns over the ability of NR to deliver the required quality and durability of renewal and refurbishment work.

Embedded Efficiencies

5.13.18 As noted above, a detailed review of efficiencies has not been undertaken as part of this mandate.

5.13.19 For the Track asset no renewals 'embedded efficiency' has been assumed by NR. This reflects NR's view that '*... the Track policy review we completed in 2009/10 has already produced significant scope reductions during CP4. These reductions continue through CP5 and into future control periods and whilst substantial, are not a distinct change from the end of the current period to the next*' [SBPT220].

5.13.20 NR have not assumed any Track maintenance efficiencies associated Track Policy ('embedded efficiencies').

5.14 References

Ref	Document Title	Version / Date
SBPT3010	Track Asset Policy	v1, December 2012
TK05	Network Rail, Track SBP uncertainty analysis – Tier 1 Volumes, Issue 1, 12 December 2012	Issue 1/ 12 December 2012
SBPT3030-6	Amey, Case Study Summary, WLCC-01, Issue 0, Sept 2012	Issue 0/ Sept 2012
JW Email	RE: T2 Track Modelling Query	25 February 2013
SBPT3030-1	Tier 2 Track Model R4.01a	R4.01a/30 September 2012
SPBT3030-3	Halcrow, Network Rail, Track Tier 2 Whole Life Cycle Cost Model, Phase 3, Methodology and Verification Report, Draft 1, 15 June 2012	Draft 1/15 June 2012
SPBT101	SBP for England & Wales	7 January 2013
ÖBB	Presentation - ÖBB: network information, strategies track diagnosis - 13 years of experience with rail-mounted formation rehabilitation	Conference, West Ealing, 24th-26th June 2008

6 Structures Asset Policy

6.1 Performance Requirements / Outputs

Introduction

6.1.1 NR have made significant progress with the development of their Structures Asset Policy since IIP.

6.1.2 The NR SBP submission includes a CP5 Structures Asset Policy [SBPT3013] which explains NR's proposed management approach for structures. Structures consist of several main groups:

- Bridges (underbridges and overbridges);
- Major Structures;
- Tunnels;
- Other Assets (retaining walls, footbridges, culverts, and coastal, estuarine and river defences (CERDS)); and
- Structures Other.

6.1.3 Since IIP, NR have also prepared an additional document, Policy on a Page (PoaP) [S6], which provides detailed guidance on the management of structures assets. PoaP makes the link between the Policy, WLC strategies and asset groups. It groups structures assets according to key similarities (material, form, failure mode) and defines intervention thresholds in terms of level of risk at critical element level.

6.1.4 Given the range of structures assets listed above, we consider it would be logical to extend the coverage further to include all signalling, OLE and telecoms structural assets and station footbridges within the Policy.

6.1.5 There is a line item in the SBP for 'Structures Other' which sets out funding for those Policy objectives set to reduce risk and comply with statutory obligations, which are not covered elsewhere. The 'Structures Other' category includes an allowance for:

- Planned Preventative Maintenance (PPM);
- Scour protection;
- Spandrel wall strengthening;
- Hidden shafts;
- Road vehicle incursion (and for neighbouring sites);
- Pigeon proofing; and
- Route specific schemes such as compliance with working at height regulations and contribution to Thameslink.

Performance Requirements

6.1.6 The NR Structures Policy [Ref. SBPT3013, 10.2] sets out the strategic Policy outputs related to HLOS requirements as:

- Ensuring current safety levels are maintained or enhanced;
- Contributing to achieving an overall level of PPM of at least 92.5 moving annual average (MAA) by the end of CP5; and
- Taking account of climate change risks and opportunities.

6.1.7 NR aim to address these requirements through the introduction of a risk-based Policy. This has been completely rewritten since IIP, in particular by prioritising the interventions according to safety risk. Three levels of service have been defined: safety, availability and capability. Condition has been taken as a proxy for level of risk. Route Criticality is used as a proxy for demand; this parameter is indirectly related to annual tonnage.

6.1.8 NR Structures Asset Policy [Ref. SBPT3013] summarises structures reliability trends by reference to Major Structures related events from the early days of the railway through to 1999. For safety events post 2000 NR have assessed the existing level of risk at system level by reference to NR Standard NR/L3/CIV/028 [Ref S1], which defines how safety related events are reported. The number of CIV/028 reports has increased sharply over the last12 months, from a quarterly average of about 3 to 12, shown in Figure 6-1 [Ref. SBPT3013, Fig 2.1].

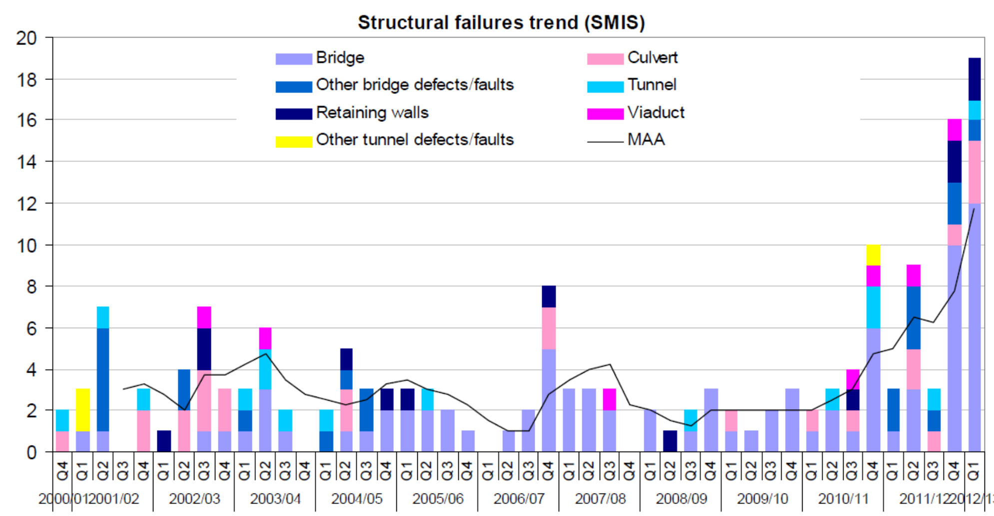


Figure 6-1: Structures Failures Trend 2000-2012

6.1.9 In addition, NR have listed twelve major structural failures which have occurred between 2009 and 2012 including Stewarton, Balcombe Tunnel and Enterkin Burn.

6.1.10 NR consider the current classification of risk position derived from the RSSB Safety Risk Model, which is Broadly Acceptable, is optimistic because it only captures incidents which result in injury. The significant increase in recent safety events and their potential to have caused fatalities or injuries had led NR to conclude that *'structures assets would likely fall within the Tolerable Region of risk'* as defined in the HSE Tolerability of Risk Framework [Ref. SBPT3013 page 23]. This is illustrated in Figure 6-2 [Ref. SBPT3013, Figure 2.4].

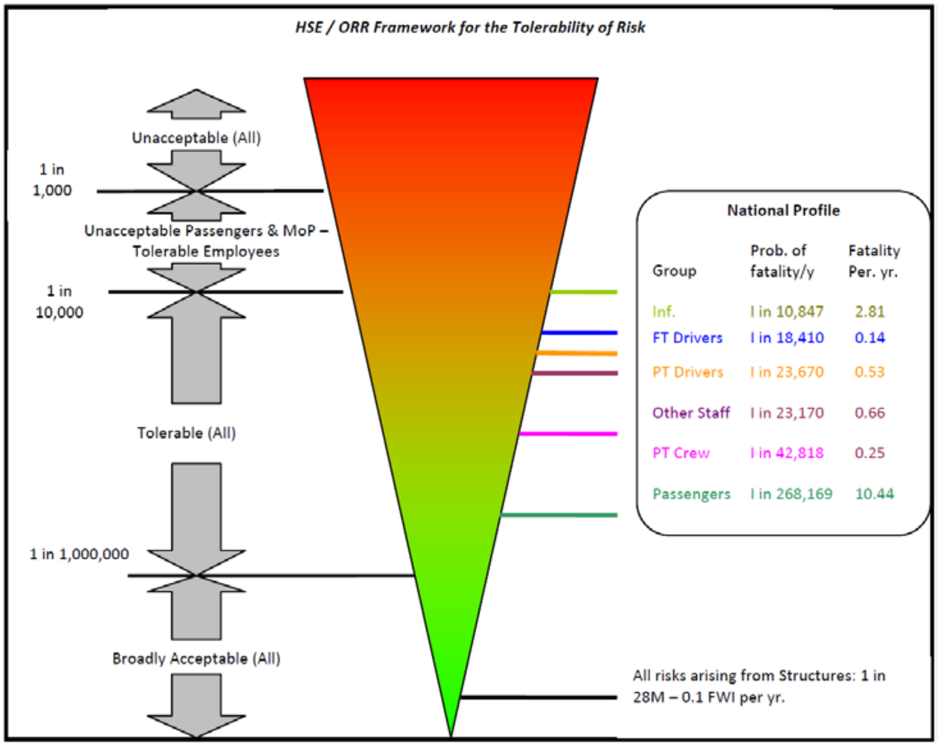


Figure 6-2: Overlay of Tolerable Risk and Structures SRM score

6.1.11 Although this appears to be a partially subjective conclusion and NR have not provided any detailed analysis to support it, we consider it is a reasonable assessment of the current position of NR's structures at population level.

6.1.12 Structures can impact performance (PPM) in several ways:

- Consequences of failure;
- Speed restrictions;
- TSRs due to capability shortfalls and lack of availability; and
- TSRs due to bridge strikes.

6.1.13 The number of structure related TSRs is reported as the ‘M4 Measure’ in the NR Annual Return. Data from 2001 to 2012 is shown in Figure 6-3. This shows a significant reduction from 2003 to about 2008, since when the trend is an increase.

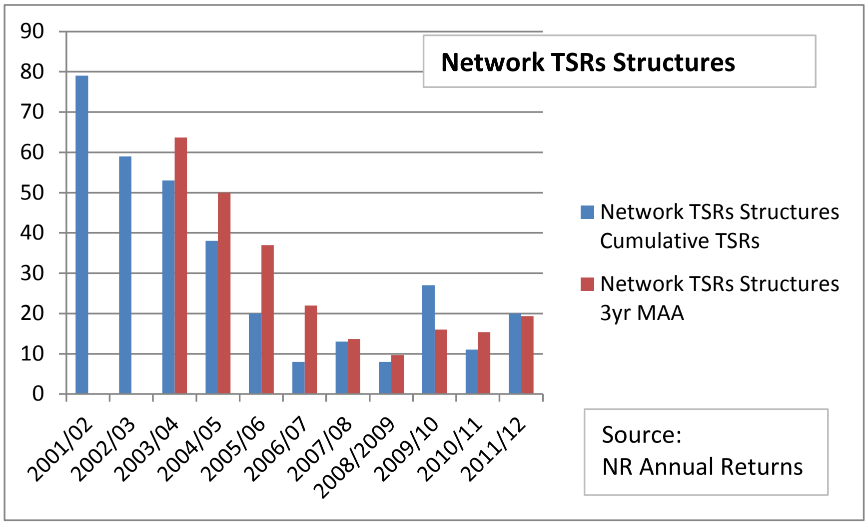


Figure 6-3: Number of Structures TSRs per annum ('M4 Measure')

Tunnels and Minor Assets

6.1.14 Of the twelve significant structures events [SBPT3013, 2.1] to have occurred since 2000, two relate to tunnels assets and one to retaining wall failure. No specific performance data has been provided at tunnel or minor asset level.

6.1.15 For structures, NR have matched HLOS performance requirements for safety by focusing the Policy objectives on understanding and managing safety and performance risks. Climate change has not been considered in detail.

6.2 Line of Sight

Relationship between Business Objectives and Outputs

6.2.1 The Network Rail Corporate Asset Management Policy [Ref. S3] states, as a core principle that:

"we will prevent an increase in the overall risk to passengers, workers and members of the public from the degradation or failure of infrastructure and will reduce it where reasonably practicable."

6.2.2 The SBP Structures Asset Policy is risk-based, setting intervention thresholds using risk based principles.

6.2.3 The second main corporate policy objective is to base strategies on 'minimising whole life, whole system costs'. NR have used the Tier 2 WLCC model to determine the intervention strategies for overbridges and underbridges, which constitute about two thirds of the Structures CP5 expenditure. WLCC analyses are discussed in more detail in Section 6.7.

6.2.4 No WLCC model has been developed for tunnels or Other Assets.

6.2.5 NR and ORR have agreed three key tests for Asset Policies in the SBP:

- Robustness: the ability of the policy to deliver the required CP5 outputs;
- Sustainability: the application of the same policy continuing to deliver the same outputs indefinitely if demand on the network remains constant; and
- Efficiency: delivering the required outputs in the most effective way at lowest life and whole system cost, taking into account efficiency improvements with time.

6.2.6 In the SBP, NR have developed a series of asset output measures for the major asset disciplines (track, signalling, electrical power, buildings, structures and earthworks). For Structures, the measures proposed by NR are "Open risk items with risk score >20", with totals of 291 for CP4 and 218 for CP5 [SBPT101 p69]. We are unclear about the definition of 'Open risk items'.

6.2.7 In developing its CP5 Asset Policy, NR have adopted a risk based approach to the identification of structures requiring remedial work. This is a significant step forward from the CP4 policies and the Structures Policy at IIP stage. This approach is consistent with NR's Corporate Asset Management Policy.

Bridge Intervention Strategies

6.2.8 In previous Structures Asset Policies, NR used the bridge condition marking index (BCMI) score for each structure as the main indicator of bridge condition. The maximum BCMI score of 100 represents a structure in perfect condition. In the SBP Structures Asset Policy, NR have made a significant change, which is to consider condition of the critical principal load bearing elements (PLBE) of a structure.

6.2.9 For bridges, NR have developed the policies by considering the condition requirements for PLBEs, which are "*components of the asset that transmit the applied load safely through the structure, for example a steel cross-girder*" [Ref. SBPT3013, p25]. Data related to the condition of PLBEs is collected and scored as part of the detailed examination process for bridges (excluding Major Structures), and these scores form the basis for the intervention criteria.

6.2.10 The NR risk based approach uses PLBE condition as a proxy for likelihood of failure, specifically using detailed examination data in the form of BCMI condition data for PLBEs of bridge structures, and uses route criticality to give a proxy for consequence to determine the risk levels.

6.2.11 NR have defined three levels of intervention: safety, performance and for local asset specific reasons, shown in Figure 6-4. Safety criteria are applied equally across all Routes. Performance interventions are only applied on Routes Criticality 1 and 2 – this is intended to maintain structures to a higher condition level on the higher criticality Routes. For the other Route Criticality levels, Routes can intervene at their discretion for specific (undefined) reasons.

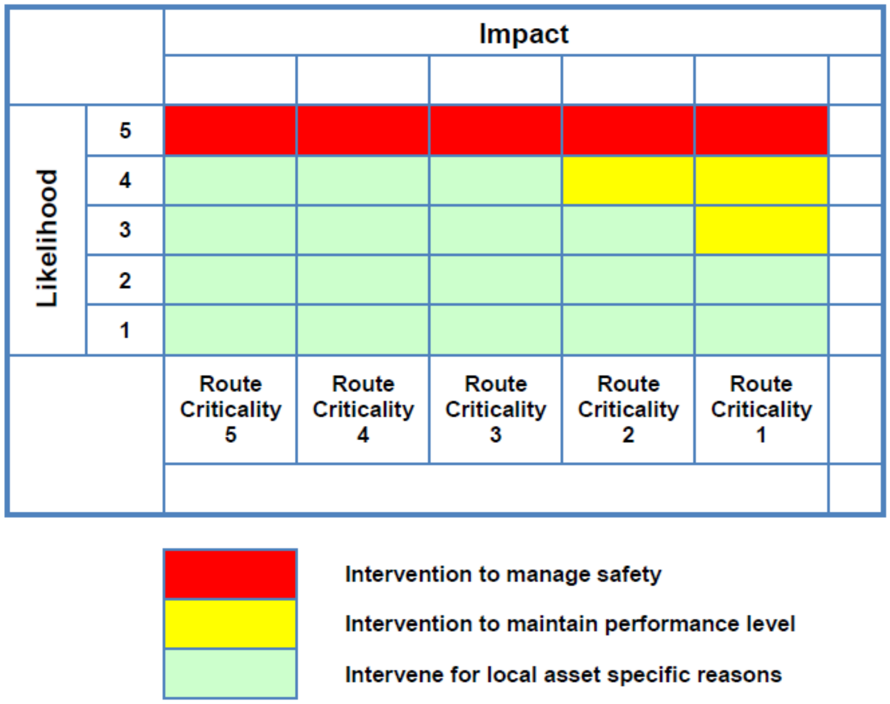


Figure 6-4: Intervention Matrix for Underline and Overline Bridges [Ref. SBPT3013, Figure 6.2]

6.2.12 PoaP [S6] provides detailed guidance to Routes on interventions in accordance with Policy for each of the above asset groups except Major Structures and CERDs which are not included. NR should consider this as one of the development objectives.

6.2.13 NR advise that PoaP sits alongside the Structures Asset Policy and provides guidance for the Routes on selecting interventions for typical assets that can be evidenced as providing Lowest WLCC. PoaP contains key information related to the application / implementation of Policy but has not been submitted as part of the SBP documentation. NR acknowledge that further development of PoaP will be undertaken in late spring 2013.[7]

6.2.14 The Policy defines minimum condition PLBE thresholds and performance driven intervention thresholds based on the BCMI element scores for PLBEs which are varied according to bridge type and material. These threshold values have been defined by NR experts. NR have advised that PLBEs and Critical Elements are synonymous[8]. Specific information related to the minimum condition PLBE thresholds in the Policy was provided by NR on 4th February 2013.

6.2.15 The minimum condition PLBE thresholds and interventions apply equally for all Route Criticalities for all sub-groups. Performance interventions are related to high criticality routes. Routes have local flexibility in other cases. This is a

[7] Question log STR1057
[8] Question log STR 1053a

balanced approach to the intervention philosophy.

6.2.16 Figure 6-5 sets out the minimum PLBE BCMI thresholds for bridge asset sub groups; SevEx marks which generate PLBE BCMI scores less than these threshold values are considered to be potentially unsafe and require some form of intervention. The variation in trigger levels is marked – this is indicative of the sensitivity of different structures to degradation and also demonstrates that BCMI was not designed as a risk indicator – at neither structure nor PLBE level can a particular score be directly related to a given level of risk.

6.2.17 We note in particular the high PLBE BCMI threshold value for Concrete Post-tensioned structures (85 on a scale of 100) – we are unclear why such a high value has been adopted. This requires further review.

6.2.18 In this Table, SevEx refers to the mark given by the bridge examiner to an element during the detailed examination based on the severity of a defect and its extent. SevEx codes are converted by an algorithm to a BCMI score for the element. Element scores are then weighted and summed algorithmically to derive a score for the structure.

6.2.19 The SevEx approach to defect marking has been used by NR for several years and is similar to that used by LoBEG (London Bridges Engineering Group) and the Highways Agency. We consider it represents good practice.

Asset Sub-Group	Measure	Trigger
Masonry Arch (SE)	BCMI	50
	SevEx	EX4
Masonry Arch (Cracked Masonry)	BCMI	65
	CM	M9
Metallic Through or Half-Through Girder	BCMI	40
	SevEx	C6
Metallic Truss / Lattice	BCMI	50
	SevEx	C5
Metallic Box Girder	BCMI	40
	SevEx	C6
Metallic Cast Iron Arch	BCMI	50
	SevEx	C5
Concrete Pre-cast / In-situ	BCMI	50
	SevEx	E5
Concrete Pre-tensioned	BCMI	55
	SevEx	E4
Concrete Post-tensioned	BCMI	85
	SevEx	C2

Figure 6-5: 'Basic Safety Limit' (minimum condition PLBE thresholds) for Bridge Asset Sub-Groups [Ref. SBPT 3013, Appendix I].

6.2.20 Intervention thresholds for performance are set out in Appendix D of the Policy, with different thresholds for asset subgroups and route criticality, and also related to the Intervention policy derived from the WLCC analysis. Sample data sets for metallic underbridges are shown below in Figure 6-6 and Figure 6-7 show how these are used in Policy on a Page to select Intervention Strategies for different Route Criticalities and Starting Conditions.

Metallic Through or Half-Through Girder

Measure of Likelihood (Standard Major)

Rank		Measure of likelihood
5	Increasing likelihood	BCMI score of 0 to 70
4		BCMI score of 71 to 75
3		BCMI score of 76 to 80
2		BCMI score of 81 to 90
1		BCMI score of 91 to 100

Measure of Likelihood (Do Minimum Minor)

Rank		Measure of likelihood
5	Increasing likelihood	BCMI score of 0 to 60
4		BCMI score of 61 to 70
3		BCMI score of 71 to 80
2		BCMI score of 81 to 90
1		BCMI score of 91 to 100

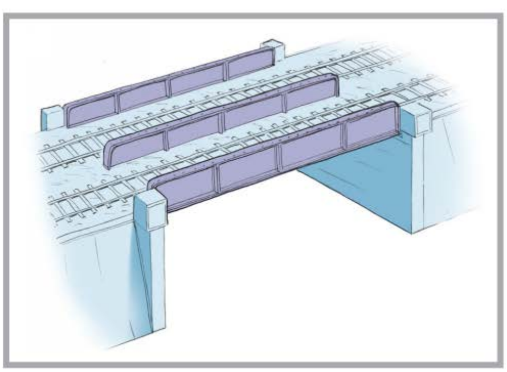
Measure of Likelihood (Managed)

Rank		Measure of likelihood
5	Increasing likelihood	BCMI score of 0 to 50
4		BCMI score of 51 to 60
3		BCMI score of 61 to 70
2		BCMI score of 71 to 80
1		BCMI score of 81 to 100

Figure 6-6: Likelihood Tables – Metallic Through or Half Through Underbridge [Ref. SBPT 3013 Page 105]

UNDERBRIDGE

Metallic, Through or Half Through Girder, Ballasted, Single Span



Selection of Intervention Type			
	Route Criticality Band	Starting Condition	
		Fair/Poor	Good
LWLC	3-5	B	E
	2	A	A
	1	A	A

A - Standard Major **B** - Standard Minor **C** - Do Minimum Major **D** - Do Minimum Minor
E - Managed **LWLC** - Lowest Whole Life Cost **R** - Standard Replace

Figure 6-7: Selection of Intervention Types – Metallic Through or Half Through Underbridge [Ref. S5, Page 7]

6.2.21 The intervention thresholds are generally set at or above the minimum PLBE threshold values. Rank five likelihood risks according Figure 6-4 represents the thresholds for safety interventions, which according to Figure 6-5 is 40 for metallic structures. The corresponding figures in Figure 6-6 are greater than these values (better condition), which is conservative. It appears that the Likelihood tables relate to performance interventions, which we consider to be the intended long-term norm of the Policy.

6.2.22 The approach adopted by NR in relating PLBE BCMI scores to safety and performance thresholds is a major advance on previous policies. However, as a fundamental part of the intervention strategy is related to safety management, we consider that the intervention matrix should have a sixth row for safety interventions and the Likelihood tables should also explicitly define minimum PLBE threshold intervention thresholds. This would give clarity to safety threshold values throughout the Policy and PoaP.

6.2.23 In setting intervention strategies (Figure 6-6), PoaP uses BCMI structure values. We consider this may be appropriate for setting long term strategies for the overall asset sub-groups once the issue of elements below minimum PLBE threshold thresholds has been resolved. However, for CP5 activities, the dominant activities for bridges will be related to minimum PLBE threshold issues and we question the applicability of PoaP for this work.

6.2.24 We are unclear why PoaP recommends (Figure 6-7) that metallic underbridges in good starting condition on minor routes are maintained using a 'Managed' strategy (e.g. no repainting). This seems to be similar to the approach which has led to the current situation and appears to be unsustainable.

6.2.25 The overall concept of the using condition parameters to drive interventions is sound, in that these relate to the recorded asset inventory examined under NR standards and are related to potential condition based failures. We note that condition is not the only parameter which influences failure.

6.2.26 The Structures Asset Policy [SBPT3013, paragraph 10.3] confirms prioritisation, stating 'the workbanks are prioritised firstly by elements below the minimum condition PLBE threshold, then capability, works for risk reduction programmes, and finally performance interventions.' Paragraph 10.2 lacks this clarity when it states the number one safety objective is '*Prioritising and undertaking interventions on PLBE for underline and overline bridges in accordance with Policy on a Page*' for the reasons outlined in 6.2.19 above.

Bridges – Workbank Development

6.2.27 The SCMI database has been analysed centrally to identify element scores below these two thresholds, indicating elements which require intervention. NR advises that there are circa 367,000 PLBEs in the SCMI database, [9] and 9,666 bridges with

[9] Question Log STR 1053b

one or more PLBE below the safety threshold level[10]. At the LNW Route meeting, we were advised that LNW alone has about 9,500 safety and an additional 19,000 performance non-compliant elements in 7,000 structures[11].

6.2.28 To develop a bottom-up workbank, non-compliant elements can be categorised – for example, Wessex initially used three categories – monitor (benign), CP5 definite and CP6 (gather more data) groups. We know Wessex has been making such an assessment for some months; LNW considers that it will take 18 months to produce a policy compliant workbank.

6.2.29 Two of the key attributes required for a determination are the location of the defect, which may not be not currently recorded in sufficient detail, and an understanding the stress level and capacity at the location of the defect, which may have to be taken from a structural assessment. NR have a backlog of 12,000 structures requiring assessment[12].

6.2.30 On the basis of condition data that we have seen (central and Route level) we have little doubt that there is a substantial amount of repair and renewal work to be carried out, primarily on underbridges; however, there is significant uncertainty about the makeup of this work. This relates to the fact that to apply the Policy, NR asset engineers will have to evaluate each element below the minimum PLBE threshold to determine the type and scale of intervention required.

6.2.31 It may be argued that route teams should already be aware of the defects which require action because that is the purpose of the examination system. Elements with low BCMI scores in critical locations requiring action should have been identified by the examiner and the asset engineer should have determined what intervention would be required. What has changed is that the CP5 Policy specifically defines the levels at which interventions are required. We are unaware of any changes to NR Standards arising from the development of the Policy.

6.2.32 NR’s first priority for bridge activity is directed at elements in a condition below the minimum condition PLBE thresholds. We agree that this is the correct approach. In addition to this work, NR have several programmes of work to address capability shortfalls, hidden critical elements etc. We are unclear about the degree of overlap and prioritisation between each of these and also the major enhancement programmes planned for CP5.

Bridges – Targets

6.2.33 The Renewals Expenditure Summary [Ref. SBPT223] notes that structures *“expenditure increases in CP5 by over 25% compared to CP4, triggered by the investment needed to achieve the minimum condition levels stipulated in PoaP”*. We disagree with this second half of this statement because PoaP does not define

[10] Question Log STR 1033
[11] LNW Route Meeting 7 Feb 2013
[12] SBPT3013 p30

minimum PLBE intervention thresholds, nor does it stipulate minimum conditions levels.

6.2.34 The Renewals Expenditure Summary [Ref. SBPT223] continues:

"At £2.1 billion for CP5, this represents the peak expenditure over the planning horizon CP5 to CP11 (when the Policy is phased in over two Control Periods). The increase is the result of directing activity to the most critical condition PLBEs to achieve the risk reduction targets for CP5." [Ref. SBPT223, page 15]

6.2.35 The chart indicates that the peak annual underbridge expenditure planned in CP5 is about £250m in 21014/15 compared with a CP4 peak of £200m in 2013/14; the increase in expenditure between 2012/13 and 2013/14 is about 100%.

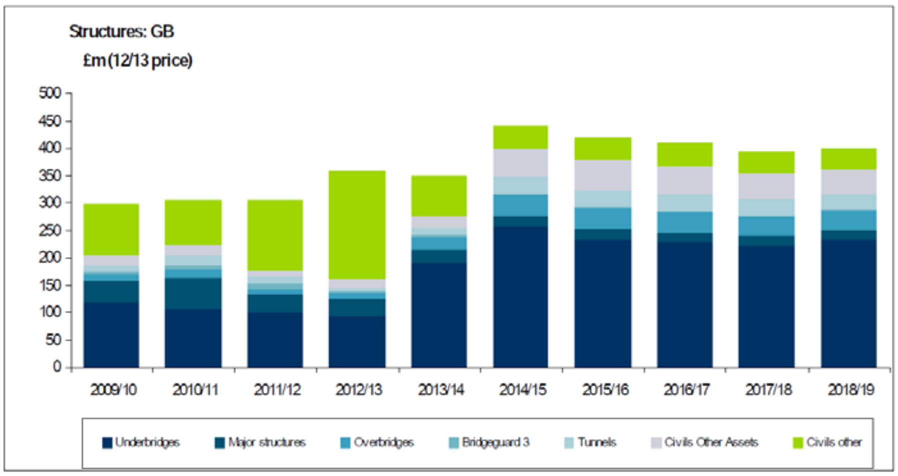


Figure 6-8: Structures Expenditure CP4 / CP5 [Ref. SBPT 223]

6.2.36 It is unclear how NR will set the 'baseline' at CP4 exit. This would require rescoring of structures and updates to NR asset records at the end of CP4 following remedial work, which is not practical. This is a particular issue as it is noted that considerable additional investment monies were allocated in CP4 under the Enhanced Spend Programme to achieve a reduction in the risk profile for a large number of assets. The on-going improvement in CP4 will also have an impact on the volume and type of work required in CP5.

6.2.37 Figure 6-9 below is based on analysis of examination results and demonstrates the decline in asset condition during CP4 and also the difference between scores for average, worst PLBE and minor elements.

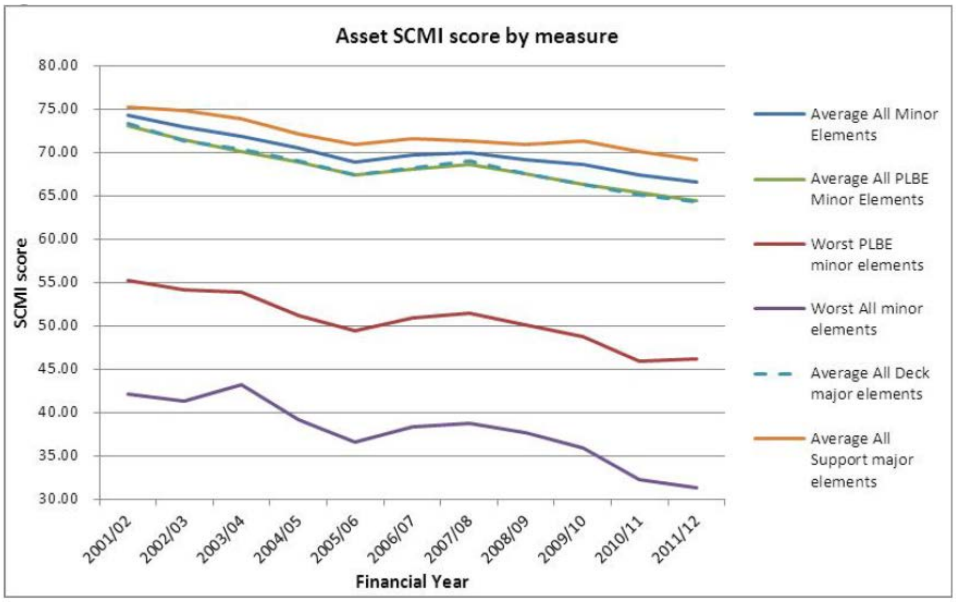


Figure 6-9: Asset SCMI Score by Element [Ref. BCAM-TP-0267 Ref S4]

6.2.38 Figure 6-10 below is taken from the Structures Renewals Expenditure Summary [Ref. SBPT223, p21]. We are unclear about the source of this graph and the data used to derive it. It shows that in CP5 almost all elements in 'Very Poor' and 'Poor' condition will be improved to 'Good' or 'Very Good' condition in CP5, which would appear to contradict the two Control Period Policy proposed by NR. The graph relates to residual PLBEs. We are unclear about the precise relationship between 'Very Poor' and 'Poor', PLBE BCMI scores and the minimum PLBE intervention threshold at Network levels. As discussed earlier, there is no direct correlation between PLBE BCMI scores and minimum PLBE threshold.

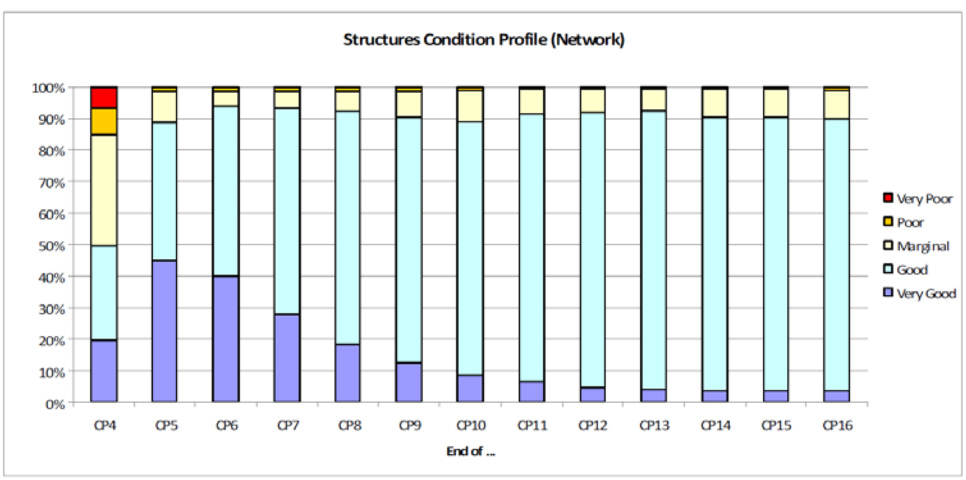


Figure 6-10: Structures Condition Profile (Network level) [Ref. SBPT223, page 21]

6.2.39 The exact improvement in condition profile / risk reduction is not stated in the SBP Submission, and at the time of writing we are unclear as to exactly what the CP4 exit condition and proposed improvement in condition profile / risk reduction will be in CP5.

6.2.40 In planning the application of the Policy in CP5, NR have considered three Output Scenarios, as follows:

- Unconstrained application of Policy in CP5;
- Phase-in Policy over CP5 & CP6; and
- Phase-in Policy over CP5 to CP7.

6.2.41 In Paragraph 7.3 of SBPT3013 NR identifies full application of the Policy entails that the following activities:

- Application of Policy-on-a-Page to underline and overline bridges;
- Remediation of currently identified sub-standard category D, E & F underbridges and overbridges with capability and Bridgeguard 3 obligations;
- Completing the level zero assessments and proposing actions based on the conclusions for each structure;
- Application of PoaP for tunnels;
- Completing the programme of examinations for culverts to confirm condition and apply risk based interventions triggered by new culverts risk/rating assessment system (CRAS);
- Complete the programme of prioritised examinations for retaining walls to confirm condition and then apply risk based interventions triggered by new risk matrix;
- Complete the collection of footbridge condition data and prioritise interventions in accordance with risk profile;
- Completing preparation of asset management plans for Major Structures and CERDs and commence implementation;
- Continuing programmed work associated with the risk reduction programmes (spandrel walls, hidden critical elements, scour etc.);
- Complying with statutory obligations including Working at Height and Listed Structures;
- Prioritising National Bridge Strike Initiative to Route Criticality; and
- Undertaking planned preventative maintenance activities.

6.2.42 This long list of activities is consistent with our understanding of the Policy and the outputs of the work being carried out by the BCAM Transformation team and illustrates that significant work is required in terms of both asset knowledge and physical intervention.

6.2.43 PoaP is written around performance level interventions and provides guidance on intervention long-term strategies based on WLCC principles. In our opinion, this relates primarily to a steady state population condition. We consider that engineers assessing minimum PLBE threshold interventions will need a Tier 3 tactical decision support tool to enable them to determine the lowest WLCC solution for particular structures – for example to determine whether it is more economical to repair or replace a deck. This is one of the major uncertainties in the Policy.

6.2.44 In Paragraph 7.4 of SBPT3103, NR state:

"If the Policy is constrained by funding, then the optimum risk target will not be achieved in the desired timescales unless the outputs relating to the other levels of service are reduced. However, in all scenarios, elements that fall beyond the defined Basic Safety Limit will be addressed within CP5."

6.2.45 This statement reaffirms the primary focus as safety and is evidence of the intention to deal with minimum PLBE threshold issues in CP5, which is encouraging. The on-going examination cycle means that further elements are likely to emerge during CP5 which are below the safety threshold.

6.2.46 Chapter 9 of the Policy reviews the results of the modelling of the three scenarios using early CeCost runs. The outputs are forecasts of risk profiles for bridge subgroups presented in terms of the percentage of PLBE by material type that are forecast to fall below the minimum condition PLBE threshold. Examples are shown in Figures 6-11 and 6-12 below. The horizontal green target line represents the percentage of PLBEs below the minimum PLBE threshold that have been determined not to pose a potential safety risk due to their location.

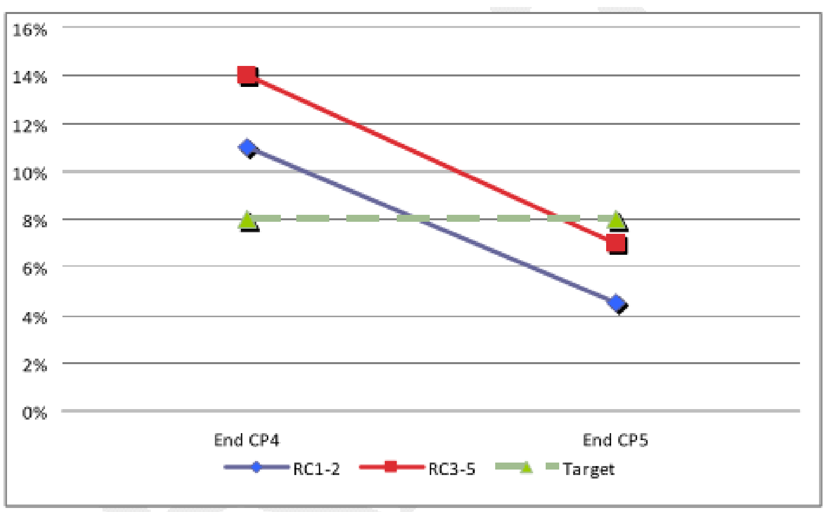


Figure 6-11: Scenario 1 Forecast Risk Profile for Metallic Bridges [Ref. SBPT 3013, Figure 9.2]

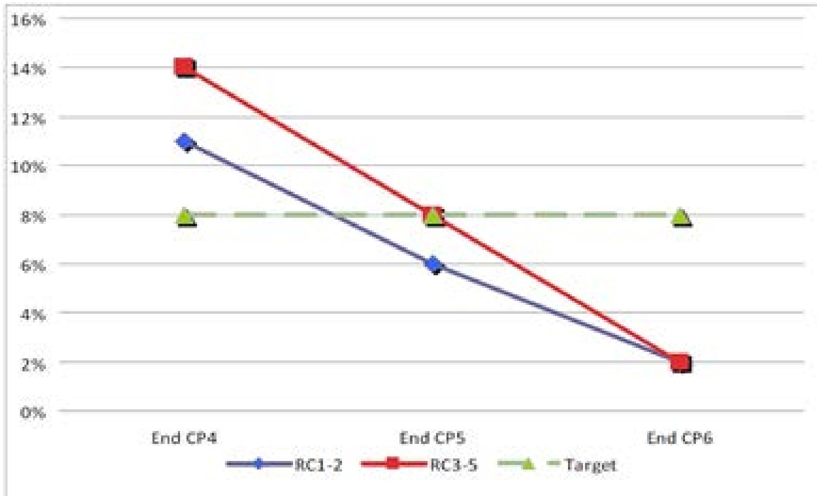


Figure 6-12: Scenario 2 Forecast Risk Profile for Metallic Bridges [Ref. SBPT 3013, Figure 9.6]

6.2.47 Scenario 1 has a funding requirement of £2.7Bn for CP5 (p70 SBPT3013), whereas for Scenario 2 the figure is £2.25Bn (p73 SBPT3013). We note that in both cases the target is achieved at the end of CP5 as shown in Figures 6-9 and 6-10 above. NR have explained that this is due to the effect of lowest WLCC interventions (over and above safety related interventions).[13] If this is the case, then there could be an element of overfunding. This should be further clarified.

6.2.48 The Policy (Ref. SBPT3013, Section 10.1) states that interventions will be 'prioritised by safety risk'. It is unclear which Scenario 1 activities will be deferred or reduced in scale until CP6 under Scenario 2.

6.2.49 We are also unclear why, in Scenario 2, having met the target in CP5, the plan for CP6 is to reduce the risk further. Para 10.11 of the Policy states:

'Target A: To reduce the poor condition PLBE of under and overline bridges. The percentage remaining is an estimation of the elements that have a low BCMI score but do not pose a safety risk due to the location of the recorded defect. Targets for CP6 will be set once the asset data systems improve, allowing greater definition and refinement'.

This statement supports the case for defining a deliverable Policy for CP5.

[13] STR1053f

Bridges – Measures

6.2.50 The Asset Output Measures [Ref. SBP 232] are shown in Figures 4-5, 4-6 and 4-7 above. These measures for 'robustness' and 'sustainability' are not referred to in the Structures Policy, and, as written, lack clear definition. We assume that for the robustness measure, structures with a risk score of greater than 20 applies the risk scores applied by the Route Engineers using a 5*5 matrix, in which case the target would relate to structures scoring 5 in each (undefined) category, which suggests that the structures are in a critically poor condition.

NR have subsequently clarified that the measure should read *'a risk score of greater than or equal to 20*'.

We question why 225 represents a satisfactory target. NR should provide further details of this measure.

6.2.51 Similarly we are unable to relate the sustainability measure, which refers to *'Condition score for PLBEs (Bridges)'* ranging from 7.7 in CP4 to 4.1 in CP6 to the Measures given in paragraph 10.11 of the Policy. We are also unclear as to what these '4.1 to 7.7' numbers mean. This requires clarification from NR.

6.2.52 NR sets out Targets and Measures in paragraph 10.11 of SBPT3103. Targets are identified for each subgroup. For bridges, the Target (A) is to "*reduce the poor condition PLBE of under and overline bridges*". As a target this is a somewhat vague statement. To monitor progress towards the target, NR propose six measures for the end of CP5, which are summarised in the following table.

Table 6- 1: Bridge Measures

Material	Route Criticality	PLBE BCMI test	Measure – no of elements passing test
Metallic	1,2	<40	<6%
Metallic	3-5	<40	<8%
Concrete	1,2	<50	<2%
Concrete	3-5	<50	<2%
Masonry	1,2	<50	<7%
Masonry	3-5	<50	<8%

6.2.53 The introduction of defined attributes to measure is a positive step. However, we are unclear about several key aspects about how outcomes will be verified which are discussed below.

6.2.54 The Measures for bridge sub-groups shown above are similar, but not the same as the minimum condition PLBE thresholds – for example there are no measures for pre- and post- tensioned concrete bridges. NR have advised that this is not currently possible, and is dependent on completion of the data improvement programme. We would expect all bridge sub-groups to have measures to provide consistency of reporting. This is particularly important for Post-tensioned Concrete bridges where the minimum PLBE threshold is set at and PLBE BCMI score of 85.

6.2.55 The relationship between minimum PLBE thresholds, the Measures proposed in Section 10.11 and Figure 6.2, and which does not appear to be defined in the Policy, although it can be interpreted. An explicit statement would provide suitable clarification of this important feature.

6.2.56 Target A states: *"The percentage remaining is an estimation of the elements that have a low BCMI score but do not pose a safety risk due to the location of the recorded defect"*. We agree that this is a reasonable approach to setting targets, but it raises several questions in terms of implementation:

- For each sub-group, what is the definition '*elements that have a low BCMI score but do not pose a safety risk due to the location of the recorded defect*'? How will such elements and defects be identified within BCMI, the examination process, and the data storage system?
- How up to date is the data (does it take account of the Enhanced Spend Programme)?
- What is the anticipated CP4 exit condition for such elements?
- Is having a different target according to Route Criticality consistent with the philosophy that safety risk should be equal on all routes?

6.2.57 We note that NR have permitted typically 6% of bridges to be 'below' the minimum condition PLBE thresholds. We are unclear as to the detailed rationale for this.

6.2.58 For bridges, focusing the targets and measures on the area which has been identified as the first priority for CP5 provides a pragmatic 'line of sight' between interventions and asset risk, which is linked to performance (bridge condition, number of failures etc.) and network performance (derailments, delay minutes. Schedule 8 costs etc.). We are unclear about the practical implementation of the measure, including the CP4 exit condition.

6.2.59 NR have indicated that at the end of CP5, the targets allow for circa 70% of elements below the minimum PLBE threshold to remain due to the defect location not creating a safety risk. This percentage will be further reduced during CP6. This does not appear to be consistent with other forecasts and indications in the Policy and needs further clarification. If the value of 70% is correct, it points to an issue with the long term use of the current BCMI scoring system to identify critical elements in critical condition – amendments to the examination system would be required.

Major Structures

6.2.60 NR have not proposed any Measures for Major Structures. This is a significant omission for assets which are vital for the performance of the rail network and should be corrected.

6.2.61 The general target criteria for overbridges/underbridges cannot easily be applied to Major Structures because NR does not generally use the BCMI system for them.

Tunnels

6.2.62 In CP5, NR plan to "*prioritise and undertake interventions on tunnel elements in accordance with Policy on a Page*" [Ref. SBPT3013, 10.2]. Policy on a Page for tunnels is incomplete. The key Policy target (Target B) for tunnels is to reduce the number of poor condition sections over CP5. According to the condition data for tunnels, this target is already achieved, by a significant margin, as shown in Figure 6-15. The other Tunnels Policy target is to complete the hidden shaft identification programme by 2020, including risk reduction measures where practicable. Hidden shafts are a serious hazard for tunnels assets; these have not been included as part of the risk evaluation and we have not seen evidence to show why a completion date of 2020 is considered to be acceptable.

6.2.63 The Renewals Expenditure Summary Report [Ref. SBPT223] does not mention any quantifiable outputs for tunnels or minor assets, other than maintaining condition across all routes and an expected reduction in safety risk in the long term.

6.2.64 It is unclear whether NR aim to maintain or improve tunnel condition and risk over CP5 since the targets in the Policy differ from the overall outputs stated in SBPT223 for CP5. Target B should be reconsidered and more appropriate measures developed.

6.2.65 NR state in SBPT223 that *"Data collected for these (other asset) groups during CP5 will be used in the development of lifecycle plans or models for these assets to provide a sound basis for supporting their longer term funding need"*.

6.2.66 We support the decision to improve data collection and understanding of the tunnels and minor assets groups over CP5.

Other Assets

6.2.67 In CP5, NR plan to further understanding of degradation and complete the collection of asset data for their minor assets. Steps towards review and implementation of a risk based approach for these assets will be undertaken.

6.2.68 The particular targets for culverts, footbridges and retaining walls are to *"reduce"* the number of assets which are currently in poor condition in these groups; however, the measure for these targets requires the number of assets categorised as poor *to "not increase"* by the end of CP6 [Ref. SBPT3013, 10.2].

6.2.69 In addition to this, the new risk based methodology for minor assets will be reviewed and implemented during CP5, which may have the effect of re-baselining the condition of the minor assets portfolio, making it difficult to assess at the end of CP5 whether these targets have been met.

6.2.70 A Policy objective to prepare asset management plans (AMP) for CERD assets has been set; however, there are no particular targets for CERDs.

6.2.71 The targets and associated measures for minor assets are poorly defined. It is unclear whether NR aim to maintain or improve minor asset condition over CP5. In addition to this, there are no specific requirements for CERDs other than to develop AMPs. This could lead to uncertainty around where to target funding and interventions. There is no Line of Sight for these asset sub-groups.

6.2.72 NR provide a series of targets for Structures Other, addressing the specific ongoing improvement programmes.

6.3 Asset Knowledge

6.3.1 NR divide their structures assets into four primary asset types namely bridges, (underline and overline), Major Structures, tunnels and 'other assets', which comprise retaining walls, culverts, footbridges and CERDs.

Inventory

6.3.2 A summary of the structures asset inventory and condition is presented in Figure 6-13 below:

Asset Type	Asset Count
Underline bridges	19,483
Overline bridges	9,337
Major Structures	34
Parent tunnels	617
Footbridges	1,353
Culverts	21,997
Retaining walls	20,812
Coastal, estuarine and river defences	559

Figure 6-13: Structures Asset Count Data [Ref.SBPT3013, Section 1.4]

6.3.3 The number of designated Major Structures has been significantly reduced since IIP, when it was given as 283. NR have returned to the 'Short List' of Major Structures and created a subsidiary category of Critical Assets [Ref. SBPT 3013 Appendix B] which contains many of the Major Structures which were previously on the 'Long List'.

6.3.4 A detailed breakdown of structures assets by sub-group and by route has not been included in the Policy. In addition to this, some routes have not declared their asset count in their Route Plans. This does not give us confidence that the structures asset inventory is accurate.

Bridges – Condition and Capability

6.3.5 NR have focused their analytical work on understanding the condition of their bridge stock. From Figure 2.11 in SBP3013, shown below (Figure 6.14), NR conclude [Ref. S4, p 28] that across the network the percentage of PLBEs with 'unacceptable' scores is 18% for metallic, 11% for brick/masonry and 4% for concrete.

6.3.6 However, the document indicates [Ref. S4, p33] a significant reduction at the end of CP4 in the number of metallic bridge elements in poor condition (reduced from 18% to 13%), and notes that these updated figures are consistent with CeCOST modelling. We are unclear how this figure has been derived, and the cost and volume associated with it.

6.3.7 Information provided by LNW indicates that analysis of BCMI data will be undertaken to complete the unconstrained workbank. Initial analysis indicates 9,446 components exceed the 'basic safety limit' / minimum condition PLBE threshold, and 28,452 components exceed intervention trigger described in PoaP. [Ref. S5 Slide 7]. LNW has 6,965 structures [Ref. S5, Slide 3].

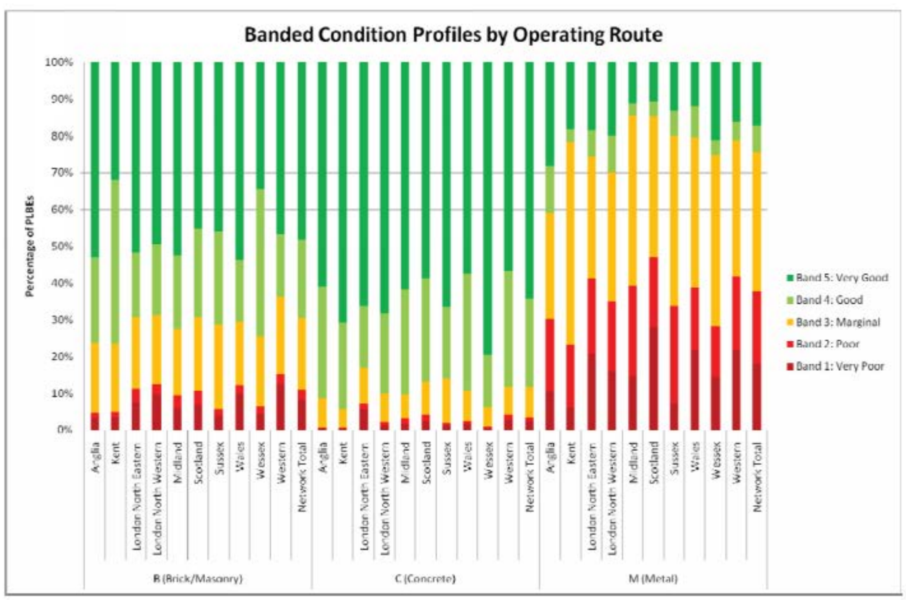


Figure 6-14: Current Condition Profiles of PLBE by Operating Route and Material

6.3.8 Since our IIP Review in December 2011 [Arup 2011a], NR have continued to improve their asset knowledge for bridges, primarily through detailed analysis of the BCMI database to provide element level and degradation data. The Policy document states that further improvement is required and planned for CP5 – for example matching the population to sub-groups.

6.3.9 NR have an on-going programme of detailed structures examinations which are used to record condition using a system known as BCMI. Bridges are scored in accordance with NR Handbook for the examination of Structures Part 2C: Condition marking of Bridges (NR/L3/CIV/006/2C) (marked using this data, Route Asset Engineers currently develop workbanks, using intervention criteria based on CP4 Policy, recorded condition and evaluated risk criteria.

6.3.10 The Policy for bridges relies on PLBE BCMI scores which are subject to regular programmed examinations, so condition data is likely to be reasonably robust.

6.3.11 NR's analysis indicates that they have 564 bridges that have been assessed as sub-standard (assessed categories A3 to F), with 191 of those within categories D-F. NR note that a proportion has no assigned category and that a further 78 assets may also be in categories D-F. NR are targeting interventions at the 191 sub-standard underbridges D-F by the end of CP5, not the estimated number of 269.

6.3.12 To assist understanding of the overall condition of the bridge assets, we consider that NR should provide, for each asset, attribute information related to

- condition (bridge and summary element level);
- capability;
- each of the safety reduction programmes (spandrel wall, hidden critical elements etc.); and
- attributes related to safety, (about more details of asset numbers affected by capacity shortfalls and the safety reductions programmes, and clearly identify the assets which are any overlaps the numbers. We are unclear about the number of these sub-standard bridges which also contain elements below the minimum PLBE threshold.

Major Structures and Critical Assets

6.3.13 NR have committed [Ref. SBPT3013, para 2.2.6] to prepare an AMP for each Major Structure before the start of CP5. NR will apply the risk-based approach for the future management of these assets. We consider it is imperative that the intervention thresholds and interventions are set at a level which recognises the unique, often historic, and operationally vital nature of these structures.

6.3.14 We understand that the BCMI system is generally not used for Major Structures. We are unclear which examination regime will be applied to Critical Structures and other 'delisted' Major Structures. We were informed by LNW that they are investigating the condition of some of their post-tensioned concrete bridges. NR have not provided any condition data for Major and Critical Structures.

6.3.15 NR have provided no evidence related to the condition of Major Structures. We consider this to be a significant omission, giving rise to moderate uncertainty.

Tunnels

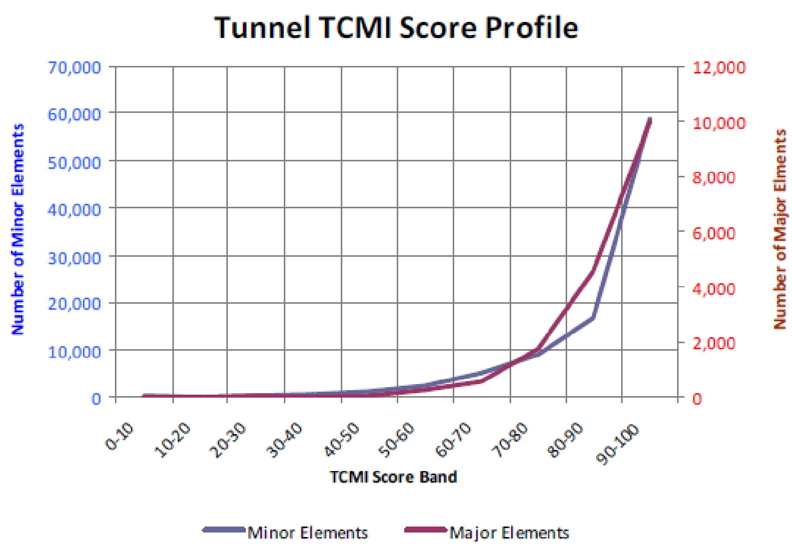


Figure 6-15: Condition of Tunnel Population [Ref. SBPT3013, Figure 2.12]

6.3.16 In CP4, NR moved towards a quantitative scoring system, TCMI, to report tunnel condition at both major and minor element level. Overall, the tunnels portfolio appears to be in generally fair or good condition. The practice of undertaking minor works in tunnels at the same time as detailed exams, making best use of possessions, could be applied to bridges and may help to improve efficiencies and maintain better asset condition of the bridge stock.

6.3.17 We consider that this is due to the different approach to tunnel maintenance, which adopts the philosophy that tunnels are irreplaceable assets and maintenance strategies focusing on PPM and minor works, resulting in generally good or fair condition profiles.

6.3.18 According to the data presented in the Policy, reproduced in (Figure 6-15), the number of minor elements with TCMI <40 appears to be minimal, approximately 1,000 out of nearly 60,000 minor elements, which is already considerably less than the 8% specified in the measure for Policy Target B. We consider the Target for tunnels should be revised and an appropriate range of supporting Measures devised. In making this revision, NR should also demonstrate that the proposed minimum intervention threshold values are appropriate (see paragraph 6.4.3).

Other Assets

6.3.19 The number of examined assets varies by route and by asset. The proportion of examined assets is generally quite high for footbridges (average 90%), but lower for culverts (58%) and for retaining walls (41%).

6.3.20 Figures 6-16 to 6-18 below show the current understanding of asset condition and national split by asset [Ref. SBPT3013, 2.23 to 2.24]. In all cases, the majority of assets are a 'fair' state.

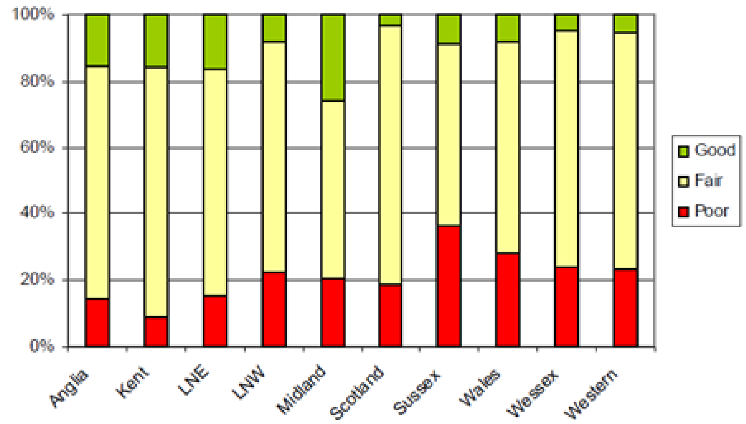


Figure 6-16: Condition Profile for Footbridges: National Good / Fair / Poor is 12% / 68% / 19%

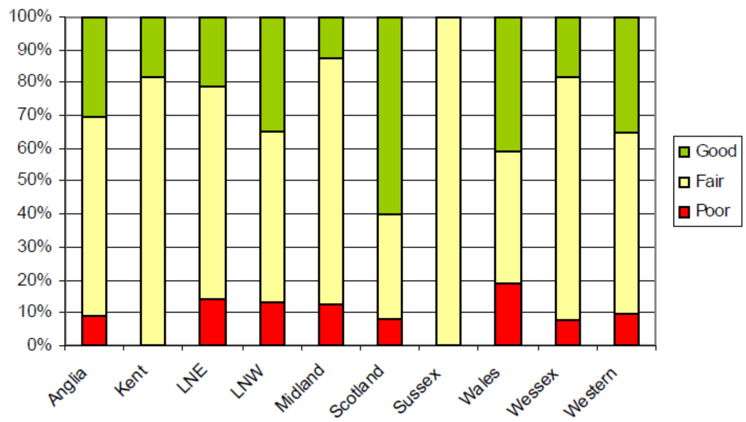


Figure 6-17: Condition Profile for Culverts: National Good / Fair / Poor is 38% / 49% / 13%

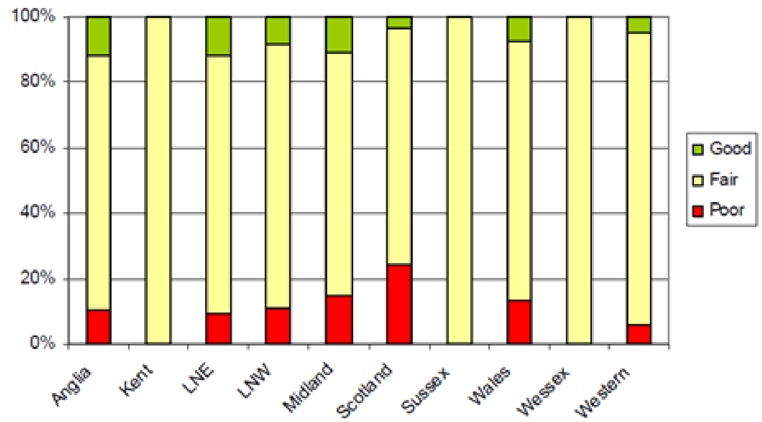


Figure 6-18: Condition Profile for Retaining Walls: National Good / Fair / Poor is 7% / 69% / 13% (with 11% unclassified)

6.3.21 There is no analysis of current condition for CERDs. It is understood that asset knowledge in this area is poor. The proposal is for each route to develop an AMP for these assets prior to the start of CP5. Progress on this is unclear.

6.3.22 NR have indicated that work has begun to develop improved scoring systems for other asset groups which will provide more detailed data enabling a better understanding of risk for these structures.[14]

6.4 Asset Behaviour, Degradation and Criticality

Bridges Behaviour

6.4.1 A Failure Mode and Effect Analysis (FMEA) has been carried out to identify and rank critical components in bridges and other structures. The results have informed the Policy development process.

6.4.2 For bridges, NR have developed the Policy by considering the condition requirements for PLBEs. PLBE scores form the basis for the intervention criteria.

6.4.3 Asset condition can at any time be categorised into one of the five BCMI bands in the Policy (Very Poor, Poor, Marginal, Good, Very Good) [Ref. ST3, Section 2.2.1]. We are unclear how these correlate with the 'Good' and 'Poor' starting condition bands used in Policy on a Page and CeCost, or the 'Good', 'Marginal' and 'Poor' bands used in the Tier 2 model. It is considered that consistency around these definitions across the models and Policy (even if the bands are comparative only) is essential. BCMI scores are not set to a common risk profile, so comparison between asset groups requires careful consideration.

[14] Question log STR1006

Bridges Degradation

6.4.4 For structures, the primary use of degradation data made by NR is to inform modelling. It is not used in a predictive sense for short term tactical intervention decision making.

6.4.5 NR have analysed data from repeated detailed examinations to derive probabilistic degradation rates for minor elements in masonry, metallic and concrete bridges which are then incorporated into the Tier 2 WLCC and CeCost models. The timespan for which reliable data exists is relatively short, which generates some uncertainty about the results of the analysis, in addition to the probabilistic nature of the analysis.

6.4.6 NR acknowledge that further work is required to validate bridge degradation rates. We agree with this conclusion.

Major Structures

6.4.7 NR have not provided any information on behaviour, degradation or criticality for this asset group.

Tunnels

6.4.8 PoaP lists failure modes and defect types for tunnels; the TCMI scoring system also uses principles such as a defect hierarchy to determine the extent to which elements contribute to the overall TCMI score. Since the TCMI scoring system has been in place since 2009, relatively little data exists for tunnels and as such, no degradation relationships have been derived.

6.4.9 In comparison to other types of asset, NR do not own many tunnels (617 parent tunnels); however, they are classified as 'high criticality' [Ref. SBPT3013, Table 3.1] due to the impact of service level failure and replacement cost. NR's FMEA analysis has shown unlined tunnels to be the highest criticality sub group of the tunnels assets and as such they demand a more regular examination schedule (annually at the very least, as defined in PoaP and NR Standards).

6.4.10 We consider that NR's understanding of tunnels failure modes and critical components is adequate; however, we support NR's plan for further understanding and development of degradation relationships as new examination data is received. Hidden shafts are a hazard, are subject to degradation and failure and we consider they should be included in PoaP.

Other Assets

6.4.11 The Structures Asset Policy includes assessment of which types of asset are most susceptible to failure or accelerated degradation, in some cases, based on FMEA. PoaP is complete for culverts and retaining walls, but incomplete for footbridges. For CERDS, there is currently no PoaP. We consider that asset knowledge in this area will benefit from the proposed AMPs. Application of PoaP principles to CERD sub-asset groups should be considered.

6.4.12 There are currently insufficient data to fully understand deterioration of footbridges, retaining walls and culverts; however, there are plans to develop and update degradation relationships over CP5 as condition data is received. There do not appear to be plans to develop degradation relationships for coastal and estuarine defences. This is reasonable since there are relatively few of these structures and their behaviour will be highly dependent on uncontrollable weather conditions.

6.4.13 All minor assets are classified as ‘Medium’ criticality structures [Ref. SBPT3013, Table 3.1]. For culverts, a CRAS has been developed in CP4 to address the criticality of culverts in terms of their service and structural performance. Further work will be undertaken to translate this into a likelihood of failure score, using route criticality as a proxy for consequence (see Figure 6-19).

6.4.14 A similar system has been proposed for retaining walls, and has been included as Appendix H in SBPT3103.

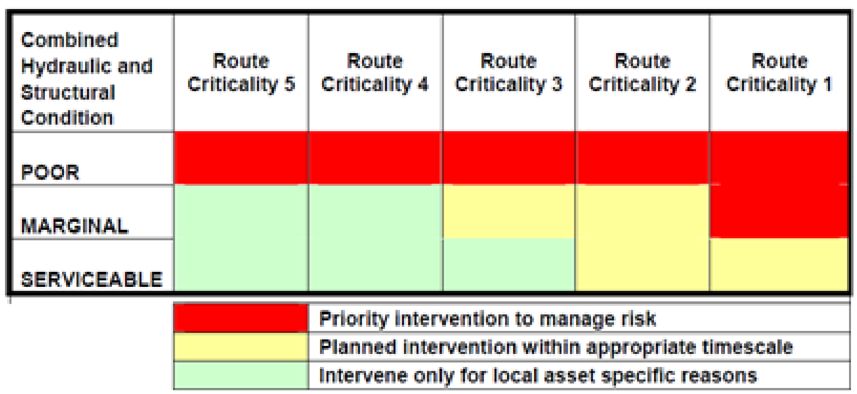


Figure 6-19: Proposed Risk Based Intervention Matrix for Culverts

6.4.15 We consider that NR currently have fair knowledge of the behaviour and criticality of its minor assets, with significant improvement required. NR’s proposals for further development in this area are very positive.

Structures Assets Criticality

6.4.16 NR recognise the importance of asset criticality and has attributed each asset group to a criticality band as shown in Figure 6-20 [Ref. SBPT3013, Section 3].

Asset Group	Impact on Level of Service	Asset Count	Average Replacement Cost	Overall Score	Criticality
Underline Bridges	H	H	H	9	HIGH
Overline Bridges	H	H	H	9	HIGH
Major Structures	H	L	H	7	HIGH
Tunnels	H	L	H	7	HIGH
Footbridges	L	M	L	5	MEDIUM
Culverts	M	H	L	6	MEDIUM
Retaining Walls	M	H	L	6	MEDIUM
Coastal, Estuarine	M	L	M	5	MEDIUM

Scoring: H = 3, M = 2, L = 1

Criticality: Low (overall score 0 – 3), Medium (4 – 6), High (7 – 9)

Figure 6-20: Ranking of Asset Criticality [Ref. SBPT3013, page 38]

6.4.17 Asset criticality has been defined by NR to determine the impact of costs and outputs. Three factors are used for each sub-group, shown above in Figure 6-16. It is not clear how safety risk is factored into this assessment. We consider this assessment is over simplified, and using spend as a factor is incorrect – there is no obvious correlation between spend and risk. However, it is not clear how this assessment has been used.

6.4.18 The ranking of criticality of asset groups fails to consider overall population condition and does not provide great differentiation within asset groups; for example not all retaining walls have equal criticality. We consider that a well-designed decision support tool would give more meaningful analysis and reliable guidance on criticality.

6.5 Renewal and Maintenance interventions

Bridges

6.5.1 The following intervention strategies have been developed by NR. They are not included in Policy, but referenced inn PoaP and also considered within the Tier 2 WLCC model. There are three principal strategies – 'Standard ', 'Do Minimum' and 'Managed' detailed in PoaP, which have Minor Works variations.

Table 6-2: Intervention Strategies

Strategy	Definition
Standard	Includes both major and minor works. Prioritises major interventions if the average condition of minor elements within the major elements reaches 70% of the trigger score, or when their average condition is above state 10. Pending clarification from NR.
Standard with Minor Works	Same intervention trigger scores as 'Standard', but results in more frequent minor interventions rather than major interventions. Major interventions are only triggered when the average condition of PLBEs within the major element exceeds 100% of the intervention trigger, or when the permitted number of minor interventions is exceeded.
Standard with Early Replacement	This strategy is the same as 'Standard' but replaces the bridge rather than triggering the first scheduled major intervention.
Do Minimum	Has higher intervention triggers than 'Standard' and fewer interventions in total. This strategy prioritises major interventions if the average condition of minor elements within the major elements reaches 70% of the trigger score.
Do Minimum with Minor Works	Same intervention triggers as 'Do Minimum', however major interventions are only triggered when the average condition of PLBEs within the major element exceeds 100% of the intervention trigger, resulting in a higher number of minor interventions.
Managed	Similar to 'Do Minimum' however intervenes even later, resulting in fewer interventions than all other strategies. Does not include any painting of metal elements. Designed for circumstances where improvement is not desired and some deterioration is tolerable

6.5.2 NR state that '*targets for both route criticalities are above what NR engineers judge to be the basic safety limit*.' (CP5 Bridge Strategy Selection report [Ref. S8, p10]) and therefore the strategies are focused around providing a trade-off between cost and condition, which relates to performance only not safety [Ref. S8, p10]. We agree that this is the correct approach.

6.5.3 In theory, minimum condition PLBE thresholds are met by the intervention triggers / thresholds. This appears to not necessarily be the case in practice and some inconsistencies are noted between the threshold stated in the Policy and the triggers applied on PoaP.

6.5.4 For example, for underbridge, masonry arch, multi-span, [Ref. PoaP, p5] masonry defects, PoaP interventions for Train Impact Loading, Cracking or Crushing are set at a SevEx value of EX4, which equates to a BCMI score of 50 and is lower than the corresponding minimum PLBE threshold is 65 (See Figure 6-5).

6.5.5 In the Policy [Ref. SBP3013 paragraph 6.2.1], and reflected in PoaP, NR are proposing three main categories of structures interventions for bridges, as follows:

- Managed:- Maintaining condition by primarily by cleaning and minor repairs;
- Do Minimum:- Improving condition by local replacement;
- Standard:- Renewing condition by more major works;
- There are variations on these categories (early replacement, emphasis on minor works). 'Do Minimum Minor' appears to be a 'repetitive' designation and unnecessary;
- Examine: - Periodic detailed examination to assess condition; and
- Monitor: - Periodic measurements to assess change in condition.

6.5.6 We acknowledge that NR have made a significant investment in preparing PoaP as part of NR's planned further development work. Thorough reconciliation of intervention criteria, minimum PLBE thresholds, PoaP and target values is required.

Major Structures

6.5.7 NR are committed to preparing AMPs for each of the 34 Major Structures before the start of CP5. We have not been provided with any sample AMPs as part of the SBP submission. Our understanding is that each Major Structure has a bespoke intervention plan based on the AMP. In paragraph 2.2.6 NR indicate that a risk-based approach similar to other bridges will be applied to Major Structures. This approach has not been defined, and gives rise to some concern that it could lead to a decline in the condition of Major Structures.

6.5.8 At IIP, NR's approach for Major Structures was that *"lowest WLCC is generally delivered by maintaining the existing asset in a good serviceable condition so that replacement is delayed as long as possible. For those assets that are Listed for their heritage value, the intervention options are restricted by the consent process to maintenance and "like for like" component replacement."* [Ref. S9, p140].

6.5.9 The proposal to use a risk-based approach for Major Structures would provide consistency with other bridges, but should not be allowed to obscure the fact that these are generally considered to be unique structures which are irreplaceable and should be maintained to a high quality standard.

Tunnels

6.5.10 No specific details of historic intervention types or volumes have been provided, although it is understood that in CP4, 79,363m^2 of tunnels works were planned.

6.5.11 In CP5, NR plan to undertake 123,005m^2 of major tunnels works, (a 55% increase on CP4 volumes) at a cost of approximately £35.4m per annum. From CP6 onwards, it is proposed that this expenditure will remain constant, but the volume of interventions will rise by approximately 20,000m^2 to 142,615m^2.

6.5.12 It is understood that these will be focussed on elements with TCMI <40 for all route criticalities and performance interventions considered on TCMI <80 for route criticalities 1 and 2. As noted in section 6.13 above, there appear to be a relatively small number of tunnel elements with TCMI <40, when compared with bridges.

6.5.13 Target B in SBPT3013 states that *"some elements have a low BCMI score but do not pose a safety risk due to the location of the recorded defect"*. It is not clear from the Policy how safety risk is defined for tunnel assets. Currently there is no guidance in the Policy around safety risk for tunnels (they are not included in Figure 6-5).

6.5.14 Interventions are detailed in PoaP. It appears that intervention thresholds are still being developed and that the activities are a generally a continuation of current practice. These are based on minimum TCMI intervention levels, in a similar way to bridges. No information has been provided as to the effect of these interventions on either the tunnel condition or future degradation.

6.5.15 We are unclear if the intervention thresholds proposed will maintain the generally fair or good condition which has been achieved by the philosophy adopted in CP4 (that tunnels are irreplaceable assets) for all route criticalities.

Other Assets

6.5.16 The range of renewal and maintenance interventions for footbridges, culverts and retaining walls is stated in PoaP and look to be appropriate. The thresholds for footbridge interventions are currently incomplete. No information has been provided as to the effect of these interventions on condition or further degradation.

6.5.17 In CP5, NR plan to undertake major renewals works on 11,620m^2 footbridges, 8637m^2 culverts, 24,478m^2 retaining walls and 14,111m^2 CERDs for a combined cost of £272m. NR are proposing that during CP5, these interventions will be prioritised according to risk for culverts, footbridges and retaining walls and according to bottom up Route Plans for CERDs.

6.5.18 NR have a sound approach for 'Other Assets' for CP5, but a significant amount of work is required to achieve the objectives.

6.6 Asset Cost Data

Bridges

6.6.1 Unit rates for underbridges, overbridges, footbridges, culverts and retaining walls have been derived by NR from historic data or actual cost information (from CAF and Monitor) and are presented in SBPT3074 Structures Unit Rates and Assumptions [Ref. SBPT3074, Section 3.0].

6.6.2 Some external audit of these rates has been undertaken by Faithful and Gould and we have been provided with a copy of their report 'Independent Audit of Structures Assessment Unit Rates for SBP, Version 2.1a'.

6.6.3 The rates are aligned with repeatable work types and represent average costs for types of activity. The methodology to derive these rates appears to consider the aspects required to develop an accurate rate, i.e. uses actual cost information and includes items such as inflation, contractor's preliminaries and profit as required.

The rates exclude possession costs, contingency and NR project management costs. Regional factors have been calculated although it is not clear where these are applied. The methodology and estimating assumptions used to develop unit rates has been reviewed under Mandate AO/34, which has identified and reported on a number of significant issues.

6.6.4 Maintenance and renewal intervention unit rates for lifecycle modelling have been derived separately from the cost data provided in SBPT3074, Section 3.0. These rates are also derived from CAF and Monitor data but have not been subjected to an external audit.

6.6.5 Cost data has been provided for the range of maintenance and renewal interventions used in the modelling; however, it is unclear whether the same principles (inclusion of inflation, efficiency etc.) apply to the modelled rates.

6.6.6 It is considered that whilst absolute costs are not critical for a WLCC modelling tool, the relative difference between intervention costs needs to be accurate for the model to select the lowest WLCC output strategy.

6.6.7 Other costs for examinations and possessions have been provided for modelling but with no mention in Structures Unit Rates and Assumptions [Ref. SBPT3074] of their provenance.

6.6.8 Whilst we accept that unit rates originate from actual data and include the necessary elements to build up an accurate rate, we have not been able to trace all costs used in the structures modelling back to the data presented in Ref. SBPT3074. Therefore, we have concerns as to the accuracy and reliability of the intervention costs used in the modelling.

Major Structures

6.6.9 Cost data for Major or Critical Structures is removed from historical CAF data before unit rates are built up. SBPT3074 states that the application of an average unit rate to these unique structures is ‘inappropriate’ and therefore unit rates have not been prepared for these assets. Instead, ‘individual estimates for each work item’ are used.

6.6.10 Major Structure workbanks are derived bottom-up. The nature of the structures and the scale and type of work required varies greatly. We consider that the best information on unit and relative costs is held at Route level. For some structure types, for example swing bridges, and some activities, for example full re-painting, there will be common activities across routes where sharing of knowledge would be beneficial.

6.6.11 We are unclear how unit costs for Major Structures have been compiled.

Tunnels

6.6.12 The unit rates for tunnels are summarised in the Route Price Book (Sheet 'Price Book National', BCAM-TP-0215) and in the Unit Rate Commentary [Ref. SBPT3074].

6.6.13 Tunnels unit rates are built up from first principle estimates by Franklin and Andrews/ Mott MacDonald [Ref. SBPT3074, Appendix C] to take account of labour, plant, material and project on cost estimates. The national rates provided are compatible with the work items considered in the strategic Tier 1 level modelling:

6.6.14 The rates do not appear to include any allowance for possession costs which is similar to other structures unit rates. In most cases, two rates are provided for each of the rates to account for change in quantity of work (e.g. interventions to one or three sections).

6.6.15 The cost data for tunnels are derived up from first principles and include the necessary components to build up an accurate unit rate.

Other Assets

6.6.16 The minor assets modelling uses the relevant national unit rates from SBPT3074 and include uplifts for design fee and NR central overheads. The rates do not appear to include any allowance for access or possession costs.

6.6.17 No rates have been derived for CERD assets and whilst these are not modelled, a total cost for these is included in the SBP submission, for which we have had no sight of the underlying cost data.

6.6.18 The unit costs for 'Other Assets' can be traced back to SBPT3074. No unit rates have been provided for CERDs.

6.7 Policy Selection and Preferred Lifecycle Options

Whole Life Cycle Cost Modelling - Overview

6.7.1 NR have developed and used their Tier 2 WLCC Model to compare the cost of carrying out different combinations of maintenance and renewal works over a 100 year period.

6.7.2 This modelling has been used to inform the Policy and PoaP by selecting, from the three options defined in PoaP, the lowest WLCC strategy to achieve a certain condition output, for each asset sub group.

6.7.3 The Policy notes that further development of the WLCC model into a Tier 3 decision support tool is planned. This tool will be used by the routes to apply the rules from Tier 2 to a particular structure in order to assist the routes when refining their constrained workbanks. This tool has not been used at SBP stage, but is essential for CP5 to enable consistent application of the Policy which has been developed.

6.7.4 The Structures Policy outlines the relationship between the Tier 2 WLCC model and the Policy in Figure 6-21 below.

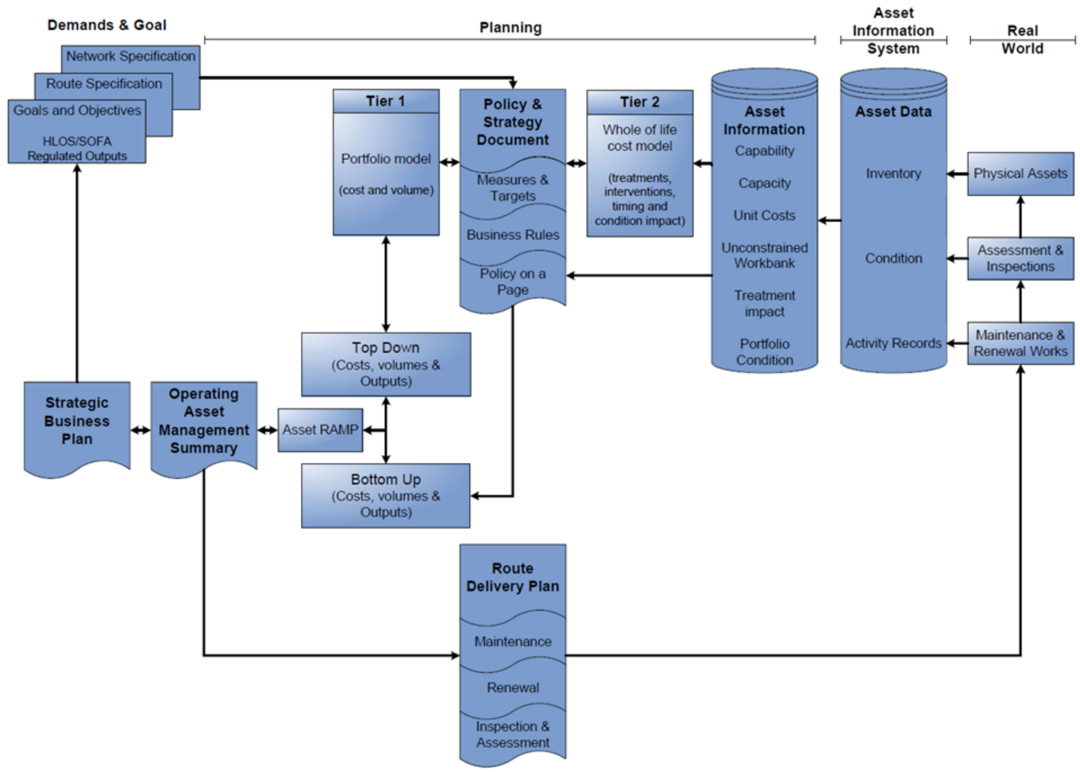


Figure 6-21: Relationships between Structures Models and Products

6.7.5 It is understood that the selection of lowest WLCC Tier 2 strategies have been used to calculate cost forecasts for overbridges and underbridges in CP5 and have therefore contributed to the final SBP sum.

Whole Life Cycle Cost Modelling – Tier 2 Structures Model

6.7.6 The Structures WLCC model has been reviewed in detail in our report AO/030/2B 'Civil Structures WLCC Model Review'.

6.7.7 The Tier 2 WLCC model recognises assets which have similar characteristics and maintenance strategies and uses these to rationalise asset groups for modelling, which is consistent with WLCC good practice. The model also considers a three tier hierarchy (asset, major elements, minor elements or PLBEs) to reflect the grouping and criticality of bridge components. This allows decisions to be made within the model as to whether to intervene on an element or group of elements.

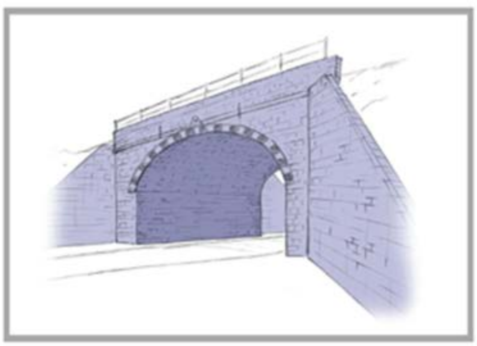
6.7.8 In summary, the model is a tool which runs a sample of 242 bridges, against six strategies. For each run, the model uses probabilistic degradation matrices to predict the condition after each annual iteration and trigger interventions and uplifts as per the rules on PoaP. The result is a cost (NPC, including possessions and examinations), condition and comparative risk output for each of the strategies modelled.

6.7.9 In simple terms, the model has been used to:

- Determine which of the strategies listed on PoaP provides the cheapest cost over the 100 year period for each type of bridge, depending on its route criticality and starting condition; and translate these decisions into PoaP as a table of preferred strategies (see Figure 6-21 for example); and
- Inform Policy decisions on replacement of structures, based on lowest WLCC analyses.

UNDERBRIDGE

Masonry Arch, Single Span



Selection of Intervention Type			
	Route Criticality Band	Starting Condition Fair/Poor	Starting Condition Good
LWLC	3-5	C	C
	2	A	B
	1	A	B

A - Standard Major B - Standard Minor C - Do Minimum Major D - Do Minimum Minor
E - Managed LWLC - Lowest Whole Life Cost R - Standard Replace

Figure 6-21: Example Strategy Matrix [Ref. PoaP. 7 Jan 2012, Page 3]

6.7.10 The range of lifecycle options and strategies modelled appears to be reasonable. A suitable range of intervention options is available; however, the model has not been used to challenge current practice or identify possibilities for new working approaches, for example developing highly efficient methods of repair ('high output techniques') for civils interventions.

6.7.11 There are no safety or failure risk costs or consequences in the model, which limits the extent to which the model can value residual life and provide a reliable trade-off between cost, performance and risk. We consider this is a significant weakness in the model.

6.7.12 The model provided is complex, with some 19,000 lines of code; however, no records of verification or sensitivity testing have been provided.

6.7.13 Outputs can be compared to a risk target; however the implication of this risk does not appear to have been a factor in any decisions.

6.7.14 In light of the fact that NR has a number of elements which require immediate intervention, we are unclear whether the elected strategies represent lowest WLCC for CP5 Policy, which is focused on interventions on a specific family of bridge elements, whereas the Tier 2 outputs are an average annual cost of following the lowest WLCC strategy over 100 years.

6.7.15 NR have made much progress on their WLCC model and have come a considerable way in the last year. The approach which NR have adopted for the Tier 2 model, and the principles behind it are not unreasonable; however, we have significant reservations about several aspects of the modelling and the robustness of its output. In particular:

- The interpretation of Policy and PoaP;
- The currency and reliability of degradation data;
- The currency of targets used and method of selecting lowest WLCC option; and
- The consistency of volumes of work predicted for different scenarios.

For full details, refer to report AO/030/2B.

6.7.16 The Tier 2 WLCC model was developed by NR to identify long term lowest WLCC strategies for bridge interventions at a population level. This approach is good practice; however, such tools are more helpful where the owner has a reasonably steady state bridge population which is in satisfactory condition, and are less applicable in NR’s immediate position. Where an element is already below an intervention threshold, more detail is required to decide on an appropriate intervention.

Major Structures, Tunnels and Other Assets

6.7.17 NR have not supplied any specific strategic whole lifecycle costing analyses for Major Structures, tunnels or other minor assets and hence no life cycle options have been developed for these assets.

6.7.18 This is reasonable for Major Structures or CERD assets since they are often bespoke in their behaviour and management plans and therefore it is more appropriate in terms of whole life treatment options to consider these assets on an individual basis.

6.7.19 We consider that a WLCC tool could be developed for retaining walls and culverts assets, of which there are many; however, NR are currently limited by the quality of its data for these assets.

Policy Objectives

6.7.20 NR have stated that their objectives for the CP5 Structures Policy are to define the levels of service for the structures assets and the performance targets and measures they intend to use to demonstrate their progress towards meeting them.

6.7.21 The HLOS objectives related to structures and the Policy are shown below:

- Ensuring the current safety levels are maintained or enhanced;
- The PPM should achieve an overall level of at least 92.5% moving annual average by the end of CP5; and
- To take appropriate account of the risks and opportunities from anticipated climate change.

6.7.22 The principal focus of the Policy is on the first two of these objectives. Safety has been clearly demonstrated to be the main driver for implementation of the new Policy for bridges which defines and prioritises intervention on critical elements which are below safety thresholds.

6.7.23 Bridge capability is one of structures' factors contributing to PPM. NR are committed to remediating currently identified Category D, E and F bridges during CP5.

6.7.24 As described above, the condition of tunnels has been demonstrated to be significantly better than that of bridges, with the number of elements in poor condition already apparently lower than Policy Target B. Tunnels and other structures assets have not been analysed to the same depth as bridges, primarily because of a lack of suitable data, so that the level of risk is unclear. We have not seen evidence of a relative risk assessment for tunnel components. NR are introducing a newly developed system for risk assessment of retaining walls and are developing new examination regimes for other asset groups.

6.7.25 We consider it will take some time for these programmes for other structures asset groups to mature to the point where asset policy objectives are comparable to that of bridges.

6.7.26 In planning the application of the Policy in CP5, NR have considered three Scenarios, as follows:

- Scenario 1 – Unconstrained application of Policy in CP5;
- Scenario 2 – Phase-in Policy over CP5 & CP6; and
- Scenario 3 – Phase-in Policy over CP5 to CP7.

6.7.27 NR have selected Scenario 2 because they consider Scenario 1 to be undeliverable. NR have not provided evidence to support this choice. As discussed in Section 6.2, we are unclear how activities will be prioritised between the two Control Periods. We have noted instances in the SBP submission where NR state that the primary focus for CP5 is safety. However, as an example, the commitment to remediate currently identified sub-standard bridges seems to contradict this.

6.7.28 We believe it is highly likely that for CP6 there will be a new asset policy for structures which we would expect to build on the Policy proposed for CP5, in the same way that for Track the CP5 Policy is a development of the CP4 Policy. Therefore, we consider that the Policy selection should be tailored to CP5 only, and should provide a clear statement of CP5 outputs – numbers and volumes and measures – to deal with known and emerging sub-threshold PLBE issues, and other specific topics from the list of activities given in the policy [Ref. SBPT3013, Para. 10.2.2].

6.8 Overall Planning Process

6.8.1 For bridges, the SBP Policy is applied at element (PLBE BCMI) level, related to Route Criticality. The existing central data systems and processes (primarily CARRS) work at structure level (overall BCMI).

6.8.2 Examination standards have not been changed, but the new policy requires a more detailed review of examination findings to positively categorise intervention requirements for all elements below set thresholds. Under the normal CP4 process, bridge examiners only flag up defects which in their judgement require action; this does not rely explicitly on PLBE BCMI scores.

6.8.3 Using the Policy to develop a bottom up workbank requires Routes to identify verify appropriate interventions for each sub-threshold element (which may include taking no action). The SBP Policy was issued in December 2012, and although Routes were well aware of the development of the policy and its principles, there was a serious shortage of time to allow Routes to implement the final Policy in time for the SBP submission; this problem is more acute on the larger Routes. Ideally, the bottom-up workbanks would have been iteratively aligned with the Tier 1 outputs to provide a harmonised submission. This process is underway, but incomplete. LNW advised that it would take them eighteen months to develop a policy compliant bottom-up workbank. Other Routes, for example Scotland, are much closer to achieving this.

6.8.4 NR have stated that:

"The unconstrained workbanks are being produced by each Route, with prioritisation following the outline stated in Policy section 6.5. Each asset should be assessed using the LWLC guidance within PoaP to generate the initial workbank. Where the condition of PLBEs fall beyond the basic safety limit indicator, these would be reviewed and prioritised where a safety risk is identified. Within the proposed SBP funding allocation, there is sufficient allowance for all capability (cat D to F) interventions, condition-based works for elements identified to be a safety risk, and to progress the risk reduction programmes (e.g. scour) in accordance with their overall programmes"[15].

This appears to be a realistic set of activities for bridges.

[15] Question log STR 1031

6.8.5 As stated elsewhere, we are unconvinced about the suitability of the WLCC model for the particular issues which have been identified during the development of the Policy.

6.8.6 Routes have used a mix of approaches in applying top down and bottom up data in preparing their Route Plans.

6.9 Systems Approach

6.9.1 There is no information in the Structures Policy about consideration of a systems approach.

6.9.2 Policy or PoaP indicates that waterproofing should be coordinated with track renewals. Some routes are looking into this, for example by aiming to replace waterproofing during track renewals as a local policy.

6.9.3 Whilst we agree that if full track renewal is taking place, the need for waterproofing renewal should be assessed or in some cases be made mandatory, waterproofing renewal should also be considered as an essential stand-alone maintenance activity, recognising that for lower route criticalities full track renewal will be infrequent.

6.9.4 We note that BCMI does not include waterproofing and water management as a specific item and that PoaP for masonry arch underbridges does not refer specifically to waterproofing failure, which is one of the primary causes of degradation.

6.9.5 The data needed to enable a systems approach not is currently available – BCMI does not score drainage, waterproofing or vegetation. NR are planning to improve the condition data for other structures asset groups.

6.9.6 From our review it is unclear how NR have equated safety risk between the ‘principal’ asset types such as Buildings vs. Earthworks vs. Structures. This gives rise to a significant uncertainty that asset outputs cannot be equated between asset types and that it may be being proposed that assets are funded to achieve different levels of risk.

6.10 Risk

6.10.1 As noted above NR have adopted an explicit risk based approach in their structures policies for bridges, culverts and retaining walls.

6.10.2 As described earlier, the Policy for bridges has been soundly developed so far and NR are committed to its further development and improvement. We strongly support this commitment.

6.10.3 The Policy for tunnels uses a similar approach to Bridges, with PoaP interventions being developed. Interventions are based on SevEx element scores for some of the defects. NR have not linked different intervention thresholds to route criticalities, so the Policy has to be considered as condition based.

6.10.4 The Policy for footbridges does not currently evaluate risk; interventions are based on condition alone.

6.10.5 The Policies for culverts and retaining walls are being developed using risk based principles; further development and improvements in asset knowledge are required to provide the necessary information to implement the Policy.

6.10.6 The underlying approach being used for Major Structures and CERDs assets is unclear. For each asset in these sub-groups, AMPs are to be developed. We have not been provided with any examples as part of the SBP submission. NR state that risk-based principles will be applied to Major Structures [Ref. SBPT3013, Para 2.2.6]. We have no information about this approach and have some concerns that it could lead to a decline in the condition of Major Structures.

6.11 Deliverability

6.11.1 NR have concluded that the policy should be implemented over two Control Periods on grounds of deliverability. Deliverability constraints and the rationale for implementation over CP5-CP6 are not explained in detail in the submission.

6.11.2 NR proposes that 'Scenario 2 – Phase in Policy over CP5-CP6' should be adopted. We do not agree with this selection in relation to bridges as it potentially means that there could be bridges with individual PLBE scores below the minimum condition threshold for the next 10 years. We are concerned that NR do not appear to be seeking resolve this issue more urgently.

6.12 Continuous Improvement

6.12.1 It is noted that the majority of the recommendations made in our previous review of the IIP Asset Policy have been taken into account by NR in the SBP Asset Policy for Structures.

6.12.2 The Policy explicitly identifies a number of improvements planned in the future. There are eighteen in total, and relate to all aspects of policy development.

6.12.3 Data improvement is a significant area for further development where the proposed activities include:

- A data improvement programme is underway to identify gaps in the existing data to allow the asset population to be matched against the defined sub-groups;
- Capture data for all culverts, retaining walls and footbridges that will confirm condition profiles to new measuring systems;
- Improve data collected during detailed examinations to reflect risk by location of defect;

- Capture additional data to improve asset and portfolio management, for example bridge deck area - much of this data will improve lifecycle planning and forecasting activities; and
- Complete the development of the new data system for structures assets.

6.12.4 More general improvement plans include:

- Implementation of the Level Zero Assessment Tool to provide capability information that is currently not available;
- Continuously review and update the FMEA. Expand the decision support tool to include all structures asset groups;
- Update the degradation tables within the models annually;
- Create degradation tables for the other assets;
- Carry out detailed monitoring of carefully selected assets (Marker Structures) to provide greater understanding of asset degradation and act as a check and balance against predicted condition states within the asset modelling;
- Improve the relationship between asset condition and capability data;
- Review unit rates on a regular basis to ensure they are reflective of emerging cost information and working practices;
- The Routes will populate the unconstrained workbank, as defined in Section 6.5. This will be evaluated against Policy both prior to and during CP5;
- Produce condition / risk profiles from the Tier 1 model to evaluate the outcome of each scenario on the asset population; and
- Validate outputs through comparison of 'bottom-up' workbanks for CP5 provided by the Routes.

6.12.5 These further development plans are a very positive indication that NR acknowledge that the Policy needs considerable further fundamental development and improvement work. NR have not provided a timescale for completion of these activities.

6.12.6 There is no explicit mention of reviewing the performance improvement (e.g. failures) achieved by implementing the new policies and reviewing whether they are delivering the benefits sought.

6.13 Targets, Robustness, Sustainability and Cost

6.13.1 As Independent Reporter we have been asked to consider the degree to which NR have demonstrated that the asset policies are robust, sustainable[16] and the degree to which the asset policy been demonstrated to deliver the required outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.[17] The targets set by NR are one of the key aspects of asset policies and we have therefore included a section on these below.

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[16] ORR letter dated 1st June 2010 (document ref. 379948)
[17] ORR-#430597-v1-20111028_ORR_PR13_Policy_review_note and Mandate AO/030.

6.13.2 'Structures Other' comprises a range of 'Policy objectives' set to reduce risk and comply with statutory obligations. The tests of robustness, sustainability and lowest possible whole system cost are not applicable to these items.

Targets

Underbridges and Overbridges

6.13.3 In the Policy [Ref. SBPT3013, paragraph 10.11] NR have proposed a series of measures which would limit the number of elements whose condition is worse than the minimum PLBE threshold for different element subgroups. The values for these measures range between 2% and 8%. In response to our questions NR have advised that "*There are currently 9,666 bridges with one or more PLBE below the safety threshold.*"[18]

6.13.4 NR have also indicated that at the end of CP5, the targets allow for circa 70% of elements below the minimum PLBE threshold to remain due to the defect location not creating a safety risk. We are unclear how the measures percentages relate to the value of 70% given above.[19]

6.13.5 There is an apparent contradiction – NR are stating that there is a basic safety threshold, and that 70% of the elements which are below the threshold are believed not to be a safety risk. We are unclear how these statements have been reconciled and how they have been incorporated in the models, which appear to be based on performance level (PoaP) interventions.

6.13.6 For bridges, focusing the targets and measures on the area which has been identified as the first priority for CP5 provides a pragmatic 'line of sight' between interventions and asset risk, which is linked to performance (bridge condition, number of failures etc.) and network performance (derailments, delay minutes. Schedule 8 costs etc.).

6.13.7 We have low uncertainty that the targets proposed by NR for bridges are reasonable.

Major Structures

6.13.8 NR have not proposed any measures for Major Structures. This is a significant omission for assets which are vital for the performance of the rail network and should be corrected, as it creates a high level of uncertainty.

[18] Question Log STR1033
[19] Question Log STR0065

Tunnels

6.13.9 In CP5 the key Policy target (Target B) for tunnels is to reduce the number of poor condition sections over CP5. According to the condition data for tunnels, this target is already achieved, by a significant margin, as shown in Figure 6-15.

6.13.10 The other tunnels policy target is to complete the hidden shaft identification programme by 2020, including risk reduction measures where practicable. Hidden shafts are a serious hazard for tunnels assets; we have not seen evidence to show why a completion date of 2020 is considered to be acceptable.

6.13.11 Therefore we are somewhat uncertain whether the targets proposed by NR for tunnels are reasonable.

Other Assets (Retaining Walls, Footbridges and Culverts)

6.13.12 The targets for retaining walls, footbridges and culverts are not well defined. Therefore it is uncertain whether the targets proposed by NR for these assets are reasonable.

Other Assets (Coastal Estuarine and River Defences)

6.13.13 There are no targets in the Policy for CERDs and therefore we are highly uncertain about the intended outputs for this group of assets.

Structures Other

6.13.14 NR provide a series of targets for 'Structures Other', addressing the specific ongoing improvement programmes. We have not seen evidence to support these targets and the chosen completion dates (where stated). We therefore are uncertain whether these targets are reasonable.

Robustness

6.13.15 NR have made significant progress with the development of their Structures Asset Policy since IIP in September 2011, building considerably on the IIP analysis and indicators. In the SBP [Ref. SBPT101, page 34] NR notes that the civils policies are new and largely untried and that work will continue to develop them during 2013. NR go on to state [Ref. SBPT101, page 41] that:

"Despite considerable progress in defining a sustainable approach to the management of these assets, there still remains a degree of uncertainty whether the policies will result in appropriate activities and outcomes. Since the policies are new, there is still limited degradation information over the whole life of the assets and the modelling is complex due to the heterogeneity of the asset base. While recognising that an output based determination is desirable, we do not believe that it

would be appropriate for Civils during CP5. We need to deliver increased activity levels while continuing to review whether the revised asset policies are recovering the backlog and reducing the level of risk relating to Civils assets. We believe that it is important for both ORR and Network Rail to jointly continue to assess whether our revised policies are appropriate"

6.13.16 We agree in principle with this assessment for reasons outlined in the paragraphs below.

6.13.17 NR have introduced of a risk-based Policy which prioritises the interventions according to safety risk for most of the structures asset groups.

Underbridges and Overbridges

6.13.18 For underbridges and overbridges, NR have based its policy on the condition scores (BCMI) for PLBEs. These scores are determined by NR's (contracted) examiners during detailed examinations which are programmed at variable intervals of between three and eighteen years, according to structure type. NR have detailed records of these scores which have been reviewed and analysed. A review of safety and failure records has been carried out which shows a significant increase in the number of failures.

6.13.19 Based on a FMEA, NR have determined PLBE BCMI scores which they consider represent a minimum condition PLBE thresholds for the major bridge asset sub-groups. These are defined in the Policy [Ref. SBPT3013, Appendix I]. The BCMI score is based on Severity and Extent of particular defects. We consider this can only be an initial filter because the likelihood of failure is also affected by other factors, for example defect location, load-bearing capacity, stress, applied load, structural redundancy and resilience, which are not (and cannot be) taken into account at the examination stage.

6.13.20 The Structures Asset Policy states that the first priority for bridge activity is directed at elements below the minimum condition PLBE threshold. This links directly back to HLOS objectives.

6.13.21 The CP5 Policy has a clear linkage to asset outputs and is based on reasonable inventory and condition information and has an explicit risk based intervention approach. However, the evaluation and prioritisation of the required interventions to comply with the Policy is incomplete and represents ongoing work.

6.13.22 We consider that the Asset Policy for underbridges and overbridges is based on sound principles, and is capable of delivering a reduction in asset risk, whilst noting that further work, including significant improvements in asset knowledge for all asset groups, is required. We disagree with the proposal to introduce the policy over two Control Periods. We conclude that from an overall perspective it is reasonably likely that the CP5 Policy for underbridges is robust.

Major Structures

6.13.23 The Policy for Major Structures currently appears to be to prepare AMPs for each structure prior to the start of CP5. We consider AMPs for this asset group to be appropriate, but because NR have submitted little information to support their plans, we are uncertain about the content and data to be provided. We consider that the targets are poorly defined. We are consequently uncertain about the robustness of the Policy for Major Structures.

Tunnels

6.13.24 For tunnels, NR hold reasonable inventory and condition data and the assets appear to be maintained in significantly better condition than bridges. The Policy for tunnels which drives interventions appears to be mainly condition based. We are unclear about the outputs which NR intend to deliver for the tunnel bores as the existing condition appears to be significantly better than the proposed target. Regarding hidden shafts, from a risk perspective we have some uncertainty about the timescales for completing the hidden shaft identification programme.

6.13.25 There is some uncertainty about the robustness of the Tunnel Policy.

Other Assets (Retaining Walls, Footbridges and Culverts)

6.13.26 For this group of structures assets, the condition rating system is currently relatively simplistic. NR intend to improve asset knowledge during CP5 and there is a possibility that the condition parameters will need to be re-baselined as a result. We are consequently uncertain about the robustness of the Policy for this asset group.

Other Assets (Coastal Estuarine and River Defences)

6.13.27 NR have provided very little information relating to CERD assets. A Policy objective to prepare asset management plans for CERD assets has been set. There is no clear line of sight and therefore we have high uncertainty that the Policy for CERDs is robust.

6.13.28 Application of the Asset Policy is covered in our separate reports [Ref. Arup 2013, Arup 2013a].

Sustainability

Underbridges and Overbridges

6.13.29 With respect to sustainability we have two principal concerns. The first is whether the Structures Policy for bridges is applicable for two Control Periods as proposed by NR, or over one Control Period, which appears to Arup to be the appropriate and pragmatic approach. Our other concern relates to the intent of the Policy. Our interpretation is that the Policy identifies that the overall existing condition of NR's bridges assets is below acceptable levels, and that the aim of Policy is to significantly reduce the number of elements which are in unacceptable condition. This implies a step change improvement in overall condition in CP5/6, which would then be sustained over future Control Periods.

6.13.30 There is some uncertainty about the definitions of CP4 exit and the targets and measures for CP5, which relates directly to the sustainability of the Policy for bridges. In addition, there is some uncertainty about the long term condition requirements.

6.13.31 It may be argued that for bridges, the CP5 Policy is what is needed for that Control Period to deliver a step change in condition. Thereafter a different 'longer term' policy might be implemented which explicitly considers 'sustainability'. On this basis sustainability would not be relevant criteria in CP5.

Major Structures

6.13.32 The statement that NR intend to apply a risk based approach [Ref. SBPT3013, Section 2.2.6] policy for Major Structures, which has not been provided in detail, raises concerns that NR may be prepared to allow the overall condition of Major Structures to deteriorate. We consider this would be a retrograde approach to assets which are vital to the long-term performance of the network. We are consequently uncertain about the sustainability of the Policy for Major Structures.

Tunnels

6.13.33 We are unclear about the outputs which NR intend to deliver for tunnels, whether NR aim to maintain or improve tunnel condition and risk over CP5 because the targets in the policy differ from the overall outputs stated in SBPT223 for CP5. In addition, the existing condition appears to be significantly better than the proposed target. A pro-active approach to interventions over recent years has delivered assets in generally fair or good condition; we are uncertain if the Policy would continue to apply this approach for all route criticalities.

6.13.34 For these reasons we consider there to be some uncertainty about the sustainability of the Tunnel Policy.

Other Assets (Retaining Walls, Footbridges and Culverts)

6.13.35 We are uncertain about the sustainability of the Policy for this asset group.

Other Assets (Coastal Estuarine and River Defences)

6.13.36 We have high uncertainty that the policy for CERDs is sustainable.

Lowest Whole Life Cycle Cost

Underbridges and Overbridges

6.13.37 NR have made much progress on their structures WLCC model and have come a considerable way in the last year. The approach which NR have adopted for the Tier 2 model, and the principles behind it are not unreasonable; however, we have significant reservations about several aspects of the modelling and the robustness of its output.

6.13.38 In our opinion, there is some uncertainty that the policies based on the modelling will deliver lowest WLCC outputs.

Major Structures

6.13.39 NR have not supplied any explicit WLCC analyses for Major Structures, hence no lifecycle options have been presented for these assets. It is therefore uncertain as to whether the Policy will deliver the outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.

6.13.40 This is reasonable for Major Structures since they are often bespoke in their behaviour and management plans and therefore it is more appropriate in terms of whole life treatment options to consider these assets on an individual basis.

Tunnels

6.13.41 NR have not supplied any explicit WLCC analyses for tunnels, hence no lifecycle options have been presented for these assets. It is therefore uncertain as to whether the Policy will deliver the outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.

Other Assets (Retaining Walls, Footbridges and Culverts)

6.13.42 NR have not supplied any explicit WLCC analyses for retaining walls, footbridges and culverts, hence no lifecycle options have been presented for these assets. It is therefore highly uncertain as to whether the Policy will deliver the outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.

6.13.43 We consider that a WLCC tool could be developed for retaining walls and culverts assets; however, NR are currently limited by the quality of its data for these assets.

Other Assets (Coastal Estuarine and River Defences)

6.13.44 NR have not supplied any explicit WLCC analyses for CERD and no lifecycle options have been presented for these assets. It is therefore highly uncertain as to whether the Policy will deliver the outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.

6.13.45 This is reasonable for CERD assets since they are often bespoke in their behaviour and management plans and therefore it is more appropriate in terms of whole life treatment options to consider these assets on an individual basis.

6.14 References

Ref	Document Title	Version / Date
Arup 2011a	Mandate A0/017: Initial Industry Plan (IIP) 2011 Review :- Summary Report – Observations and Conclusions	Issue 1 16 December 2011
Arup 2012a	Mandate A0/017: Initial Industry Plan (IIP) 2011 Review :- Review of Tier 2 Whole Life Cycle Cost Models	Issue 1 23 April 2012
Arup 2013	Mandate AO/030 Summary Report	Draft A
Arup 2013a	Mandate AO/030 Tier 1 Report	Draft A
Arup 2013b	Mandate AO/030 Policy and Tier 2 Report	Draft A
Arup 2013c	Mandate AO/030 Addendum Report	Draft A
Arup 2013d	Mandate AO.034 Costs	Draft A
Arup 2013e	Mandate AO/035 Efficiencies	Draft A
Arup 2013f	Mandate AO/026 CP4 Policy	
Arup 2013g	Mandate AO/028 Data Quality	December 2012
Arup 2013h	Mandate AO/029 CP4 Regulated Outputs	
NR 2013a	Modelled Earthworks Risk and Condition Trends by Route CP5-CP11	Rev 05d 6 Feb 2013
SBPT101	Strategic Business Plan England & Wales	January 2013
SBPT102	Strategic Business Plan Scotland	January 2013
SBPT3015a	CP5 Earthworks Asset Policy	Rev 08 Final 14 Dec 2012
SBPT3013	Structures Asset Policy	BCAM-TP-0165 7th Dec 2012
SBPT3015b	CP5 Mining Policy	Rev 07 Final 14 Dec 2012
SBPT3017	CP5 Drainage Asset Policy	18 Dec 2012
SBPT3074	Structures Unit Rates and Assumptions	29 November 2012
SBPT3076	CP 5 Earthworks Unit Rates Submission	V2.1 13/12/12
SBPT 220	Efficiency Summary	Version 2.0
NR/L3/CIV/065	Network Rail Standard NR/L3/CIV/065	Issue 3 dated June 2012
NR 2012a	CP5 earthworks and drainage modelling, Degradation and failure rate inputs [219]	
	CP5 Drainage Asset Policy	
SBPTxxxx	Policy on a Page	Issue 1.1, 7 December 2012
S1	NR/L3/CIV/028 – The Management of reports of safety related events on buildings and civil engineering infrastructure	
S2	HSE – Tolerability of Risk Framework	
S3	NR Asset Management Policy February 2011	
S4	BCAM-TP-0267 CP4 Bridge Condition Analysis	Issue 1.0, 30 November 2012
S5	20130206 Structures Slides_v3.1ppt	V3.1
S6 S7	Policy on a Page Structures NR Structures: CP5 SBP CAPEX Funding Plan	Issue 1.1 7 December 2012 BCAM-TP-0305 v0.50

S8	Tier 2 Strategy Selection Report 061212	BCAM-TP-0264 v1.0
S9	Structures Asset Policy - September 2011	September 2011

7 Earthworks Asset Policy

7.1 Performance Requirements / Outputs

7.1.1 The NR SBP submission includes a CP5 Earthworks Asset Policy [Ref. SBPT3015a] which explains NR's proposed management approach for embankments, soil cuttings and rock cuttings.

7.1.2 Since IIP, NR have also prepared a specific Mining Policy [Ref. SBPT 3015b] and included this as an Appendix to their Earthworks Asset Policy. The Mining Policy explains their approach to mining, waste disposal and landfill sites that may pose a hazard to railway operation.

7.1.3 The management of the drainage asset is covered in the NR CP5 Drainage Asset Policy Document [Ref. SBPT3017] including earthworks, track and tunnel drainage assets. Drainage is intimately linked to these assets. This linkage is discussed in the Track and Earthworks sections; the Drainage Policy itself is discussed in Section 10.

7.1.4 NR Earthworks Asset Policy [Ref. SBPT3015a] summarises earthworks reliability trends with respect to performance indicators that relate to:

- Earthwork failures;
- Derailments;
- Delay minutes (Schedule 8 costs);
- Temporary Speed Restrictions (TSRs);
- Shallow mine working incidents; and
- The impact on train operation and safety is considered.

7.1.5 NR have analysed earthworks failure data between 2004 and 2012, a summary plot is presented in Figure 7-1 below.

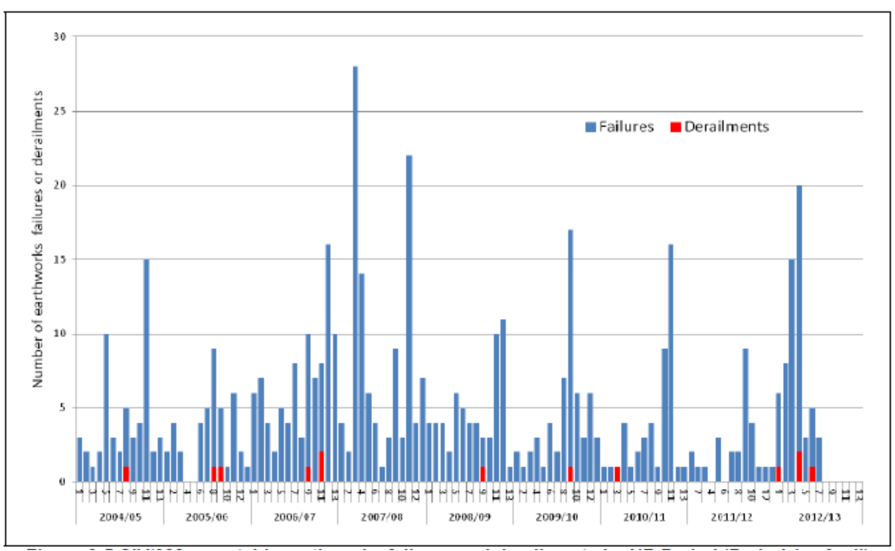


Figure 7-1: Reportable Earthworks Failures and Derailments 2004-2012

7.1.6 NR note that the historic failure data does not show a clear reducing trend that might have been expected bearing in mind the renewals work to poor condition sites over that period. NR note that 80% of failures are related to high rainfall.

7.1.7 NR have identified derailments due to earthwork failures over the period 2004 to 2012 – see Figure 7-2. For derailments between 2007 and 2012, NR consider that 50% were directly attributable to inadequate earthworks drainage. It is also notable that all the derailments were at cutting sites or sites on sidelong ground and that the consequences of derailment could have been far more severe save for mitigating local circumstances in each case.

Location & date	Cause	Consequence
Hooley January 2007	Tree stump root ball fallen down cutting face together with debris from kingpost wall	8 car class 377 with 413 passengers derailed
Kemble January 2007	Debris on track from soil cutting and toe wall failure due to inadequate crest drainage	Class 158 DMU derailed
Gillingham November 2009	Soil cutting failure due to water overtopping crest ditch	Train derailed
Cruachan June 2010	Boulders on track loosened from soil sockets above rock due to soil shrinkage and root jacking	Train derailed
Clarborough April 2012	Soil cutting failure due to water overtopping crest ditch resulting in tree stump and soil on track	Class 143 DMU derailed with 19 passengers. 2 minor injuries
Loch Treig June 2012	Debris flow containing large boulders from the natural slope above the cutting slope	Class 66 locomotive and 5 aluminium bauxite wagons derailed. No injuries. Loco damaged with very difficult recovery
Rosyth July 2012	Cutting slope failure due to surface water runoff from an industrial development that washed out the cutting face	Class 158 DMU 2 car passenger train with 32 passengers. Leading bogie derailed, train damaged. No injuries.
St Bees August 2012	Failed natural slope	Class 153 DMU 2 car passenger train with 100 passengers. 1 minor injury. 200 litres fuel spilt

Figure 7-2: Summary of Recent Derailments Attributed to Earthworks

7.1.8 NR have recognised that the number of derailments is only broadly related to peaks in the number of earthworks failures and specifically that the consequence of a failure needs to be explicitly considered in their approach to earthworks management – i.e. the need for a ‘risk based approach’.

7.1.9 Where an earthworks failure of any kind causes a delay to train operation this is reported against the earthworks asset as the number of ‘Schedule 8’ minutes of delay accumulated against each incident. This data is recorded in NR’s Train Running System (TRUST) database and provides an indirect measure of the performance of the earthworks asset.

7.1.10 NR analysis of this data indicate that in 2010/2011, earthworks failures were responsible for 4.7% of reported delay incidents, and 7.8% of the total delay time (this higher percentage reflecting the longer time typically required to clear an earthworks incident compared with other types of incident).

7.1.11 The Schedule 8 costs attributed to earthworks incidents from 2000/2001 to 2010/2011 are shown in Figure 7-3.

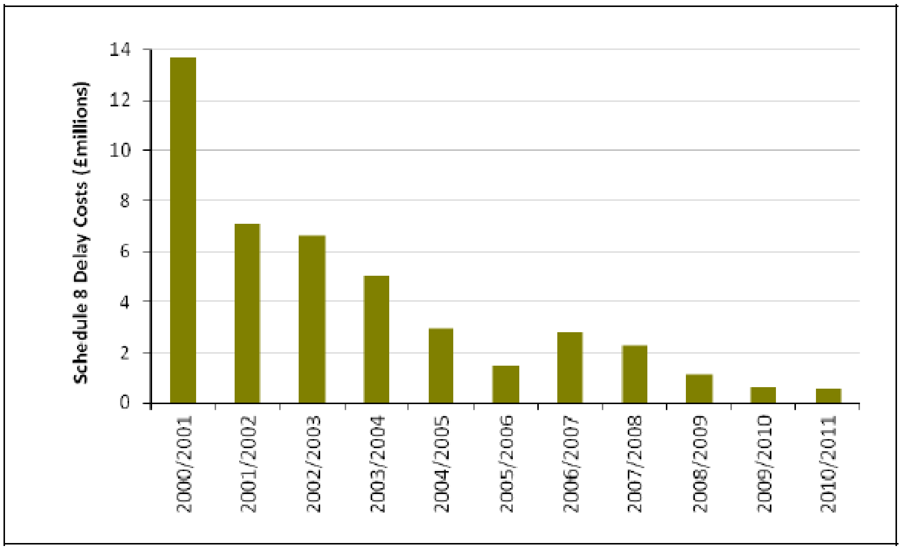


Figure 7-3: Delay (Schedule 8) Costs Attributed to Earthworks Incidents

7.1.12 NR note that the Schedule 8 delays and TSRs mainly relate to restrictions imposed on poorly performing embankments. NR note that these show a general reducing trend since active management of earthworks began in 2000 and specific focus on embankment performance issues.

7.1.13 The number of earthwork related TSRs is reported as the 'M4 Measure' in the NR Annual Return. Data from 2001 to 2012 is shown in Figure 7-4.

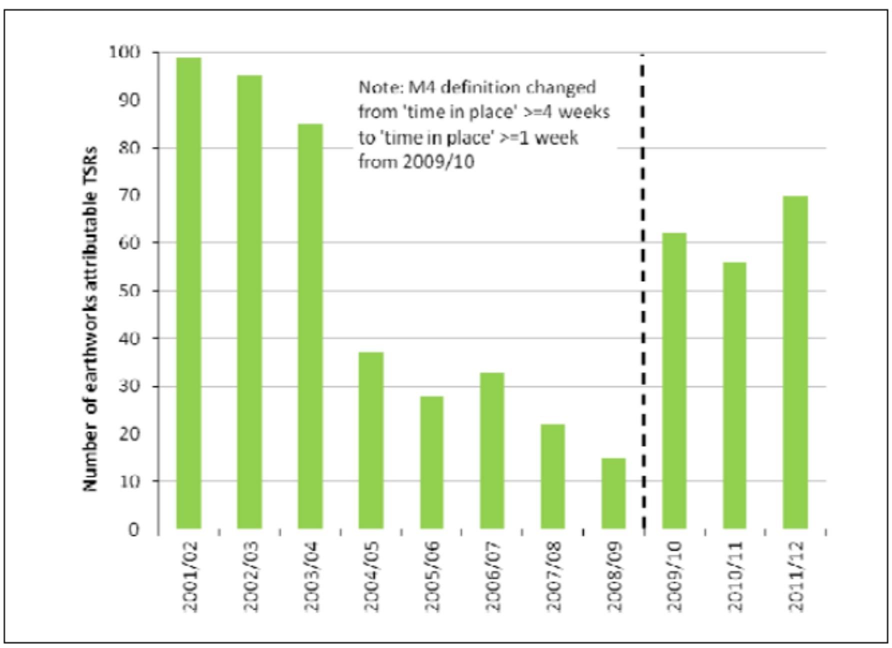


Figure 7-4: Number of Earthworks TSR's per Annum ('M4 Measure')

7.1.14 Other earthworks related measures reported in the NR Annual Return are:

- Earthwork Failures (M6);
- Earthwork Condition (M33); and

- Earthwork remediation (M28) – activity volumes in terms of number of remediation projects and total volume (m^2).

7.1.15 NR are currently undertaking research work to improve the understanding of the relationship between earthwork condition and loading from increased tonnage / traffic. At the moment there is no reliably established relationship and NR in their modelling have ignored any possible effect. This is not unreasonable.

Mining

7.1.16 Mine workings under or adjacent to the railway can present a risk to railway operation which is managed as part of the earthworks portfolio. The historic trend in shallow mine working failures is shown in Figure 7-5 as recorded instability incidents affecting the railway per five year period from 1859 onwards. A projected total for the end of CP4 is also shown. No data on other types of mining incident is provided.

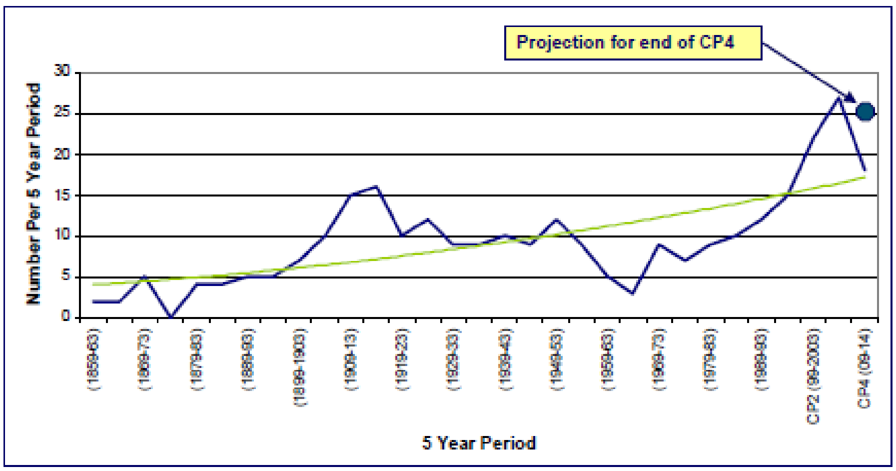


Figure 7-5: Number of Mining Related Railway Incidents (per 5 year period)

7.2 Line of Sight

7.2.1 As set out in the Strategic Business Plans for England & Wales, and the Strategic Business Plan for Scotland [Ref. SBPT101 and SBPT102] NR have developed a set of a series of asset output measures for the major asset disciplines (track, signalling, electrical power, buildings, structures and earthworks). These measures have been proposed by NR to assess:

- "Robustness: whether our assets will deliver the required outputs; and
- Sustainability: whether our asset policies continue to deliver the outputs over the longer term."

7.2.2 For earthworks the 'robustness' measure is noted as being 'under development'. In terms of earthworks 'sustainability' NR are proposing to adopt a 'Risk Index' and to target maintaining this at the CP4 'baseline' of 100. This is discussed below.

7.2.3 In developing their CP5 Asset Policy NR have adopted a 'risk based approach' to the identification of sites for remedial work. This is a significant step forward from the CP4 polices and the earthworks policy at IIP stage.

7.2.4 The NR 'risk based approach' uses 'earthwork condition' (Soil Slope Hazard Index (SSHI) or a Rock Slope Hazard Index (RSHI)) as a proxy for 'likelihood' of failure and developed an 'asset criticality' based on line speed, track layout, route importance and track quality (embankments) to give a proxy for 'consequence'.

7.2.5 Each five chain length of earthwork from the NR inventory can be 'plotted' on an overall 'risk space' as shown in Figure 7-6 below. Sites are then selected based on their risk ranking. This is very positive, as it places the primary emphasis on 'safety' based interventions rather than those to achieve 'track performance'.

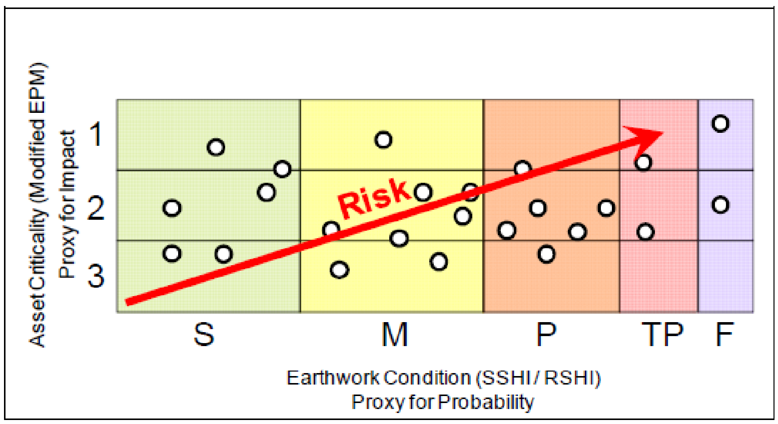


Figure 7-6: Earthworks Risk Space [Ref. SBPT3015a]

7.2.6 NR Asset Policy [Ref. SBPT3015a] defines the 'Risk Index' as :

$$\textbf{Risk Index} = 100 \times \frac{\sum \text{condition score} \times \text{criticality score} \times \text{No. earthworks future}}{\sum \text{condition score} \times \text{criticality score} \times \text{No. earthworks current}}$$

7.2.7 This is shown diagrammatically in Figure 7-7 below.

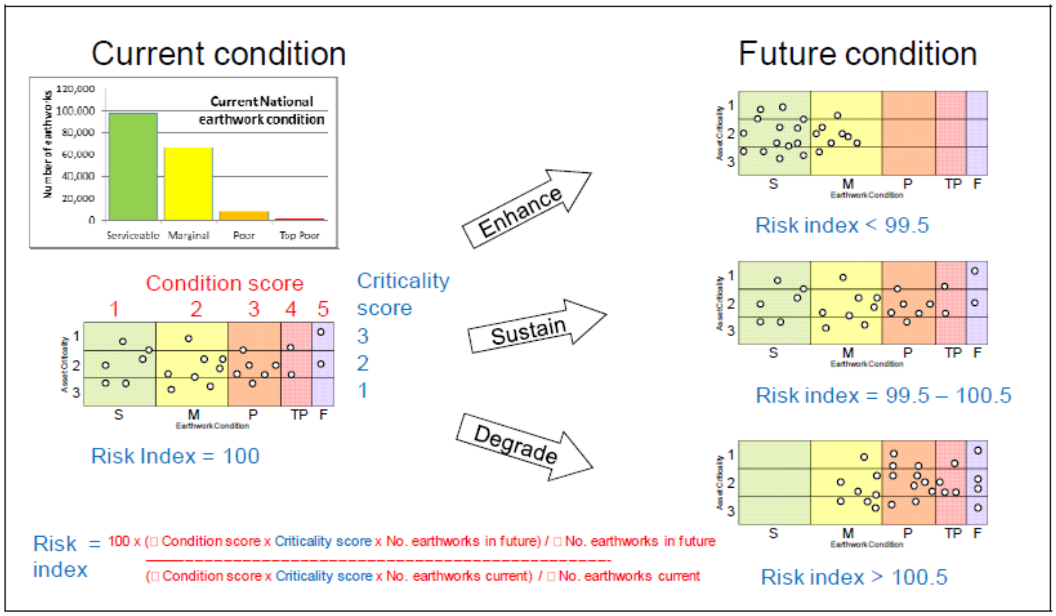


Figure 7-7: Earthworks Risk Index [Ref. SBPT3015a]

7.2.8 The proposed Earthworks Risk Index for CP5 to CP11 is reproduced in Figure 7-8.

Asset	Sustainability measure	CP4	CP5	CP6	CP7	CP8	CP9	CP10	CP11
Track	Used life (%)	52%	51%	50%	50%	53%	55%	56%	57%
Signalling	Remaining life (years)	13.3	15.0	17.8	21.1	21.0	20.0	18.4	17.8
Telecoms	Remaining life (%)	72%	46%	36%	44%	69%	53%	36%	37%
E&P	Remaining life (%)	61%	57%	55%	54%	53%	53%	53%	51%
Buildings	Remaining life (%)	41%	42%	45%	49%	53%	55%	58%	58%
Structures	Condition score for principal load bearing elements (bridges)	7.4	5.8	4.2	4.3	4.5	4.6	4.6	4.5
Earthworks (GB total)	Earthworks Risk Index	100	99.6	99.7	99.7	99.7	99.7	99.7	99.6

Note: remaining life is based on the estimated average asset life.

Figure 7-8: Earthworks Risk Index [Ref SBPT101, 102, 232]

7.2.9 NR are proposing that the ‘baseline’ earthworks Risk Index of 100 will be set at CP4 exit based on the actual risk profile at that time, and that a reduction in Risk Index to 99.6 will be achieved by CP5 exit. NR note that this will result in a significant improvement in ‘poor’ assets in CP5 [Ref. SBPT232].

7.2.10 NR also note that the solution for subsequent Control Periods is less certain but will aim to slightly improve the Risk Index through to CP11.

7.2.11 The overall concept of the proposed Risk / Condition indices as key performance indicators for the earthworks asset is sound, in that the indices directly relate to the recorded asset inventory and condition (in five chain lengths) examined under NR standards which in turn are related to condition based failures.

7.2.12 The Renewals Expenditure Summary [Ref. SBPT223] notes that “*There will be a reduction in high risk sites in CP5 from 5.7% to 4.7%*”, which is very encouraging.

7.2.13 NR have provided the following table (Figure 7-9) showing a forecast improvement in improvement in condition profile / risk reduction. Unfortunately the data does not include 'CP4 Exit' values and so it is still unclear improvement in condition profile / risk reduction that is being proposed for CP5.

At Feb-2012 data cut No. asset 5ch lengths	Serviceable	Marginal	Poor	Top poor	*Row Total**
Criticality 1	14,892	10,197	1,208	318	26,615
Criticality 2	56,176	36,006	4,372	933	97,487
Criticality 3	27,550	20,353	2,491	627	51,021
Column total	*98,618*	*66,556*	*8,071*	*1,878*	*175,123*
End-CP5 forecast No. asset 5ch lengths	Serviceable	Marginal	Poor	Top poor	*Row Total**
Criticality 1	16,740	8,925	781	168	*26,614*
Criticality 2	52,648	40,583	3,765	489	*97,485*
Criticality 3	25,502	22,541	2,510	469	*51,022*
Column total	*94,890*	*72,049*	*7,056*	*1,126*	*175,121*

* Note that a known and documented issue in the Earthworks SCAnNeR Tier 1 model may cause the total number of asset 5ch lengths and/or the number within a particular criticality band to vary very slightly between timesteps.
Number of earthwork asset 5ch lengths per condition and criticality group at Feb-2012 data cut and End-CP5 forecast under modelled Policy IIP 6892

Figure 7-9: Earthworks Condition CP4 / CP5

7.2.14 It is unclear how NR will set the 'baseline' at CP4 exit. This would require rescoring of earthworks and updates to NR asset records at the end of CP4 following remedial work. This is a particular issue as it is noted that considerable additional investment monies were allocated in CP4 under the Enhanced Spend Programme / National Earthworks Risk Reduction Programme (NERRP) to achieve a reduction in the risk profile for a large number of assets in England and Wales. It is noted that NR have not explicitly allowed for degradation of earthworks since the last examination at the start of the SCAnNeR model run (i.e. end of CP4); the last examination in some instances, be up to 10 years ago. This may slightly under-estimate the volume of work to be undertaken in CP5 onwards. Accordingly the 'baseline condition' for the SCAnNeR modellling is an area of some uncertainty.

7.2.15 The on-going improvement in CP4 will also have an impact on the volume and type of work required in CP5 - it is unclear to what extent this will affect the modelling assumptions for CP5.

7.2.16 The exact improvement in condition profile / risk reduction in terms of five chain lengths in each condition category is not stated in the SBP Submission, and at the time of writing we are unclear as to exactly what the proposed improvement in condition profile / risk reduction will be in CP5.

7.2.17 The Strategic Business Plan [Ref. SBPT101 and 102] notes that the forecast trend for CP5 is for there to be fewer high criticality earthworks in poor condition which is very positive. However, it is noted that to some extent this will be offset by an increase in numbers of lower criticality earthworks (e.g. marginal earthworks on Asset Criticality 2 will rise from 36,006 to 40,583). We have concerns about this.

7.2.18 For earthworks, the combination of adopting a risk based approach and the Risk Index as an output measure provides a pragmatic 'line of sight' between the asset performance (earthwork condition, number of failures etc.) and network performance (derailments, delay minutes. Schedule 8 costs etc.).

7.2.19 Discussions with the Operating Routes indicate that Condition and Risk indices are in the process of being 'disaggregated' from a National level down to specific Route Targets – See Figure 7-10 below. This is very positive.

LNE earthworks modelled condition and risk profile CP4 (Feb 2012) and CP5
rev05d, 6 February 2013

Distribution of earthwork assets by condition and asset criticality

CP4 (Feb 2012)

Asset Criticality	Condition: Serviceable	Marginal	Poor	Top Poor
1	7.8%	4.8%	0.29%	0.04%
2	28.1%	19.3%	1.27%	0.36%
3	20.5%	16.0%	1.00%	0.50%

End CP5

Asset Criticality	Condition: Serviceable	Marginal	Poor	Top Poor
1	8.5%	4.2%	0.22%	0.02%
2	26.2%	21.3%	1.36%	0.19%
3	18.9%	17.4%	1.33%	0.37%

Percentage of assets in each condition and asset criticality
Length of the orange bar in each cell is proportional to the percentage of assets

Figure 7-10: Earthworks Condition CP4 / CP5 compared for LNE Route

7.2.20 In the individual Route Plans [Ref. SBPT 210-219] and Data Book summary [Ref. SBPT 3338] earthworks volumes have been disaggregated and presented in categories of proposed intervention activity 'volumes' namely:

- Renewal;
- Refurbishment; and
- Maintenance.

The exact status of these volumes at SBP stage is not defined.

7.2.21 In the Earthworks Asset Policy [Ref. SBPT3015a] there is a comprehensive set of additional earthworks measures and CP5 targets. These include a range of lead and lag indicators for capability, safety and availability. It is understood that these will be developed by NR as they develop their CP5 Delivery Plan. This is very encouraging. It is understood that these measures will be monitored by NR in addition to any existing agreed measures reported to ORR and in the Annual Return.

Mining

7.2.22 There are no proposed output measures for mining assets in the SBP [Ref. SBPT101, 102] or in the Asset Output Measures Summary document [Ref. SBPT232].

7.2.23 The Renewals Expenditure Summary [Ref. SBPT223] indicates the following CP5 outputs in terms of:

- Shallow mineworkings desk studies - 2600 no.
- Shallow mineworkings ground investigations - 75 no.
- Shallow mineworkings treatment - 19 no.

7.2.24 No details of the costs associated with these elements or where they have been included in the SBP Data Book have been provided.

7.3 Asset Knowledge

7.3.1 NR divide their earthworks asset into three primary asset types, namely Embankments, Soil Cuttings and Rock Cuttings.

7.3.2 A summary of the earthworks asset inventory and condition is presented in Figures 7-11 and 7-12 below [Ref. SBPT 3015a]. The asset inventory is defined in terms of five chain (110 yard) or 100m segments of earthworks. These segments are defined as a two-tier hierarchy of asset five chains within examination five chains. NR have used asset 5 chains as the primary means of asset description in their policy – this being the most granular level.

Asset Type	Asset 5 chain lengths	Examination 5 chain lengths
Embankments	97,815	159,407
Soil Cuttings	68,085	
Rock Cuttings	9,223	
Total:	**175,123**	

Figure 7-11: Earthworks Data (as at 15/02/12)

7.3.3 Since our IIP Review in December 2011 [Ref. Arup 2011a] NR have continued to improve their asset knowledge. Specifically, they have formally adopted ‘asset five chain lengths’ instead of ‘examination five chain lengths’ to improve clarity and undertaken a validation exercise to identify earthworks previously omitted from the Earthworks Database. NR indicate that only about 1% of the national database of assets remains to be examined. We note that there is some variability in asset data between Routes. We consider that at a National Level there is low uncertainty associated with the overall NR earthworks inventory.

7.3.4 The numbers of earthworks assets by Route is shown in Figure 7-12.

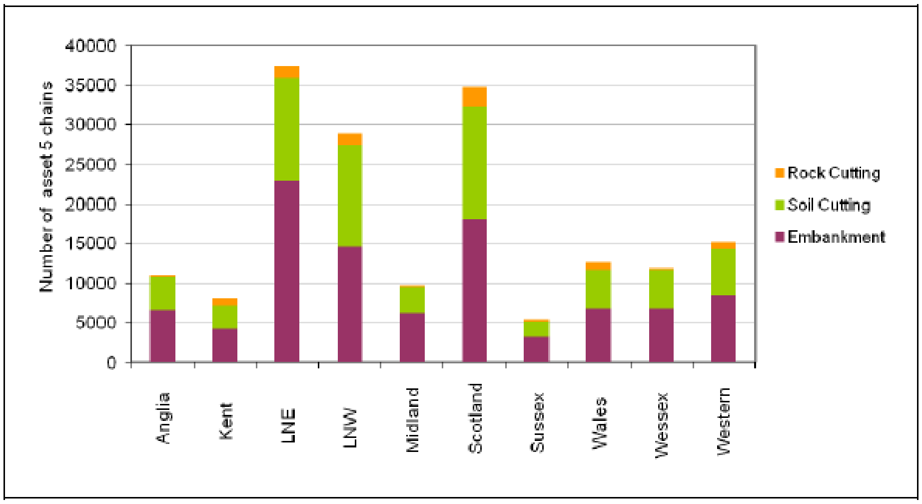


Figure 7-12: Distribution of Earthworks Assets by Route (as at 15/02/12)

7.3.5 The lengths of earthworks and condition scores reported in the Route Plans [Ref. SBPT 210-219] are broadly consistent with the national numbers quoted in the Asset Policy [Ref. SBPT3015a].

7.3.6 Condition is generally represented using a SSHI or a RSHI as defined in NR Standard NR/L3/CIV/065. NR/L3/CIV/065 defines three condition categories (Serviceable, Marginal, Poor). NR for their policy work, further sub-divided the 'poor' category into 'poor' and 'top poor' [Ref. NR 2012a] as set out below:

- Top Poor (SSHI > 14.5 or RSHI > 200)
- Poor (10 ≤ SSHI ≤ 14.5 or 100 ≤ RSHI ≤ 200)
- Marginal (6 < SSHI < 10 or 10 < RSHI < 100)
- Serviceable (SSHI ≤ 6 or RSHI ≤ 10)

	Asset Five Chain Lengths				
	Serviceable	Marginal	Poor	Top Poor	Total
Embankment	54959 (56.2%)	36800 (37.6%)	5295 (5.4%)	761 (0.8%)	97815 (100%)
Soil Cutting	39222 (57.6%)	25981 (38.2%)	2033 (3.0%)	849 (1.2%)	68085 (100%)
Rock Cutting	4388 (47.6%)	3788 (41.1%)	762 (8.3%)	285 (3.1%)	9223 (100%)
Total	98569	66569	8090	1895	175123

Figure 7-13: Earthworks Condition Data (as at 15/02/12)

7.3.7 The Policy suggests that the majority of NR earthworks five chain lengths have had at least one examination and so there is a reasonably low uncertainty associated with earthworks condition data. However, we note that there is some variability in asset data between Routes and that the last examination, in some instances, may be up to

10 years ago.

7.3.8 The distribution of earthworks assets by asset condition and Route is shown in Figure 7-14.

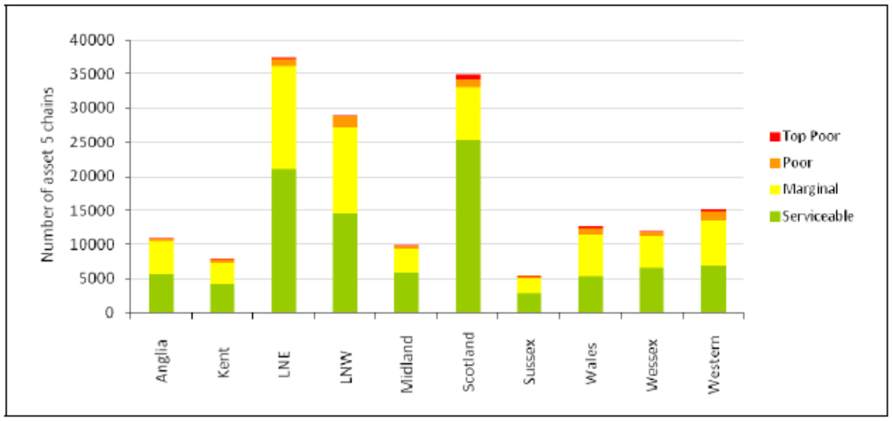


Figure 7-14: Distribution of Earthworks Assets by Condition and Route (as at 15/02/12)

Mining

7.3.9 The Mining Policy [Ref. SBPT 3015b] considers four key areas of mining hazard that present a potential risk to the railway:

- Current and proposed deep mining operations;
- Current and proposed surface mining operations;
- Current and proposed waste disposal and landfill sites; and
- Historic shallow mining hazards.

Current and Proposed Deep Mining Operations

7.3.10 NR identify four operational deep mines that may impact on the railway during CP5 and beyond. Details of the potential financial risk are tabulated in Figure 7-15.

Mine	Mineral	When	Cost estimate for CP5	Certainty
Mine A	Coal seam 1	Throughout CP5 and into CP6	£2.3m	Almost certain
	Coal seam 2	Throughout CP5 and into CP6	£8m	Possible
Mine B	Coal	During CP5	£1m	Likely
Mine C	Coal	Towards end of CP5 and into CP6	£10m	Possible
Mine D	Metal ore	Mid to end of CP5	£5m	Possible
NB: Mine names are not shown as this information is commercially sensitive.				

Figure 7-15 Quantification of Deep Mining Risks [Ref. SBPT3015b]

Current and Proposed Surface Mining Operations

7.3.11 Currently NR records include 694 surface quarries, sand and gravel pits and opencast sites adjacent to the railway, ranging from relatively distant, low risk sites to relatively close, higher risk sites. These are tabulated in Figure 7-16.

	Risk Category					
	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5	Total by route
Mitigation	Inspected twice annually	Annual inspection	< Annual inspection or monitored by alternative means	Not inspected, progress tracked	Not inspected, complete, remote, refused, withdrawn	
Route	**Number Of Sites**					
LNE	7	22	26	12	126	**193**
East Midlands	3	5	7	25	27	**67**
Scotland	2	10	23	18	22	**75**
Western	2	9	16	12	26	**65**
LNW	1	22	24	24	51	**122**
Anglia	0	8	7	4	23	**42**
Wales	0	5	17	12	23	**57**
Kent	1	7	12	6	4	**30**
Sussex	0	1	4	3	1	**9**
Wessex	0	1	14	6	13	**34**
Total by category	**16**	**90**	**150**	**122**	**316**	**694**

Figure 7-16: Surface Extraction Sites by Route and Risk Category [Ref. SBPT3015b]

Current and Proposed Waste Disposal and Landfill Sites

7.3.12 The Mining Engineers maintain a risk database of these sites. Currently there are 3,870 recorded landfill sites in the landfill database.

Historic Shallow Mining Hazards

7.3.13 NR have identified 5,049 potential historic shallow mining risk sites to date, of which 3,287 meet the criteria defined in the NR standard NR/SP/CIV/037 as Ancient Mineral Workings and are recorded in the Proactive Register. A listing is given in Figure 7-17.

	Proactive Register (features <30m deep & < 5m from track)				
Route	**Shafts**	**Adits**	**Mine Workings**	**Wells**	**Total**
Anglia	1	1	19	0	**21**
Kent	9	1	63	0	**73**
Western	80	3	137	0	**220**
Wales	41	61	128	11	**241**
Midland	72	7	77	1	**157**
LNE	242	40	456	12	**750**
LNW	326	34	468	21	**849**
Scotland	171	20	735	11	**937**
Sussex	5	1	17	0	**23**
Wessex	2	0	14	0	**16**
Total	**949**	**168**	**2114**	**56**	**3287**

Figure 7-17: Historic Mineworking Sites in Proactive Register (at July 2012) [Ref. SBPT3015b]

7.3.14 NR have made significant progress since IIP in defining the extent of mining hazards that they need to manage in CP5.

7.4 Asset Behaviour, Degradation and Criticality

7.4.1 As noted above, the NR 'risk based approach' uses 'earthwork condition' (SSHI or RSHI) and 'asset criticality' based on line speed, track layout, route importance and track quality (embankments) – see Figure 7-18 below.

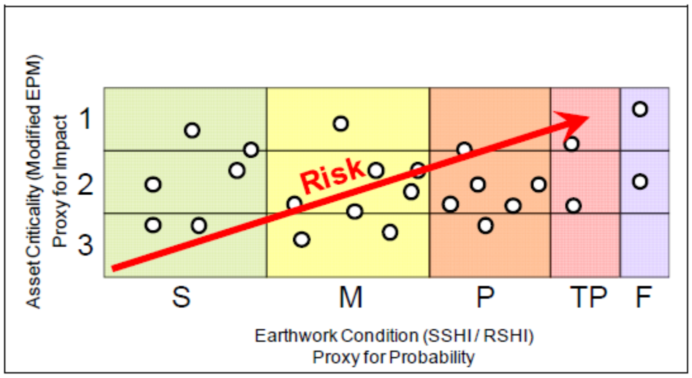


Figure 7-18: Earthworks Risk Space [Ref. SBPT3015a]

7.4.2 The NR 'risk based approach' assumes that the likelihood of the failure of a five chain length of earthwork can be linked to Earthwork Condition (SSHI or RSHI), and that the consequence of a failure can be grouped using Asset Criticality. This is not an unreasonable overall approach.

7.4.3 NR have reviewed in detail failure records for the period from 2003 to 2011and calculated the probability of earthworks failure by SSHI/RSHI Class in a five year period. The output is shown below in Figure 7-19.

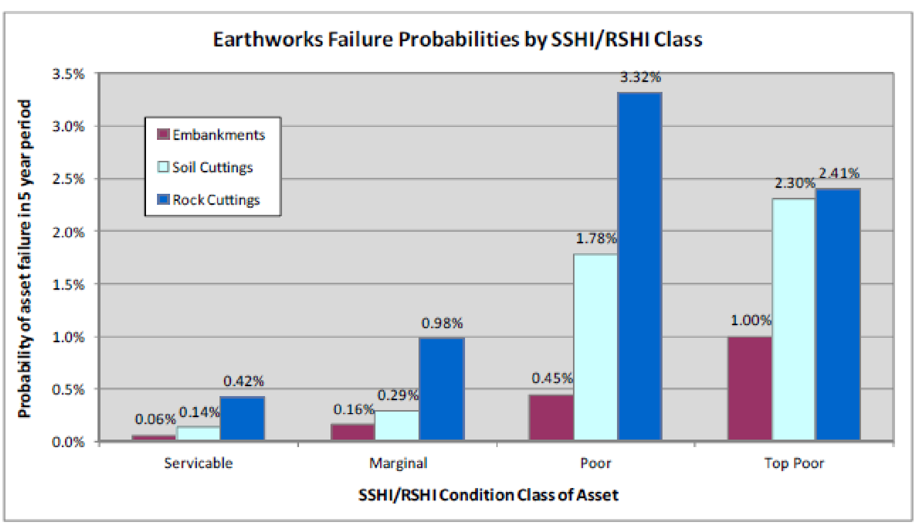


Figure 7-19: Earthwork Failure Probabilities in a Five Year Period [Ref. SBPT3015a]

7.4.4 The NR analysis has determined that 42% of primary and secondary failure triggers relate to rainfall events, and approximately 30% are related to blocked / poor drainage or water concentration features. Only 13% of failure triggers are related to age or weathering of earthworks.

7.4.5 NR have explicitly recognised the important linkage between earthworks failures and to improved drainage and included this in the Earthworks Policy. This is very positive.

7.4.6 NR analysis indicates that while SSHI/RSHI condition classification is not an unreasonable way of generally categorising earthworks and relating condition to failure, a notable proportion of failures are 'non condition related' i.e. they emanate from a range of condition classes unrelated to the condition of the earthwork.

7.4.7 The exact impact of these 'non condition' related failures on the risk based analysis is unclear but NR recognise that the susceptibility of an earthwork to failure due to an external factor is higher when the slope is in poorer condition, but the failure trigger is often adverse weather (heavy rainfall). We note that NR have work planned to review SSHI.

7.4.8 The Asset Policy notes that NR are continuing to develop their thinking regarding the assessment of Asset Criticality. In parallel we are aware that discussions are on-going with ORR about the potential shortcomings of using 'Asset Criticality' as a proxy for consequence (for example it does not consider sidelong ground or 'drop-off' potential), but the CP5 policy is a very significant step forward from the previous CP4 and IIP policies and provides one of the key inputs in deciding as to which specific five chain lengths to remediate.

7.4.9 In summary, NR have undertaken a comprehensive review and analysis of their historic asset data to determine deterioration relationships for earthworks. It is noted that there is still limited data available and that the rate of deterioration of earthworks is one of the most difficult variables to determine, however the NR analysis of available data has been comprehensive.

7.5 Renewal and Maintenance interventions

7.5.1 Historical information relating to expenditure on earthworks and volumes (m^2) of earthworks remediated are shown below. These are shown as ramping up since 2003/04 to an approximately steady level of £90m per annum / 420,000 m^2 per annum since 2006/07. No historic data on the expenditure split between embankments, soil cuttings and rock cuttings has been provided in the SBP submission.

7.5.2 In CP5 NR are proposing to undertake work to approximately 3,550 no. five chain lengths per annum at a cost of about £117m per annum[20].

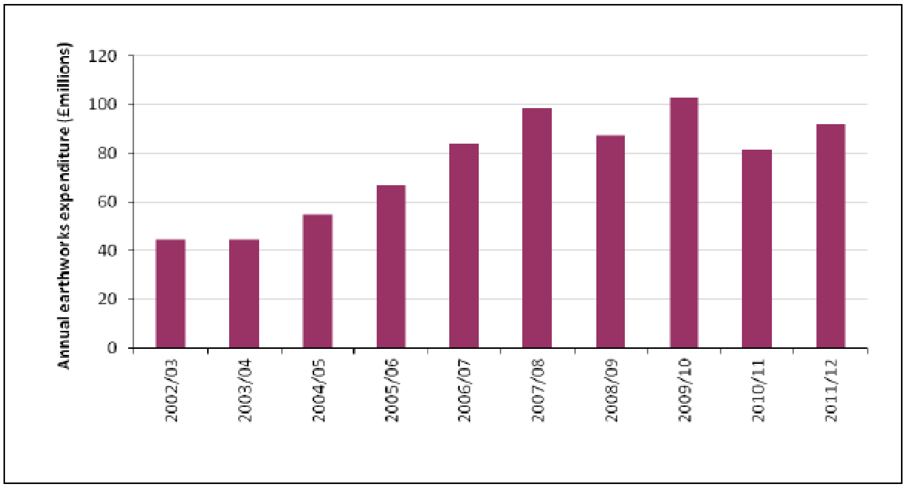


Figure 7-20: Annual Earthworks Expenditure (2002-2012)

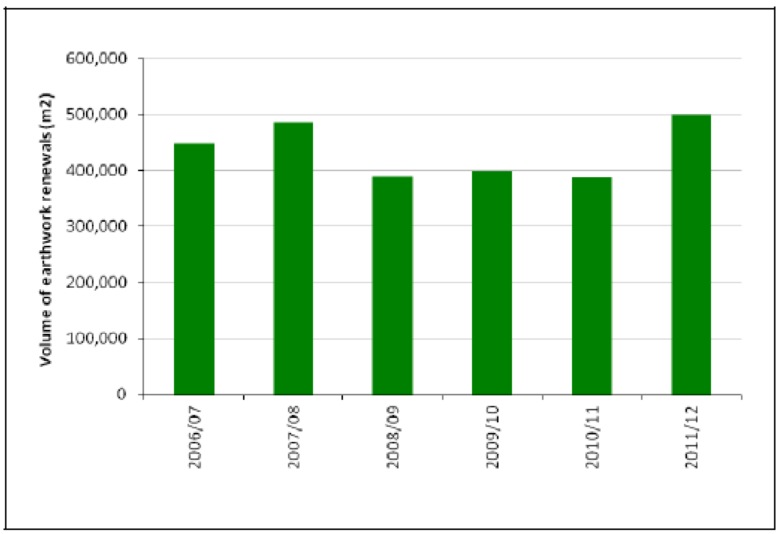


Figure 7-21: Annual Earthworks Renewal Volumes (2006-2012)

7.5.3 The change from measuring activity volumes in m^2 to five chain lengths, and the different types of intervention activity proposed between CP4 and CP5 means that it is hard to compare between CP4 and the proposed CP5 volumes. However, NR's estimate is:

- Renewals: CP4 ~ 2,400 5 chain lengths c.f. CP5 ~ 1,510 5 chain lengths
- Refurbishment: CP4 ~ £38.3M (minor works) c.f. CP5 ~ £216.5M
- Maintenance: CP4 - no data c.f. CP5 10,084 5 chain lengths

[20] Post efficient figures from Tier 0 ICM Database / SBPT 3338

7.5.4 NR are proposing four 'types' of earthworks interventions in their asset policy namely:

- Examine: Periodic detailed examination to assess condition;
- Maintain: Maintaining condition by cleaning and minor repairs;
- Refurbish: Improving condition by local replacement, re-profiling etc.; and
- Renew: Renewing condition by more major works.

7.5.5 We understand 'refurbish' interventions to be minor improvement works taking a couple of days, probably using a simple or generic design, whereas 'renewal' would be more 'traditional' earthworks projects such as soil nailing, regrading or retaining structures. These intervention 'types' seem logical.

7.5.6 The Earthworks Asset Policy suggests that there are benefits to be derived from undertaking 'lighter' interventions (such as maintenance and refurbishment) at more sites as opposed to the historic approach of 'heavier' renewals at fewer sites. This is potentially a key change compared to CP4 and previous Control Periods where there was emphasis on 'renewal' activities.

7.5.7 Based on discussions with their earthworks expert panel NR have assumed that the effect of four 'types' of earthworks interventions is as follows:

- Renew: resets the asset condition to serviceable;
- Refurbish: improves the asset condition by one condition category;
- Maintain: keeps the asset in its current condition by balancing degradation; and
- Do nothing (i.e. examination only): the asset continues to degrade.

7.5.8 These are shown diagrammatically in Figure 7-22 below.

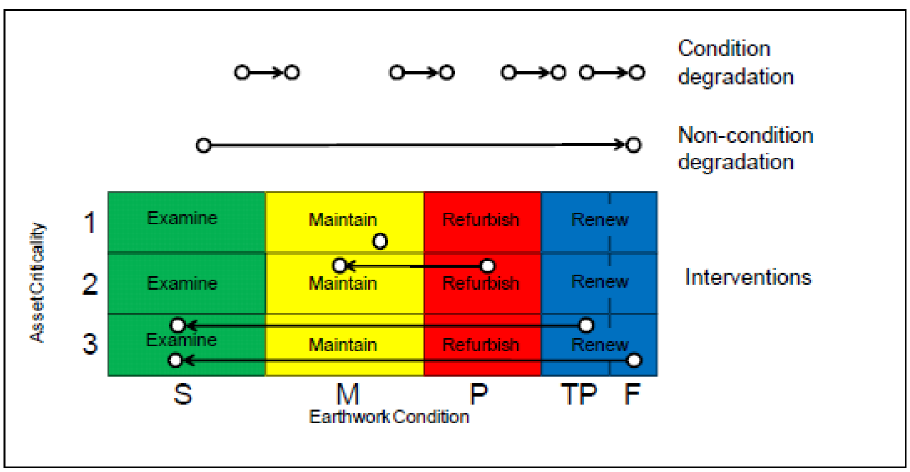


Figure 7-22: Balancing Interventions against Degradation [Ref. SBPT3015a]

7.5.9 At the time of writing, we are unclear how NR have determined the 'design life' or the period for which maintenance and refurbish activities 'last for' before another application is required. This is important as it is a key input when comparing these different intervention options with traditional 'heavier' renewals that have a design life between 60-120 years

7.5.10 NR present the preferred applications of interventions in the form of intervention matrices for embankments, soil cuttings and rock cuttings. These matrices use the 'risk matrix' axes of earthwork condition (proxy for likelihood of failure) and asset criticality (proxy for consequence). The matrices are shown in Figures 7-23a, b and c below.

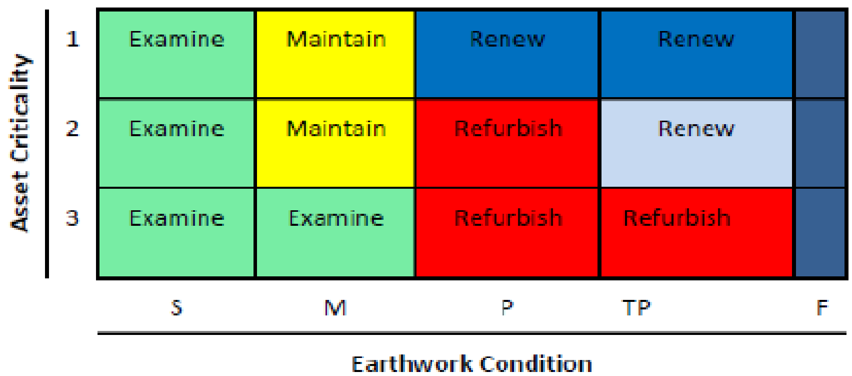


Figure 7-23a: Intervention Matrix – Embankments

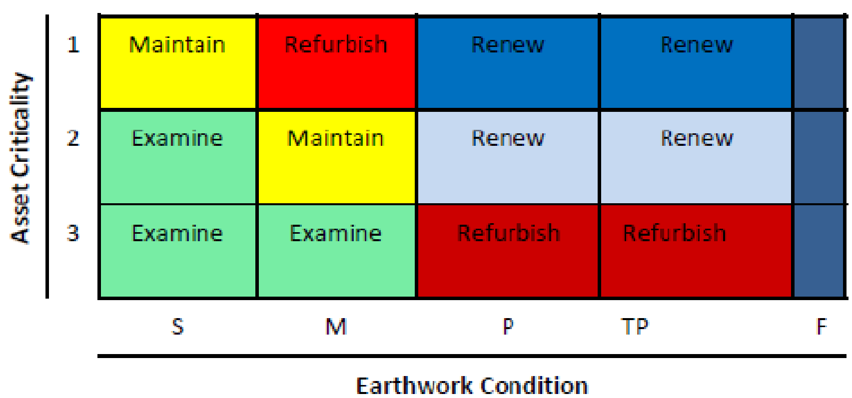


Figure 7-23b: Intervention Matrix – Soil Cuttings

Asset Criticality	S	M	P	TP	F
1	Examine	Maintain	Renew	Renew	
2	Examine	Maintain	Renew	Renew	
3	Examine	Examine	Refurbish	Renew	

Earthwork Condition

Figure 7-23c: Intervention Matrix – Rock Cuttings

7.5.11 Discussions with NR indicate that the intervention matrices qualitatively reflect a perceived safety priority between rock cuttings (most important) and embankments (least important). This ranking seems broadly appropriate. However, we have not seen evidence that the relative priorities between soil cuttings, embankments and rock cuttings have been quantitatively reviewed. This leads to some uncertainty as to whether the balance of volumes of work for each asset type is truly optimal. We also note that sidelong ground figures in a substantial number of the derailments (see 7.1.7 above) and although it is included in the existing policy matrices, as it seems to be an important asset type, it may be appropriate for NR to separate out and to develop an explicit policy matrix for sidelong ground to assist in future prioritisation of work.

7.5.12 The policy implicitly assumes that interventions should be primarily driven by ‘safety’ issues rather than say ‘track performance’. This is very positive.

7.5.13 As noted above, NR have a specific ‘Maintenance Strategy’ [SPBT 3169] and a development plan for optimising maintenance regimes [SBPT3004]. In relation to civils assets the NR maintenance documents only relate to inspections and examinations (as these are treated as included within the maintenance funding provided in the control period pricing reviews). Other aspects of ‘maintenance’ such as planned preventative maintenance work are treated as ‘renewals’ by NR.

7.5.14 NR have assessed civils (including earthworks) to be currently at ‘*Stage 2 – National regimes based on RCM techniques’* on the five stage ‘Maintenance Regime’ development scale [SBPT 3004]. Stage 2 is described as ‘*civils assets are examined at frequencies determined from risk parameters*’.

7.5.15 NR are planning to reach Stage 3 by the end of CP4 and Stage 4 by the end of CP5. It is unclear what development is planned in this area in CP4/ CP5.

7.5.16 For the Earthworks asset it is highly uncertain what the impact of the proposed maintenance optimisation during CP5 will entail and its potential impact on the effectiveness of the Earthworks examinations.

Mining

7.5.17 NR have adopted a risk based approach to the management of the risk of potential collapse of historic shallow mineworkings [Ref. SBPT3015b] – see Figure 7-24.

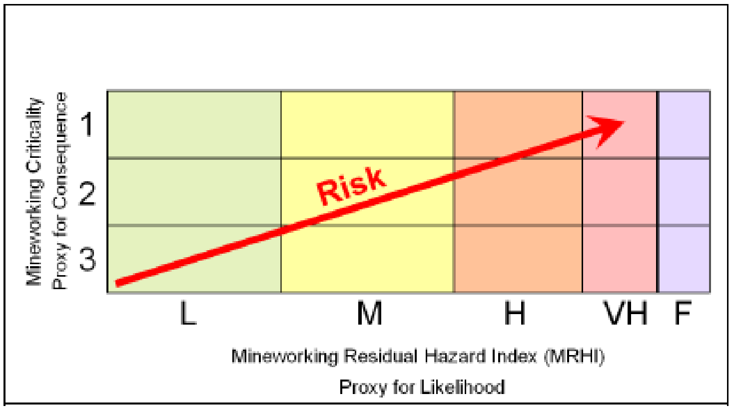


Figure 7-24: Mining Risk Matrix [Ref. SBPT3015b]

7.5.18 NR have used the Mineworkings Residual Hazard Index (MRHI) as a proxy for the likelihood that a collapse will occur, and a Mineworkings Criticality calculated based on location of feature in relation to railway, line speed and railway constraints (such as earthwork or tunnel).

7.5.19 A stage gate risk assessment process is then followed namely:

- Identification;
- Desk Study;
- Ground Investigation; and
- Treatment.

7.5.20 A breakdown of the current status of the 3,287 sites is given below.

Risk assessment process stage	Number of sites in Stagegate	Results to date of Stagegate
No. sites in Proactive Register	3287	
STAGEGATE 1 - Identification		
No. received Mining Engineer's review	1017	
No. closed out (No Further Action)		491
No. recommended for desk study		526
STAGEGATE 2 - Desk study		
No. consultant desk study reports received	199	
No. sites closed out by desk study - (No Further Action)		6
No. recommended to go to ground investigation		193
STAGEGATE 3 - Ground investigation		
No. sites completed ground investigation	96	
No. site closed out by ground investigation - (No Further Action)		28
No. site requiring further ground investigation		32
No. sites recommended for treatment		36
STAGEGATE 4 - Treatment		
No. sites treated	23	
No. sites treated & closed out (No Further Action)		21
No. sites requiring further treatment		2
SUMMARY		
No. sites closed out to date - (No Further Action)	546	16.6%
No. sites requiring Mining Engineer's review and/or desk study	2597	79.1%

Figure 7-25: Mining Risk Matrix [Ref. SBPT3015b]

7.6 Asset Cost Data

7.6.1 Since the IIP submission, NR have undertaken much more detailed analysis of earthworks and derived updated unit costs for the SBP submission. This work is summarised in the Control Period 5 Earthworks Unit Rates Submission [Ref. SBPT3076].

7.6.2 The analysis considers various historic datasets including CAF, Monitor and Ellipse. It also considers a Quantity Surveying approach, available regional data, and current framework cost data. A comparison with the cost data used in IIP is also presented.

7.6.3 Two key areas of uncertainty are highlighted, namely uncertainties from the reliability and accuracy of the historic data sets and their treatment, and the applicability of the data analysis to future NR costs. Recommendations for further improvement are also presented.

7.6.4 The methodology in pricebook regarding process and scope included with the rates appears logical and consistent. In meetings with NR they have demonstrated how these rates were derived from the historical data. However, at the time of writing the database has not yet been provided to enable a desktop study / check.

7.6.5 For their strategic modelling, NR have adopted a '5 chain length' as the 'unit' for cost measurement compared with 'm^2' used at the IIP stage and in the cost workbooks. There are pro and cons of each measure, but on balance we consider that the selection of five chain lengths is logical for strategic planning as it provides a consistent linkage to the 'asset unit' of five chains in the inventory. It may be appropriate to adopt m^2 units for the more detailed costing as schemes are developed.

7.6.6 The final earthworks unit costs used in the SBP are summarised in Figure 7-26 below. These rates are 'all inclusive' average unit rates for a five chain unit length and are 'national rates'. Based on our sampling they seem to have been uniformly adopted for all Routes.

7.6.7 It is noted that there is much less historic cost data available for 'maintenance' and 'refurbishment' interventions than the 'renew' interventions. This is primarily because 'maintain' and 'refurbish' are 'new' activities not previously regularly used by NR on their earthworks. Accordingly there is more uncertainty associated with the unit cost of these activities.

Table 11.2: Final average national unit rates per 5ch of earthwork remediated

Asset Type	Intervention Level			Additional Item
	Maintain	Refurbish	Renew	Vegetation Clearance[2]
Soil Cutting	£3,163[1]	£33,510	£222,405	£7,000
Embankment	£4,414[1]	£33,521	£209,917	£10,000
Rock Cutting	£5,039[1]	£63,075	£111,090	£11,500
Drainage	Ref drainage unit cost report			-

Notes: [1] These numbers were derived in a different manner to the other numbers in the table. A detailed description of the method is given in the interim note supplied as part of Appendix G to this report.

[2] This is an additional maintenance type item which shows higher costs than the other maintenance costs. A detailed description of its derivation is provided in the interim note supplied as part of Appendix G to this report.

Figure 7-26: Earthworks Unit Costs Adopted in SBP [Ref. SBPT3076]

7.6.8 It is noted that the earthworks unit costs set out above appear to have been used in the NR Earthworks SCAnNeR tool.

7.6.9 Unit rates within the Earthworks Unit Rates Submission have been used to derive 87% of the SBP values. It is unclear how the remaining 13% of the SBP value has been derived or what rates have been used so there is some uncertainty.

Mining

7.6.10 The Mining Policy [SBPT 3015b] notes that the cost of ground investigations and the treatment of mineworking risk sites tends to be very site specific, with costs varying significantly depending on factors such as:

- *"Anticipated extent and geometry of mine workings, and distance from the track and/or affected structures*
- *Access and safety constraints (e.g. topography, working in tunnels, presence of groundwater, availability of possessions, track layout/alternate route for potential diversions)*
- *Degree of uncertainty and likelihood of success*
- *Similarities with sites previously addressed by Network Rail"*

7.6.11 It is noted that for CP5 a workbank of ground investigation and treatment sites has been developed based on individual site estimates, rather than by applying a generic unit rate to an assessed volume. NR refer to a review of recent costs in the NR report "CP5 mining unit costs". At the time of writing, this document has not been provided or reviewed by us.

7.6.12 As noted above (Figure 7-15) NR have identified four operational deep mines that may impact on the railway during CP5 and beyond. The Mining Policy indicates a total financial risk in CP5 of £26.3m. This risk has not been costed into the SBP.

7.6.13 It is understood that the following activities are proposed for CP5, namely:

- Shallow mineworkings desk studies 2,600 no.
- Shallow mineworkings ground investigations 75 no.
- Shallow mineworkings treatment 19 no.

7.6.14 It is unclear how these shallow mineworkings activities have been costed or how they have been explicitly included in the SBP Data Book.

Drainage

7.6.15 Unit costs and the cost of drainage interventions are discussed in detail in Section 9.

7.7 Policy Selection and Preferred Lifecycle Options

Whole Life Cycle Cost Modelling - Overview

7.7.1 At IIP stage NR had developed an initial Tier 2 WLCC model for earthworks based on the generic civils Tier 2 WLCC model. At the time of our review in Spring 2012 [Ref. Arup 2012a] NR were about to embark on a further stage of development and the model had not yet been configured to support the evaluation and selection of lowest whole life maintenance and renewal strategies using the more explicit 'risk based' approach. At IIP the WLCC modelling had not been used to inform policy selection.

7.7.2 Since IIP stage NR have changed their approach and developed a 'Tier1/2' earthworks model – called 'Earthworks SCAnNeR' (Strategic Cost Analysis for Network Rail). This described as a "*portfolio level model used to simulate various* *policy options and carry out whole life cost optimisation"*. SCAnNeR considers earthworks CAPEX costs only.

7.7.3 The Asset Policy [Ref. SBPT3015a] notes that the civils Tier 2 WLCC model for earthworks being developed at IIP stage will be developed further into a Tier 2/ 3 DST to assist the routes post SBP to refine their constrained workbanks. That tool has not been used at SBP stage.

7.7.4 The Asset Policy also describes an Earthworks CeCost (Civil Engineering Cost) tool which is a 'portfolio level model that is more detailed than SCAnNeR'.

7.7.5 The relationship between these decision support tools is shown diagrammatically in Figure 7-27.

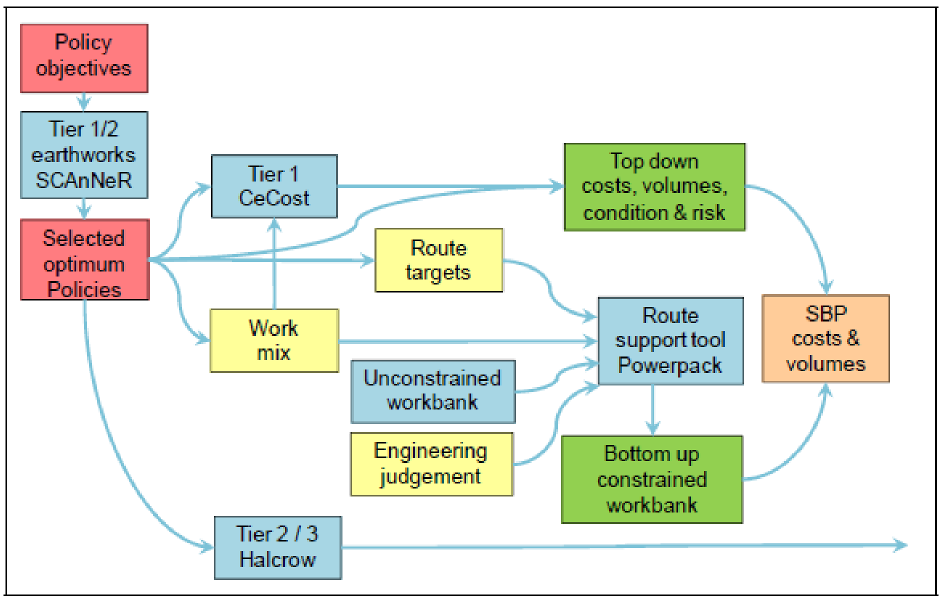


Figure 7-27: Earthworks Decision Support Tools [Ref. SBPT3015a]

7.7.6 It is understood that the final SBP was derived from Earthworks SCAnNeR, and that Earthworks CeCost was not used. This decision seems to have been made late in the SBP development process (November / December 2012). It is unclear what impact the decision has had on the reliability of the SBP figures for earthworks, but introduces some uncertainty as to the suitability of the outputs from Earthworks SCAnNeR.

Whole Life Cycle Cost Modelling - Earthworks SCAnNeR

7.7.7 In NR have used a 'Tier 1/ 2' earthworks model – 'Earthworks SCAnNeR' (Strategic Cost Analysis for Network Rail) to investigate the relationship between performance, cost and risk for earthworks. This 'trade-off' is shown in Figure 7-28 below and discussed in further detail in following sections and our accompanying report on the Tier 1 models (Arup 2013a).

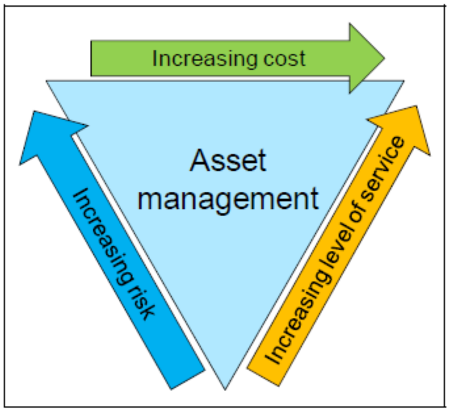


Figure 7-28: Key Trade-Offs [Ref. SBPT3015a]

7.7.8 Earthworks SCAnNeR is reviewed in detail in our accompanying 'Tier 1 Models' Report (Arup 2013a), however a brief description of its approach is given here.

"The earthworks SCAnNeR is a whole life cost decision support tool (DST) that models a portfolio of earthwork assets.

Earthworks SCAnNeR analyses many different options each time it is run, and outputs a set of graphical results from which the user can manually select an optimum option to achieve a specific set of outcomes, including optimising for a lowest whole life cost solution. It therefore has the capabilities of both a Tier 1 and a Tier 2 model.

Earthworks SCAnNeR models the balance between degradation of the earthworks asset and a mix of interventions carried out on the assets, see Figure 7.25

Degradation is described by a Markov chain state change matrix

Earthworks SCAnNeR is a trigger based DST, in that an intervention is triggered as the assets degrade and pass a condition threshold, at which point the condition of the asset is reset, the amount of the reset depending on the intervention carried out."

7.7.9 Earthworks SCAnNeR is described in more detail in following sections, but in simple terms NR have used the tool in two main ways:

- To develop their intervention strategies (see Section 7.5 above) – i.e. the 'mix' of interventions ('maintain', refurbish', 'renew') that is most appropriate for the different asset types (Soil Cuttings, Embankments and Rock Cuttings).
- To then apply these intervention strategies to their existing asset base to investigate 'trade-offs' and determine cost and volumes for different 'policy objectives'. The Policy Objectives are discussed below and their application is discussed in our Tier 1 Modelling Report [Ref. Arup 2013a].

7.7.10 SCAnNeR is different to the majority of the other NR Tier 1 models in that it is a strategy evaluation tool. The tool and model within has been used to determine the optimum policy by varying intervention strategy combinations considering the output of the asset population as a whole. The costs and volumes for the SBP are then determined for the preferred intervention strategy. As such the model fulfils the requirements of the Tier 1 models to develop volumes and costs, and some aspects of the WLCC asset model (Tier 2).

Policy Objectives

7.7.11 NR have interpreted the HLOS objectives into 'Policy Objectives' in the following way:

"10.1 Earthworks Policy objectives

The key objectives of the earthworks asset management Policy are to:

- *Maintain the overall condition profile of the national earthworks portfolio in CP5 and beyond at the CP5 entry level*
- *Prioritise sites with highest safety risk*
- *Adopt a proactive approach to intervene prior to reduction in level of service*
- *Adopt a lowest whole life cost approach*
- *Maximise the number of assets improved in condition for a given level of funding by increasing maintenance and refurbishment activities and reducing renewals"*

7.7.12 NR have considered three main output scenarios or options, each being different combinations of condition, risk and phasing over CP5-CP11 and used Earthworks SCAnNeR to investigate 'trade-offs' between 'level of service' (condition, risk) and cost in both the short and long terms.

7.7.13 This has led to three options being suggested by NR, namely:

- Option 1 - a condition based policy that sustains both condition and risk in CP5 and the longer term.
- Option 2 - a phased policy that reduces risk and maintains condition in CP5, then sustains risk and condition in CP6-CP11.
- Option 3 - a financially constrained option set at 70% of the calculated Option 2 'budget' and accepts a reduction in condition and an increase in risk.

7.7.14 NR have identified Option 2 as preferred. This is discussed further in our Tier 1 models report (Arup 2013a). As noted above this is a 'phased policy' using one interventions mix in CP5 and a different mix in CP6 onwards.

7.7.15 This mix seems to have been selected to be the lowest WLCC based on the following constraints:

- Sustain condition in CP5 and long term; and
- Improve risk in CP5 and then sustain long term.

7.7.16 It is noted that NR did not find an intervention mix that reduced risk in CP6-CP11 as well as during CP5, and that they are proposing to undertake additional work post SBP to try and identify an option that provides a risk based solution for CP6 and beyond.

7.7.17 In terms of overall approach, we consider the method adopted by NR for policy selection to be logical and well executed, with the Earthworks SCAnNeR tool being extensively used by NR to explore the output vs. cost trade-offs.

7.7.18 NR's analysis indicates that the lowest WLCC combination of interventions will be achieved by significantly increasing the volume of pro-active 'maintenance' and 'lighter' 'refurbishment' interventions at the expense of more 'traditional' 'heavier' 'renew' interventions. This is a significant change of approach from the current and historic earthworks policies.

7.7.19 We would fully support the principle of undertaking more pro-active 'maintenance' and 'lighter' 'refurbishment' interventions to reduce risk in the short-term as suggested by the Asset Policy.

7.7.20 At the time of writing, we are unclear how NR have determined the 'design life' or the period for which maintenance and refurbish activities 'last for' before another application is required. We are also unclear exactly how the behaviour of an earthwork has been assumed to change following an intervention. The relative 'improvement' for a given cost will be a key driver in the selection of appropriate interventions on a WLCC basis.

7.7.21 We are unclear how long-term 'asset value' has been considered and whether this will be maintained – i.e. is how asset remaining life has been considered in NR's WLCC evaluation.

7.7.22 We have some concerns relating to the specific application of policy principles in CP5 and long-term sustainability of a policy focusing on 'maintenance' and 'lighter' 'refurbishment'.

7.7.23 We note that one key implication of applying a constraint of improving condition in CP5 whilst maintaining overall 'average' condition leads to Routes with 'poor' start condition earthworks improving and Routes with 'better' start condition earthworks being allowed to deteriorate.

7.7.24 Whilst this does not seem unreasonable for a Route like Western – which has historically had a higher number of failures than other Routes (Figure 7-29), we are concerned that the policy selection seems to suggest that the condition of earthworks in Scotland (which have the second highest number of failures) will overall deteriorate in CP5 – CP11. This 'convergence' of condition is shown in Figure 7-30.

"The Graph below indicates a high number of failures in the Route when compared to other Routes. We also have the highest earthwork failure incident rate at 0.14/mile compared to the company average of 0.03/mile...." [Ref. SBPT219 – Western Route Plan]

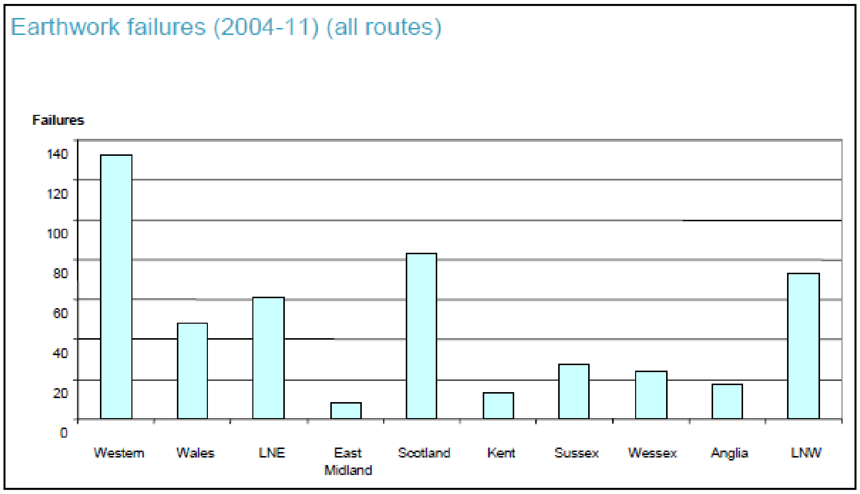


Figure 7-29: Earthworks Failures (2004-2011) [Ref. SBPT219 – Western Route Plan]

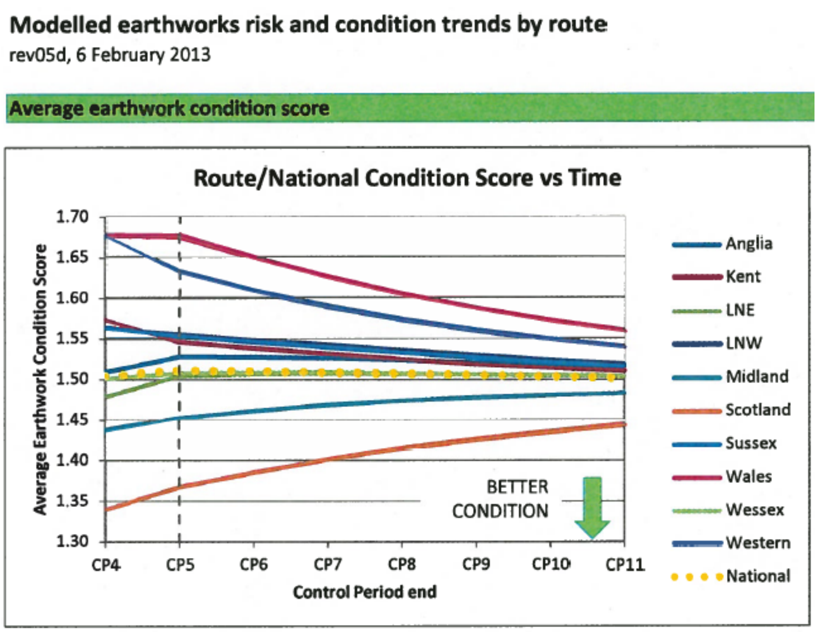


Figure 7-30: Modelled Earthworks Condition Score Trends by Route [Ref. NR 2013a]

7.7.25 We have similar concerns related to the constraint of reducing risk at a Route Level but maintaining overall 'average' risk, in that this seems to suggest that the earthworks risk at some Routes (such as Scotland) will increase – see Figure 7-31.

7.7.26 In addition we are unclear as to whether the proposed policy / intervention mix would comply with Statutory Obligations under ALARP principles[21].

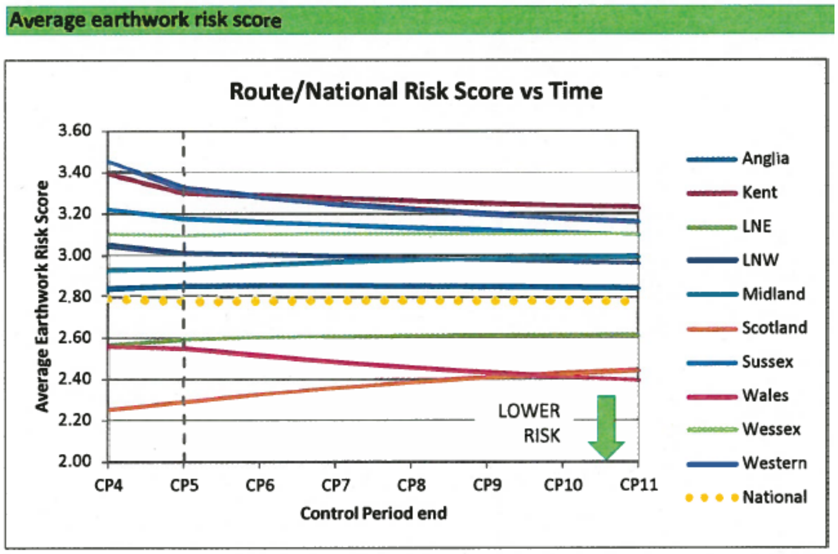


Figure 7-31: Modelled Risk Score Trends by Route [Ref. NR 2013a]

7.7.27 The apparent 'mismatch' between observed failures and 'calculated risk' makes it uncertain as to the potential acceptability and effectiveness of the selected asset intervention mixes. Further work is required to enable us to comment further.

Mining

7.7.28 NR have not supplied any explicit strategic lifecycle costing analyses for mining interventions. This is probably not unreasonable given that each mining site will be highly individual. It would be expected that on a site by site basis various treatment options would be considered in terms of whole life cycle costing.

7.7.29 The NR mining policy stage gate process does not seem an unreasonable way of managing the risk of potential collapse of historic shallow mineworkings.

7.8 Overall Planning Process

7.8.1 The Asset Policy indicates that there has been extensive dialogue between the Central NR Head of Asset Management (HAM) team and the Route Asset Managers, with an 'expert panel' being used to inform aspects such as effect of interventions and deliverability of the policy. This is very positive.

7.8.2 NR have explicitly disaggregated their national Earthworks SCAnNeR outputs to a Route level and provided a 'Tier 3 Powerpack' tool to each Route to help them develop their CP5 constrained workbanks and achieve alignment with policy.

[21] NR have a duty under the Health & Safety at Work etc. Act (1974) to manage safety risks to a level as low as reasonably practicable (ALARP). Our interpretation of this is that safety improvements should be implemented unless the costs are grossly disproportionate to the safety benefits.

7.8.3 Our Route meetings indicate that all the sample Routes have had training and advice from the HAM team in the development of their CP5 workbanks and are all using the ‘Tier 3 Powerpack’ tool.

7.8.4 Our Route meetings indicate that there is some difference of opinion as to whether the ‘top down’ intervention activity volumes based on Earthworks SCAnNeR outputs are explicit targets to be met by the Route, or whether they are estimated volumes for strategic planning purposes.

7.8.5 A number of Routes questioned the deliverability and cost effectiveness of the Policy if single / specific 5 chain lengths are to be targeted, and noted that if so, some local derogation will be required. This uncertainty is discussed further in our Summary Report.

7.9 Systems Approach

7.9.1 As noted above it is very positive that, earthworks and drainage are being considered as a system and that the division of responsibilities has been explicitly set out in the Earthworks and Drainage Policies.

7.9.2 The Earthworks Asset Policy focuses on safety risk and interventions. As noted at IIP Stage, a key requirement of earthworks asset performance relates to support of track (e.g. stiffness of subgrade layer) and support of trackside equipment / OHLE. This is an area still for further development.

7.9.3 There are significant interfaces between earthworks, retaining walls and coastal / flood defences. The management of these interfaces is recognised in the Asset Policy but is still an area still for further development.

7.9.4 From our review it is unclear how NR have equated safety risk between the ‘principal’ asset types such as Buildings vs. Earthworks vs. Structures. This gives rise to a significant uncertainty that Asset Outputs cannot be equated between asset types and that it may be being proposed that assets are funded to achieve different levels of risk.

7.10 Risk

7.10.1 As noted above, NR have adopted an explicit risk based approach in both their earthworks and their mining policies. This is very positive.

7.11 Deliverability

7.11.1 As noted above, the Earthworks Policy is proposing a significant change in the type of work undertaken to the earthworks asset in CP5 onwards. It is proposed that the volume of pro-active 'maintenance' and 'lighter' 'refurbishment' interventions would be significantly increased and the volume of more 'traditional' 'heavier' 'renew' interventions would be reduced. This is a significant change of approach from the current and historic earthworks policies.

7.11.2 A significant part of discussion with the three Routes that we visited was related to the practical implementation of the new Policy.

7.11.3 Key points were:

- The change to 'lighter' interventions will require different contracting strategies such as using more 'in-house' minor maintenance resource. Two of the Routes were specifically addressing this.
- The effective application of the new policy will require more detailed knowledge of 'which sites to address'. This will require additional data / local information to supplement the existing examinations data.
- The Policy is significantly different to the current approach and some Routes were unsure that their earthworks could be adequately remediated using a 'lighter' 'refurbishment' interventions – and so they would be seeking derogation from policy.
- The cost of 'preliminaries' such as haul roads, access agreements, might make it more cost effective to still undertake traditional' 'heavier' 'renew' interventions at many sites.
- The policy assumes that the 'most appropriate' intervention would be applied to each single five chain length. In reality it is likely that adjacent five chain lengths will be 'grouped' into works 'schemes'. This may mean that a number of 'non policy compliant' five chain lengths will be 'remediated' at the same time as the adjacent 'policy compliant' five chain lengths. There is thus a risk that the economies derived from 'doing focussed activity' get lost.

7.11.4 Whilst we are supportive of the principle of targeting more 'smaller' intervention activities to reduce safety risk and the focus on drainage works, the fact that many failures may be driven by 'non condition related' aspects makes us uncertain that NR have the required data / information to effectively implement the CP5 policy. Accordingly, a key area of uncertainty relates to the degree to which the Routes will be able to effectively target 'the right slopes' for the proposed maintenance and refurbishment activities. This will impact on both the performance improvement that can be achieved and the cost of achieving that improvement.

7.12 Continuous Improvement

7.12.1 It is noted that the majority of the recommendations made in our previous review of the IIP Asset Policy have been taken into account by NR in the SBP Asset Policy for Earthworks.

7.12.2 The Policy explicitly identifies a number of improvements planned in the future. These include:

- Further development of the decision support tool (Tier 1);
- Integration of the UCWB and Powerpack capability into the CSAMS asset management system;
- Development of the Tier 3 tactical DST to assist the routes in refining their workbank plans; and
- Integration of the safety, performance and mining risk models.

This is very positive.

7.12.3 No explicit mention is made of reviewing the performance improvement (e.g. failures) achieved by implementing the new Policy and reviewing whether it is delivering the benefits sought.

7.13 Robustness, Sustainability and Cost

7.13.1 As Independent Reporter we have been asked to consider the degree to which NR have demonstrated that the asset policies are robust, sustainable[22] and the degree to which the asset policy been demonstrated to deliver the required outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.[23]

Robustness

7.13.2 NR have made significant progress with the development of their Earthworks Asset Policy since IIP in September 2011.

7.13.3 The CP5 Policy is has a clear linkage to asset outputs (e.g. Risk Index), is based on reasonable inventory and condition information and has an explicit risk based intervention approach. Accordingly we consider it reasonably likely that the Asset Policy will be robust and will be capable of delivering a reduction in asset risk in the short-term.

7.13.4 Application of the Asset Policy is covered in our separate reports [Ref. Arup 2013, Arup 2013a].

[22] ORR letter dated 1st June 2010 (document ref. 379948)
[23] ORR-#430597-v1-20111028_ORR_PR13_Policy_review_note and Mandate AO/030.

Sustainability

7.13.5 NR have adopted a sophisticated modelling approach to derive their short-term and long-term intervention policy for earthworks. However, in terms of long-term sustainability, we have concerns in relation to principle of reducing the volume of 'heavy' renewals. This primarily stems from the 'equivalence' of 'lighter' refurbishment and 'heavier' renewals.

7.13.6 Whilst we are supportive of the principle of targeting more 'lighter' pro-active intervention activities (such as drainage) to reduce safety risk, we consider that this needs to be in conjunction with a continued programme of 'renewal' activities. This is discussed further in our accompanying report on the Tier 1 modelling [AO/030/3C].

7.13.7 Due a number of issues with the Earthworks Risk Index 'baseline' of 100 and the end CP5 target of '99.6' there is some uncertainty around earthworks sustainability being measured using the figures proposed in SBPT232.

7.13.8 Whilst recognising that NR's detailed analysis would indicate that the proposed combination represents best whole life value, we have a number of concerns and therefore consider that there is some uncertainty as to whether the policy will be sustainable in the long-term.

Whole System Cost

7.13.9 It is very positive that the Earthworks Asset Policy considers earthworks and drainage as a whole system. Investment in drainage works will undoubtedly contribute to improving the earthworks condition and reducing failures.

7.13.10 Currently, there is much less historic cost data available for 'maintenance' and 'refurbishment' interventions than the 'renew' interventions. This is primarily because 'maintain' and 'refurbish' are 'new' activities not previously regularly used by NR on their earthworks. Accordingly there is significant uncertainty associated with the unit cost of these activities.

7.13.11 Our concerns about the long-term effectiveness of the proposed 'lighter' pro-active intervention activities at maintaining asset condition, together with the uncertainty of the cost of these 'lighter' interventions means that we consider it uncertain whether the proposed policy will deliver the required outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.

Embedded Efficiency

7.13.12 As noted above, a detailed review of efficiencies has not been undertaken as part of this mandate.

7.13.13 For the civils asset no renewals 'embedded efficiency' has been assumed by NR. This reflects NR's view that although the civils policies have been revised:

"the elevated level of uncertainty related to this asset makes it impossible at this time for us to assess any level of embedded efficiency that may result from the new asset policies."' [Ref. SBPT220].

7.13.14 NR have not assumed any Civils maintenance efficiencies ('embedded' or otherwise) associated with CEFA or other maintenance expenditure.

Mining

7.13.15 The NR mining policy stage gate process does not seem an unreasonable way of managing the risk of potential collapse of historic shallow mineworkings. However, we do not consider that there is sufficient information to assess whether the Mining Policy is robust, sustainable or represents lowest possible whole system cost over the lifetime of the asset.

7.14 References

Ref	Document Title	Version / Date
Arup 2011a	Mandate A0/017: Initial Industry Plan (IIP) 2011 Review :- Summary Report – Observations and Conclusions	Issue 1 16 December 2011
Arup 2012a	Mandate A0/017: Initial Industry Plan (IIP) 2011 Review :- Review of Tier 2 Whole Life Cycle Cost Models	Issue 1 23 April 2012
Arup 2013	Mandate AO/030 Summary Report	Ref AO/030/1 Draft A
Arup 2013a	Mandate AO/030 Tier 1 Report	Ref AO/030/3 Draft A
Arup 2013b	Mandate AO/030 Policy and Tier 2 Report	Ref AO/030/2 Draft A
Arup 2013c	Mandate AO/030 Addendum Report	Ref AO/030/4 Draft A
Arup 2013d	Mandate AO.034 Costs	Draft A
Arup 2013e	Mandate AO/035 Efficiencies	Draft A
Arup 2013f	Mandate AO/026 CP4 Policy	
Arup 2013g	Mandate AO/028 Data Quality	
Arup 2013h	Mandate AO/029 CP4 Regulated Outputs	
NR 2013a	Modelled Earthworks Risk and Condition Trends by Route CP5-CP11	Rev 05d 6 Feb 2013
SBPT101	Strategic Business Plan England & Wales	January 2013
SBPT102	Strategic Business Plan Scotland	January 2013
SBPT3015a	CP5 Earthworks Asset Policy	Rev 08 Final 14 Dec 2012
SBPT3013	Structures Asset Policy	BCAM-TP-0165 7th Dec

		2012
SBPT3015b	CP5 Mining Policy	Rev 07 Final 14 Dec 2012
SBPT3017	CP5 Drainage Asset Policy	18 Dec 2012
SBPT3076	CP 5 Earthworks Unit Rates Submission	V2.1 13/12/12
SBPT 220	Efficiency Summary	Version 2.0
NR/L3/CIV/065	Network Rail Standard NR/L3/CIV/065	Issue 3 dated June 2012
NR 2012a	CP5 earthworks and drainage modelling, Degradation and failure rate inputs [219]	

8 Buildings Asset Policy

8.1 Performance Requirements / Outputs

Buildings Policy

8.1.1 The NR SBP submission includes a two volume CP5 Buildings Asset Policy [Ref. SBPT3016]:

- Volume 1 describes the Policy with regard to building fabric; and
- Volume 2 the mechanical and electrical asset Policy.

8.1.2 The Buildings Asset Policy covering the building fabric has been in development for some time and the version submitted with the SBP is the latest refinement of that process. Volume 2 is a far more recent document which has not benefitted from the lengthy developmental period and modelling work of Volume 1, and as a result takes a more simplistic approach to the management of the M&E assets.

8.1.3 Within the Policy the NR building portfolio is split into a five groupings based on the type of site. These types are:

- Franchised stations (2,525 locations) – passenger stations which are operated by a Train Operating Company (TOC) under a lease agreement and governed by Station Access Conditions;
- Managed stations (17 locations) – passenger stations which are directly managed by NR;
- Light maintenance depots (LMD) (71 locations) – depot facilities which are leased to a TOC for the purposes of maintaining or servicing rolling stock;
- Maintenance delivery unit (MDU) (489 locations) – buildings used by the NR in-house maintenance teams;
- National delivery service depots (NDS) (32 locations) – locations which are used by NR for the strategic storage of materials; and
- Lineside buildings (approximately 14,000 locations) – buildings used for a variety of purposes located adjacent to the track, typically signal boxes (classified as critical lineside buildings), relay rooms, buildings associated with GSM-R, and staff welfare accommodation.

8.1.4 The approach within the Policy to each of these building types is different with varying degrees of sophistication applied to each.

PARL

8.1.5 To support their knowledge of the building asset, NR conduct annual visual examinations and detailed examinations every five years, which are carried out by trained surveyors. Condition is expressed as asset remaining life (ARL) before a major intervention is required. ARL is converted to PARL in OPAS (Operational Property Asset System -the database where inventory and condition information is held), using the standardised design lives and the following relationship:

PARL = (ARL / Design Life) x 100

Business Objectives

8.1.6 The stated business objective in the Policy [Ref. SBPT3016, Section 10.1] is to maintain individual and collective asset condition consistent with the financial, technical and other constraints such that the whole-life cost of managing the operational building asset portfolio is sustainably minimised.

8.1.7 NR claim that this process is built into the modelling which has been undertaken, particularly with reference to the application of the degradation curves and the optimised intervention scenarios associated with their largest spend buildings – Franchised Stations. Figure 8-1 below extracted from the Renewals Expenditure Summary [Ref. SBPT223] shows that for the buildings covered by the Tier 2 model the impact is that there is an improvement in the PARL measure over the course of CP5 of 0.5% and if the policy intervention criteria remain constant, a longer term improvement of 35% by the end of CP11.

8.1.8 Here PARL is taken as a proxy for asset condition. We accept that the forecast change over CP5 is not statistically significant and within the tolerances of the model. Over the longer term NR has indicated that it will monitor emerging asset condition with a view to amending the PARL and ARS thresholds at the end of CP5 if required to negate any forecast asset condition improvement. They will use this feedback loop to manage asset condition in the long term. This is also described in Section 8.12.3.

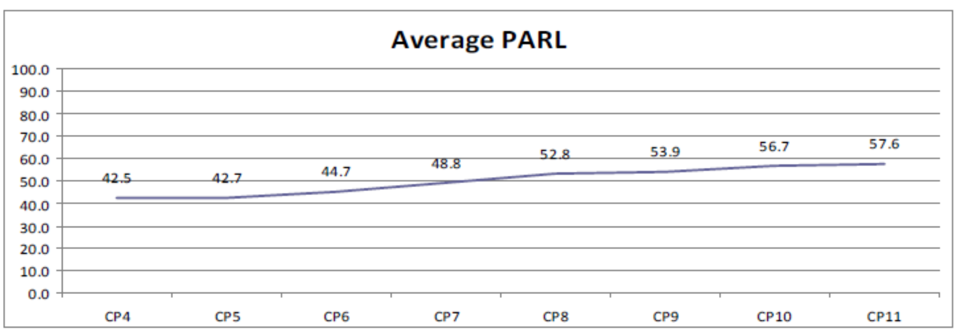


Figure 8-1: Forecast of Impact of Policy on PARL [Ref. SBPT223, Page 37]

8.1.9 Further information provided by NR in their Station Stewardship Measure (SSM) and Light maintenance Depot Stewardship Measure (LMDSM) CP5 Forecast document [Ref. NR 2013a] shows reducing (improving) SSM and LMDSM scores during CP5 – see Figures 8-2 and 8-3.

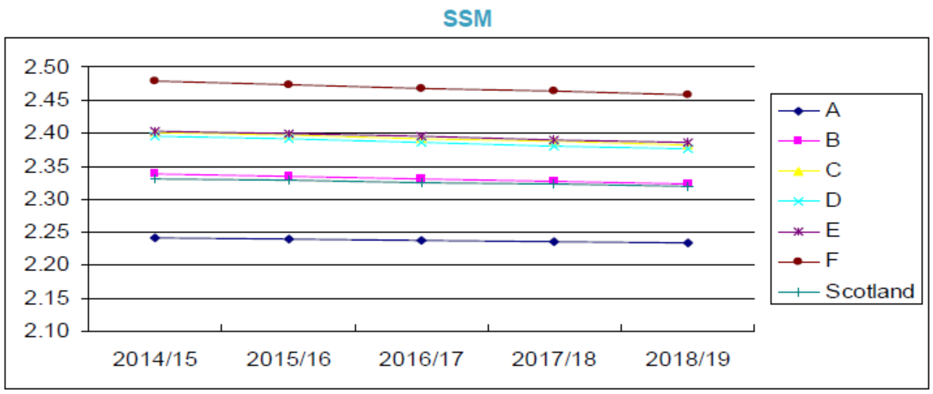


Figure 8-2: Forecast of Impact of Policy on Station Stewardship Measure [Ref. NR 2013a]

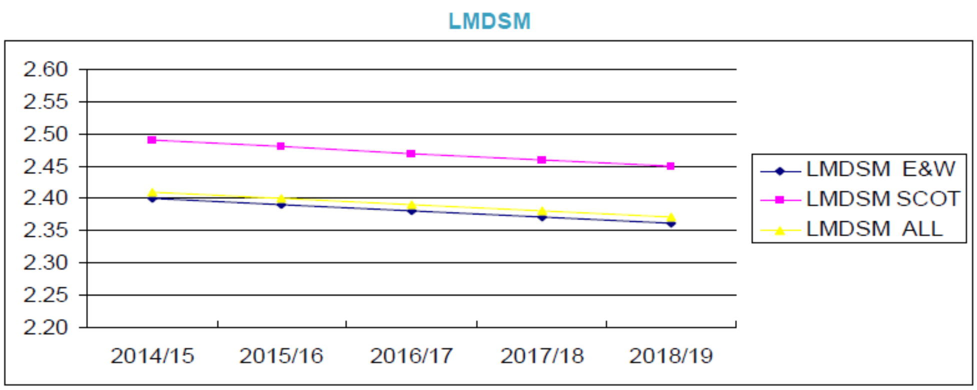


Figure 8-3: Forecast of Impact of Policy on Light Maintenance Depot Stewardship Measure [Ref. NR 2013a]

8.1.10 The level of sophistication demonstrated by the modelling for CP5 applies only to the critical blocks within the franchised station and light maintenance depot portfolios. The critical blocks are elements of each facility comprising:

- Buildings;
- Canopies;
- Footbridges;
- Platforms; and
- Trainsheds.

8.1.11 The link to the objective for the maintenance of asset condition is less well demonstrated for other building types. Here the approach is based on a combination of sampling, local asset knowledge and the rolling forward of the current CP4 levels of spend. No attempt has been made to demonstrate the forecast level of asset condition for these building groups.

8.1.12 Where the CP5 Policy is essentially based on a roll-forward of CP4 it is not possible to validate the impact of that level of spend due to a lack of historical condition data. This creates a level of uncertainty regarding the delivery of outputs.

Short-Term Measures

8.1.13 As a short-term measure NR are proposing the use of the reactive fault counts to demonstrate that asset condition is being maintained. These measures relate to the number of faults notified to the Route property teams by TOCs or the public. These are considered by NR to be a proxy for the robustness of the Policy in terms of demonstrating that it is doing the right things in order to pre-empt likely fault areas. The forecast for CP5 is to maintain the annual level of reactive faults at CP4 level. It is acknowledged that the annual rate of faults has declined as shown in Figure 8-4.

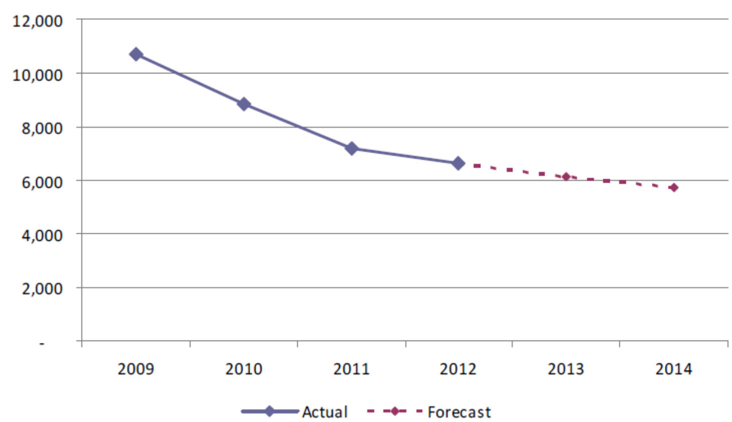


Figure 8-4: Number of Faults Requiring Attention in 2 or 24 Hours [Ref. SBPT3016, Figure 10.3]

8.1.14 We are satisfied that the use of the count of reactive faults is a reasonable proxy as an indication of the general level of asset condition. Nevertheless we are mindful of the fact that there may be elements of the faulting which are driven by external factors, for example vandalism. Counts associated with these types of incidents will bear no relation to the condition of the assets. However, we consider that since the forecast levels of faulting are to remain at CP4 levels it is reasonable to assume that levels of such external influences will remain largely stable and thus the measure is acceptable.

High Level Output Specification (HLOS)

8.1.15 Within the Buildings Asset Policy [Ref. SBPT3016, Sections 7.1] there is reference to the HLOS which includes the Government's requirements for the six key measures of:

- Safety;
- Reliability;
- Capacity;
- Financial sustainability;
- Customer satisfaction; and

- Environmental performance.

8.1.16 The Policy states that the 'baseline scenario' used in the modelling of the volumes of work associated with the maintenance and renewal of buildings addresses these requirements. We see certain linkages to these outputs in the policy processes in certain areas but not all, as is explained in the following sections.

8.1.17 The Policy [Ref. SBPT3016, Section 10.1] breaks this down to show how the various elements of the Policy contribute to the delivery of these criteria. These seek to demonstrate that the approach which has been adopted in the Policy is linked to these six requirements. This includes the use of proxy measures as in the case of customer satisfaction, or the reliance on derivatives from OPAS covering safety and performance. However, a number of these cannot be modelled from the asset portfolio data since there are acknowledged gaps [Ref. SBPT3016, Section 1.3.5] in, for example, lineside building asset data.

8.1.18 The Scottish HLOS makes reference to compliance with the SQUIRE regime aimed at providing a satisfactory railway environment both on the trains and at the stations. Whilst the majority of the measures covered by SQUIRE relate to day-to-day management and cleaning by the TOC at the managed stations this work will require to be carried out by NR. We do not consider that there are any additional measures placed on NR in relation to the maintenance and renewal of buildings as a result of this regime than would otherwise be the case.

Impact of Demand

8.1.19 There is a general acknowledgement in the SBP that CP5 will be characterised by high levels of investment to enhance the network along with growth in both passenger and freight traffic. In terms of the Policy, there appears to be a poor linkage between the growth in passenger numbers and the requirements of the Policy. This is largely because an increase in passenger numbers will have little direct effect on buildings other than to increase wear and tear. As such no specific account is taken of growth other than the use of PARL to drive intervention where usage has caused deterioration in asset condition. We support this approach.

Impact on Performance

8.1.20 Building 'failures' are generally not identified as a key delay cause when considering impact on train services, PPM etc. No specific delay attribution code exists for building faults. No specific target for the reduction in the building generated delay minutes has been set. This is considered to be appropriate.

8.2 Line of Sight

General

8.2.1 Comments made above demonstrate that there is a level of variation in the approach which has been used across the building portfolio in terms of the development of the SBP.

Business Objectives

8.2.2 As stated above, the objectives in terms of the maintenance of asset condition are clear.

8.2.3 The detailed work undertaken in the buildings Tier 2 model associated with the degradation / intervention curves is designed to be able to demonstrate that the condition of the associated portfolio is sustained over the course of CP5 and beyond.

8.2.4 However, there is no similar level of reassurance for the buildings categories for which the policy is to roll forward the current CP4 level of spend. In addition, we consider the current lack of a clear benchmark to be an omission.

8.2.5 As noted in Figure 8-4 above, the Policy demonstrates that in the final year of CP4 and the early part of the current year the level of 2 and 24 hour reactive faults will drop. It is noted that this measure is one of NR's internal performance indicators; however, the overall target is to sustain the CP4 annual level of faults.

HLOS

8.2.6 There is a reliance on the adoption of the modelled data to deliver the HLOS requirements. However, where the Routes have adjusted the modelled levels of activity to meet local needs there may be a disconnect in this linkage.

8.2.7 In general, there is no specificity of the requirements placed on the building portfolio to achieve the HLOS outputs quoted in the policy document. Indeed reference to the HLOS is not a major element throughout the Policy documentation.

8.2.8 In the Volume 2 M&E Policy document there is no mention of HLOS but rather a focus on the legal requirements associated with the operation and maintenance of plant and machinery. For a relatively immature document we consider this appropriate.

End-to-End

8.2.9 We have difficulty in assessing the line of sight from certain areas of the Policy to the required outcomes since it is currently unclear how each building type will contribute to the overall delivery of the requirements. As such there is a level of uncertainty and risk associated with the delivery of the required outcomes. The degree of risk is variable across the building types but is currently unquantifiable given the lack of asset information for the non-station building types.

8.3 Asset Knowledge

Operational Property Asset System (OPAS)

8.3.1 The core asset data system used for buildings is OPAS. This has been in existence since 2008 and in terms of the other railway asset databases it is a relatively mature system. It is a customised package from Atrium.

8.3.2 OPAS is populated with data from site inspections undertaken by the NR CEFA contractor. The CEFA scope of works for these inspections covers all of the building types in the portfolio although this coverage has only recently been expanded from a prime focus on stations (both franchised and managed) and depots. It is this asset data which has been used in the derivation of the WLCC modelling to support the Policy.

8.3.3 NR acknowledges that their asset knowledge for the smaller building types is less than that for stations [Ref.SBPT3016, Section 1.3]. This is considered to be one of the reasons that the level of sophistication employed in the modelling has been variable. Nevertheless, NR states that it is their intention to fully populate OPAS with all building asset data by the end of CP4. At that time all buildings will have detailed inventory and condition surveys in OPAS.

8.3.4 The OPAS system is capable of handling very detailed levels of survey data to provide a high degree of granularity of asset information. The system allows assets to be broken down into individual component levels within a block at each site. The term ‘block’ here is used to describe a building unit – for example a canopy, a platform or a footbridge. The relevant information held about each component within the blocks includes:

- A measurement of its size and / or number;
- An assessment of its remaining life;
- A factor indicating its potential safety implications on failure;
- A factor denoting its impact on performance on failure; and
- An indication of the probability of failure.

8.3.5 Inspections of the building portfolio are undertaken in detail every five years. However, on an annual basis the critical blocks are given a visual inspection.

8.3.6 The three key measures of the asset which are used in the modelling of their degradation and priority in terms of their impact on failure are:

- The condition rating;
- The safety factor; and
- The performance factor.

8.3.7 In studies undertaken as part of the review of station and depot stewardship condition in March 2012 [Ref. Data Assurance 2011-2012, Station and Depot Stewardship, Arup 2012] a random selection of these measures was sampled and found to be generally accurate. Based on these we are generally satisfied with the level and accuracy of asset information for the critical blocks.

8.3.8 Nevertheless, the Buildings Asset Policy acknowledges that the same level of detail does not currently exist in OPAS for the other building categories – NDS depots, MDUs and lineside buildings. The limited knowledge of the asset condition in OPAS for a significant portion of the portfolio means that there is a limited opportunity to rely on a fully modelled assessment of activity requirements for these building types. As such other means of determining volumes in the top-down model have been deployed.

8.3.9 In descriptions of the Route processes given by them in response to questioning with reference to Mandate AO/028 [Arup, 2012] there is a varied degree of trust placed on the OPAS data by the RAMS even for stations and depots. There were a number of contrasting comments on its quality. Nevertheless, the impression from the Route interviews has been that generally the RAMS and their senior team have a good knowledge of their assets which can be used to support the knowledge in OPAS and provide understanding where this information is missing.

8.3.10 Given the acknowledged incomplete level of data held centrally regarding the non-station or depot building types reliance for the development of the plan must be biased in favour of the locally held knowledge, that is, there must be a strong reliance on local knowledge in the development of the plan.

Local Knowledge

8.3.11 For the majority of the Routes it appears that a significant proportion of their plans have been developed using local knowledge.

8.3.12 Based on the sample of meetings held with the Routes as part of this review we believe that local building asset knowledge is generally good. We believe that there are particular Routes for which this process of developing good local knowledge of the asset is less well developed than others, although there is evidence that this is being rectified.

8.3.13 As well as being informed by the outputs of the CEFA contractor and direct comments from TOCs, it is clear from the Route Plan submissions that a considerable reliance has been placed for the derivation of workbanks on the local knowledge held or gathered by the RAM teams.

Lineside Building Sampling

8.3.14 In order to model the volumes associated with the lineside building portfolio a ten per cent sample of the asset population was inspected by NR with a view to determining the volumes associated with these buildings and then to extrapolate this to the whole population. The sample of buildings was based on a spread of building types, sizes and geography.

8.3.15 We have reviewed the 'Remit for Condition Surveys and Data Capture on lineside buildings for CP5 Submission' [Ref. NR 2013b]. The remit appears to provide a good basis on which to sample the spectrum of building sub-types covered by this grouping. The selection of 10% sampling is not justified in the documentation. We note that there is a requirement to avoid 'cherry picking' the worst condition buildings but it is not clear how this can be policed in practice.

8.3.16 The approach of using sampling as a means of determining the volumes of activity associated with lineside buildings for the modelling is considered reasonable; however, the impact on the condition of this regime cannot be determined from available information.

Maintenance Delivery Unit and National Delivery Service Depots

8.3.17 For MDUs and NDS depots there was little or no reliance placed on centrally based asset knowledge for those building types. It is acknowledged in the Policy that asset knowledge for these building types is relatively poor [Ref. SBPT3016, Section 1.3].

8.3.18 .

8.4 Asset Behaviour, Degradation and Criticality

8.4.1 Figure 8-5 provides an extract from the Policy document [Ref. SBPT3016, Table 8.2] which summarises the levels of development of the central modelling with respect to the various building types.

Asset Category	Status	Tier 1	Tier 2	Data Available
Franchised Stations	Critical	Numerical model for key blocks and features. Bottom-up work-bank.	Analysis of degradation curves. Intervention effectiveness	95%
Managed Stations	Critical.	Bottom-up work-bank (central)	No Tier 2 Model.	88%
Light Maintenance Depots	Non critical	Bottom-up work-bank.	Analysis of degradation curves. Intervention effectiveness	<50%
Line-Side Buildings	Small critical subset (critical line side)	Bottom-up work-bank based on 10% sample set	No Tier 2 Model.	10%
Maintenance Delivery Units & National Delivery Services	Non-critical	Bottom-up work-bank	No Tier 2 Model.	<10%
Depot Plant	Critical	Lifecycle Model	No Tier 2 Model.	100%
Lifts and escalators	Critical	Lifecycle Model	No Tier 2 Model.	100%

Figure 8-5: Summary of Modelling Undertaken for the Various Building Types

8.4.2 From the above managed stations, lineside buildings, depot plant, MDUs and NDS sites are excluded from the Tier 2 analysis as their combined expenditure varies between 32 – 44 % of the total spend for buildings' assets. As such, other techniques have been used for these assets as part of the Tier 1 analysis, as described in the Buildings Tier 1 Model Review (Ref AO/030/3D). The Tier 2 WLCC planning approach instead focuses on the seven most critical blocks within franchised stations and LMDs only.

8.4.3 To simplify the complexity of the whole life cycle planning analysis, particularly since it is carried out over a long-term time horizon (30 – 120 years in the Tier 2 model), buildings assets have been divided into the five key blocks (irrespective of their construction type, material type and size) as listed in Section 8.1.8 of this report.

8.4.4 Since buildings assets are complex and present a challenge to describe consistently, a two level system of 'Blocks' and 'Features' has used as described in Figure 8-6 [Ref. SBPT3016, Table 1.2].

Tier	Description
Block	Blocks comprise functional units of a building. For stations, these include train sheds, canopies, platforms, buildings and footbridges etc., as per Figure 1.2. Each Block is further sub-divided into Features which carry three attributes.
Feature	Feature – the 'element' within the block, e.g. boundary wall or platform coper.
	Asset - what the element does e.g. access and boundary control or platform.
	Attribute - the material from which the element is made.

Figure 8-6: Two Level Buildings Asset Description System

8.4.5 In order to undertake the analysis the Blocks have been broken down into 83 attributes - see Appendix C in the Buildings WLCC Model Review [Ref. AO/030/2C]. However, only the most critical ones have been taken into account in the Tier 2 model. The remaining attributes contribute to only 20% of the total annual expenditure. These costs have been included and aggregated at Tier 1. Table 8-1 below shows the seven blocks and the forty-two critical attributes modelled in the Tier 2 analysis. Within this grouping only those elements which are deemed to be the most critical have been taken into account in the Tier 2 model. Both critical and non-critical elements are taken into account in the Tier 1 model.

Table 8-1: Buildings Tier 2 Asset Grouping

Block Type	Attribute ID	Block Component / Attribute
BUILDINGS	1	EXTERNAL JOINERY - Windows and doors - Generally
	2	BUILDING - EXTERNAL JOINERY - Joinery - Ext. fascia board
	3	BUILDING - EXTERNAL JOINERY - Joinery - Ext. soffit or ceiling boarding
	4	STRUCTURES ROOF - Coverings - Slates
	5	STRUCTURES ROOF - Coverings – Tiles
	6	STRUCTURES VERTICAL - Walls - Masonry
CANOPY	7	STRUCTURES HORIZONTAL - Steel - Beams, girders, joists and purlins
	8	STRUCTURES VERTICAL - Steel – Columns
	9	DRAINAGE - Gutters - Cast iron lined
	10	STRUCTURES HORIZONTAL - Steel - Lattice trusses
	11	STRUCTURES ROOF - Coverings – Glass
FOOTBRIDGES	12	STRUCTURES HORIZONTAL - Steel - Beams, girders, joists and purlins
	13	STRUCTURES VERTICAL - Steel – Columns

Block Type	Attribute ID	Block Component / Attribute
	14	ACCESS & BOUNDARY CONTROL - Handrails - Steel
	15	STRUCTURE ELEMENTS - Parapets, cladding etc. - Structural painted - Lattice trusses
	16	STAIRS - Steel - Stringers and treads - Open construction steps or treads
	17	STRUCTURE ELEMENTS - Parapets, cladding etc. - Structural painted – Parapets
	18	STRUCTURES VERTICAL - Steel – Piers
	19	STAIRS - Steel - Stringers and treads - Solid steps or stairs
PLATFORMS	20	DRAINAGE - Surface water – ACO
	21	SURFACES – Tarmacadam
	22	COPERS - PCC slabs
	23	SUPPORTS - Brick riser
	24	TACTILES – Concrete
LMD DEPOT SHED	25	STRUCTURES HORIZONTAL - Steel - Beams, girders, joists and purlins
	26	STRUCTURES VERTICAL - Steel – Columns
	27	DRAINAGE - Gutters - Cast iron lined
	28	STRUCTURES HORIZONTAL - Steel - Lattice trusses
	29	STRUCTURES ROOF - Coverings – Glass
	30	STRUCTURES VERTICAL - Walls - Masonry
LMD BUILDING	31	EXTERNAL JOINERY - Windows and doors – Generally
	32	BUILDING - EXTERNAL JOINERY - Joinery - Ext. fascia board
	33	BUILDING - EXTERNAL JOINERY - Joinery - Ext. soffit or ceiling boarding
	34	STRUCTURES ROOF - Coverings – Slates
	35	STRUCTURES ROOF - Coverings – Tiles
	36	STRUCTURES VERTICAL - Walls - Masonry
TRAIN SHEDS	37	STRUCTURES HORIZONTAL - Steel - Beams, girders, joists and purlins
	38	STRUCTURES VERTICAL - Steel – Columns
	39	DRAINAGE - Gutters - Cast iron lined
	40	STRUCTURES HORIZONTAL - Steel - Lattice trusses
	41	STRUCTURES ROOF - Coverings – Glass
	42	STRUCTURES VERTICAL - Walls – Masonry

8.4.6 As stated in the Policy [Ref. SBPT3016, Section 8.4] previous versions of the model used only one degradation curve, which were based on the ageing process of new features. This method was considered inadequate as a feature with minimal maintenance will deteriorate differently from one that has had on-going maintenance. Therefore, as part of the Tier 2 modelling process, the single original approach was changed to five based on the direct relationship between PARL and probability of failure P (F) as shown in Figure 8-7. This allows tailored interventions to be applied depending on the starting condition state of the asset [Ref. SBPT3016, Section 8.4].

PARL (%)	P (F)	Asset Intervention Strategy
100 - 41	1 and 2	No intervention is required.
40 - 11	3	Intervention should be applied within 5% of ALE or 1yr, whichever is the lower, to ensure safety and performance is not compromised in the medium term.
10 - 3	4	Intervention must be applied within 1% of ALE or 6 months, whichever is the lower, to prevent further asset deterioration impacting safety and / or performance.
2 - 0	5	Intervention must be applied immediately to ensure safety.
NOTE	Routes may apply asset interventions based upon their own discretion over and above those required by this policy.	

Figure 8-7: Relationship between PARL and Intervention

Degradation Rates

8.4.7 In the Policy [Ref. SBPT3016, Section 5.4] it is noted that the degradation rates for the key features are based on work undertaken with the Building Research Establishment (BRE). As part of this work, BRE visited a number of NR sites to investigate the types of degradation that occurred; the details surrounding this work are set out in the document 'BRE Support to Network Rail CP5 Submission Executive Summary, Step 1 Maintenance' 2011 [Ref. BRE 271-023].

8.4.8 Essentially, the work undertaken by the BRE looked at degradation rates for a 'typical' critical block composed on 'typical' components. This analysis was then used in the Tier 2 model to determine the optimum intervention frequency and activity.

8.4.9 This work has then been applied to the key features located on critical and non-critical buildings assets.

8.4.10 We have previously commented on the degradation curves developed by the BRE in our Initial Industry Plan 2011 Review Summary Report Observations and Conclusions [Arup 2011]. Our view at that time was that:

"There is little doubt the present profiles in the modelling will sustain the assets in perpetuity. We believe some of the profiles are over-conservative and hence do not provide the most economic or realistic modelling of the Network Rail portfolio." [Para 10.3.57]

"We believe there should be little risk in extending some degradation profiles. It is recommended that the degradation curves be reviewed and revised where they are believed to be conservative." [Para 10.3.60]

"The degradation curves do not represent a 'real' asset. They are an amalgam of different asset characteristics. For example, there are not separate degradation models for metal and concrete footbridges. There are many configurations, materials and sizes of footbridge in the Buildings portfolio. A "typical" station

footbridge has been devised to simplify the modelling. The "typical" footbridge has been developed using OPAS data. Footbridge volume data was analysed to find the most common average characteristics of NR station footbridges (material; covered or uncovered; deck type; area, etc.) per Station Category. The model then assumes every footbridge is of this type and computes the outputs accordingly. The model does not represent any particular footbridge at any particular station." [Para 10.3.61]

"Clearly the modelling is very much an approximation and the outputs should be understood to be so. The model is intended to provide only a guide to future volumes and costs. It is difficult to establish how approximate the outputs are. It is recommended that further work be carried out to validate the accuracy of the modelled outputs." [Para 10.3.62]

8.4.11 The use of the BRE to support the development of the degradation curves is acknowledged as a reasonable approach in the development of understanding of the science associated with building asset degradation. However, the modelling, by its nature, makes certain assumptions regarding the rates of degradation and the impact of interventions. We have previously documented in our Initial Industry Plan 2011 Summary Report – Observations and Conclusions [Arup 2011] our concerns regarding the models. We note that no changes have been made to the degradation relationships since that time and as such our concerns regarding the model remain.

Failures at Stations

8.4.12 As described in the Policy [Ref. SBPT3016, Section 5.2.1] the stations service reliability can be affected by poor asset condition as there is an increased probability of service loss, which may impair passenger or train movements. This could include condition such that there is an increased risk of slips, trips and falls. This disruption, if it were to continue, would adversely impact on the National Passenger Survey or the SSM, thereby affecting customer and facility performance expectations.

Failures at Light Maintenance Depots

8.4.13 The Policy [Ref. SBPT3016, Section 5.2.2] states that the failure of LMD assets can cause operational delays and service disruption by impacting on train movements. This could include difficulties in providing train maintenance as a result of poor shed condition leading to operational failures. Depot staff work patterns can also be disrupted, resulting in inconvenience and possibly compromising safety. It would also adversely impact the LMDSM, as this is directly related to condition.

8.4.14 Where train refuelling assets are located at LMDs, their failure carries the risk of pollution and environmental damage. This also applies to discharges associated with vehicle operation (e.g. untreated sewage from CETs) and cleaning (carriage washers). These scenarios may eventually result in prosecution / enforcement action under the relevant environmental legislation.

8.5 Renewal and Maintenance Interventions

Development of Interventions

8.5.1 Section 8.3 of this report described the varying levels of asset information which are currently held for the different building types. Given these variations, the approach to the determination of the interventions which have been included in the Policy is different. Even within the franchised station portfolio, the interventions which have been described are different between those applicable to the critical and to non-critical blocks.

8.5.2 As stated above, NR used the BRE to support them in the development of a philosophy for intervention and then to develop a range of degradation / intervention curves which could be applied where appropriate asset data is known. The degradation curve approach is described in Section 8.4 above and a typical intervention regime is shown in Figure 8-8.

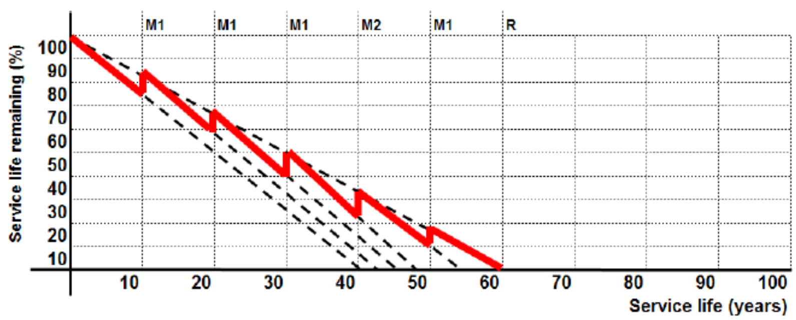


Figure 8-8: Exemplar Intervention Regime [Ref. SBPT3016, Appendix E]

8.5.3 The outcome of the work associated with the determination of interventions is included in the Policy [Ref. SBPT3016, Appendices E to I]. These appendices demonstrate the outcome of the optimisation of the intervention work which was undertaken by the NR consultant.

Franchised Stations

8.5.4 NR prioritised the modelling of degradation and the development of the subsequent intervention regimes to the critical blocks at the franchised stations, based on the asset information available to them. The determination of the criticality of the asset blocks has been driven by their potential impact on passenger safety in the event of failure. Thus, those blocks which are most likely to lead to injury are prioritised and as a result are subject to a greater level of inspection.

8.5.5 Determination of the timing and scale of the interventions for given assets has been assessed in the modelling and in the policy as being related to measures of the individual assets PARL and its average risk score (ARS). Policy dictates that when a specified threshold is breached then there is a requirement to act on the asset to improve condition.

8.5.6 The Policy defines a regime for the on-going maintenance and renewal of the asset involving interventions of varying scales for each type of assets. These are described below in Figure 8-9.

Type of Intervention	Intervention Code	Effect of Intervention
Renewal of blocks (Enhancement)		Delivering an enhanced level of functionality, environmental performance or business value.
Renewal of blocks or key components within it	B1	Used to maintain the current level of functionality and performance rather than address longer-term strategic requirements such as growth, which would be addressed through enhancement renewal. Termed 'like-for-like'.
Refurbishment of blocks	B2	Extensive repair or modification of an asset to meet performance criteria. e.g. installation of building services, access, natural lighting, equipment and finishes, using historic fabric as the carcass of a new asset.
Large scale maintenance to blocks	C1	Targeted and localised maintenance/renewal response that achieves acceptable levels performance ensuring the safe and efficient operation for users.
Small scale maintenance to blocks	C2	As above but a smaller scale intervention, possibly to reflect the overall size of asset in question, i.e. a rural station rather than a large terminus.
Other small scale works to blocks	MEW & PPM	As above but minor proactive or minor reactive works Refer to Appendix O & P for PPM details.

Figure 8-9: Exemplar Intervention Trigger Thresholds

8.5.7 The Policy describes a boundary between the ARS for certain asset types which dictate that there should be a specific intervention regime applied or whether the asset should be maintained under a planned preventative maintenance or minor emerging works regime. Figure 8-10 below shows an extract from the Policy [Ref. SBPT3016, Figure 8.3] showing an exemplar set of thresholds for ARS and PARL.

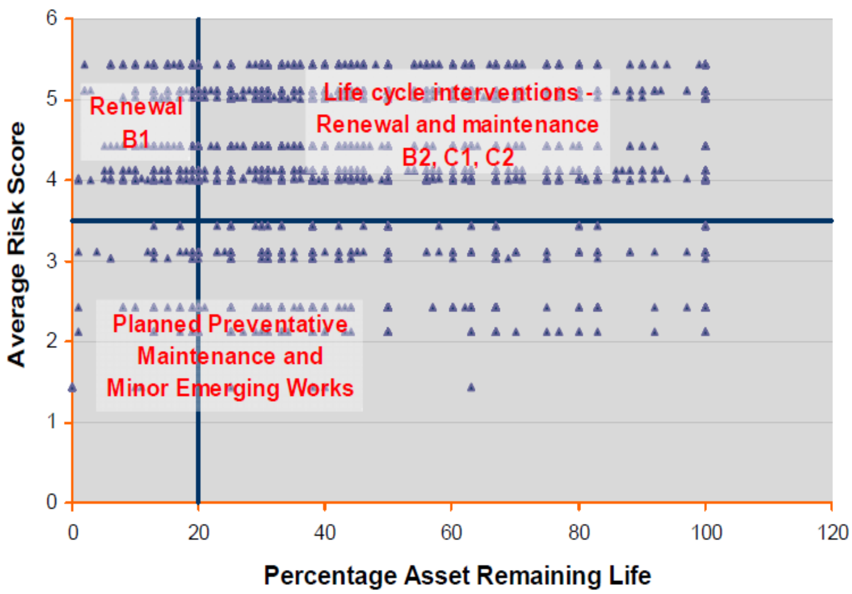


Figure 8-10: Exemplar Intervention Trigger Thresholds

8.5.8 In each case an idealised set of interventions made up of the foregoing activity types is included in the Policy and this is the basis of the modelling in Tier 2.

8.5.9 The impact of this modelled approach to the interventions for these critical blocks has been a shift away from full renewal to a more structured policy of maintenance and repair in cycles until renewal is required.

Managed Stations

8.5.10 For managed stations no Tier 2 modelling has been undertaken. Instead the Policy [Ref. SBPT3016, Section 9.4] directs future work volumes should be based on historic intervention levels and local workbanks.

8.5.11 Further justification for this approach has been made on the basis of the small number of managed stations (17no.) and the high level of understanding of their condition by the RAM teams. It has been claimed [Ref. SBPT3016, Section 9.4] that good knowledge of the asset has allowed a professional judgement to be made of the interventions that are required without the need for the use of the degradation curves.

8.5.12 In the absence of modelling or AMPs, we have been unable to verify that the long-term condition of the managed stations is sustainable. Nevertheless we understand that NR has undertaken some review of the plan volumes in the Tier 1 model to demonstrate sustainability. Following the meeting on 12 April 2013 NR provided some evidence of the output of this exercise. We have not had the opportunity to consider this new information as part of this review.

8.5.13 We note that OPAS data, to the quality of that for the franchised stations also exists for the managed stations.

Light Maintenance Depots

8.5.14 The Policy [Ref. SBPT3016, Section 9.5] indicates that the issue of criticality has also been applied to the assets in the LMDs albeit with some pending updates. The critical assets in the LMDs are said in the Policy to have been modelled in the same way as the franchised stations. This covers only those assets associated with the critical blocks.

8.5.15 In the review of the Tier 2 model it was noted that there was no spreadsheet output produced by the model which was subsequently used to generate volumes in the Tier 1 model. However, it has been explained by NR that use was made of the IIP run of the model which had unchanged costs. This confirms the policy approach.

8.5.16 The intervention regime for some of the remaining non-critical elements has been based on the requirements of legislation and PPM, particularly in the case of the key mechanical plant items (wheel lathes, train washers etc.) as well as smaller scale items [Ref. SBPT3016, Part 2].

8.5.17 For the remaining fabric elements tried and tested intervention regimes have been applied. This remaining grouping of assets account for only a limited proportion of the overall plan.

8.5.18 As described previously asset condition data from OPAS is available to facilitate the modelling of planned activities at LMDs.

Lineside Buildings

8.5.19 The basis for the derivation of the modelled asset data for lineside buildings has been previously described. The lack of detailed information on the entire portfolio of lineside buildings has precipitated a reliance on the local knowledge about the portfolio with regard to their individual condition to be able to assemble a planned programme of interventions. This may have been informed by the modelled outputs from the sample of buildings but we believe that this has been fundamentally derived from the local knowledge.

National Delivery Service Depots and Maintenance Delivery Units

8.5.20 The 521 buildings in this portfolio are known to generally have poor asset information. As a result it has not been possible to reliably model the planned activities and as such the forecast levels of intervention are based on historic levels. This is acknowledged in the Policy [Ref. SBPT3016] where the target interventions were modelled on historic spend levels.

8.5.21 In appreciation of the lack of detailed knowledge on those assets we consider this approach to be sensible. However, the lack of historic information does mean that there is some uncertainty regarding delivery of the required outputs from this Policy approach.

Future Aspirations

8.5.22 In terms of the development of the regime of interventions this is largely reliant on the completion of the asset data collection and its use in OPAS. This should provide a platform on which to roll out the broader applicability of more sophisticated degradation modelling as has been shown applicable to the franchised station portfolio.

8.5.23 Away from the station portfolio, and taking account of the planned enhancements stated in the plan, it is likely that the profile in terms of usage and age of the buildings is likely to alter. This change to the requirements may bring with it a change to the intervention regime given a potentially different asset age profile.

Modelling

8.5.24 The Building WLCC Model Review report (Ref: AO/030/2C) states that three overall types of maintenance strategy are considered for each attribute. [Ref. SBPT3035-2, Section 4.6]. These are:

- “Do minimum” – the minimum required to sustain safety and performance over the analysis period;
- “Preventative” - regular and frequent minor interventions to maintain the condition of the asset by slowing down the rate of deterioration; and
- “Targeted” -aimed towards minimising NPC while satisfying safety and performance targets and delivering a required condition score.

8.5.25 However it is unclear how these strategies, particularly "Targeted" could have been implemented within the model since there is no facility to model safety or performance risk in the WLCC model.

8.5.26 Maintenance and renewal needs for each attribute are identified using PARL levels that trigger the need for work. The setting of these intervention triggers are driven by the level of service required both now and in the future.

Intervention Options and Condition Resets

8.5.27 A total of 174 intervention options have been coded in the Tier 2 model. Different intervention types are appropriate for different blocks and their associated attributes. A list of suitable intervention types, costs and resets that are currently used for the maintenance and renewal of buildings' assets has been developed [Ref. SBPT3016, Appendices J-N].

Intervention Triggers

8.5.28 Intervention triggers have been based on the intervention year (and PARL) from the start of the analysis. Hence, no intervention threshold exists in the Tier 2 model since it is based on asset condition. The Policy and Tier 1 Model use a combination of ARS and PARL as a proxy for risk to determine thresholds for different maintenance and renewal approaches.

8.5.29 Table 8-2 shows the number of intervention strategies for each asset category.

Table 8-2: Maintenance Strategies and OPAS Design Life

Critical Block Type	Block Component / Attribute	OPAS Design Life (years)	Intervention Strategies Modelled (No.)
BUILDINGS (Model)	EXTERNAL JOINERY - Windows and doors – Generally	35	7
	BUILDING - EXTERNAL JOINERY - Joinery - Ext. fascia board	35	7
	BUILDING - EXTERNAL JOINERY - Joinery - Ext. soffit or ceiling boarding	35	7
	STRUCTURES ROOF - Coverings - Slates	70	2
	STRUCTURES ROOF - Coverings – Tiles	70	2
	STRUCTURES VERTICAL - Walls - Masonry	100	3
CANOPY (Model)	STRUCTURES HORIZONTAL - Steel - Beams, girders, joists and purlins	100	5
	STRUCTURES VERTICAL - Steel – Columns	100	5
	DRAINAGE - Gutters - Cast iron lined	60	3
	STRUCTURES HORIZONTAL - Steel - Lattice trusses	100	5
	STRUCTURES ROOF - Coverings – Glass	40	2
FOOTBRIDGES (Model)	STRUCTURES HORIZONTAL - Steel - Beams, girders, joists and purlins	80	4
	STRUCTURES VERTICAL - Steel – Columns	80	4

Critical Block Type	Block Component / Attribute	OPAS Design Life (years)	Intervention Strategies Modelled (No.)
	ACCESS & BOUNDARY CONTROL - Handrails – Steel	80	4
	STRUCTURE ELEMENTS - Parapets, cladding etc. - Structural painted - Lattice trusses	80	4
	STAIRS - Steel - Stringers and treads - Open construction steps or treads	80	4
	STRUCTURE ELEMENTS - Parapets, cladding etc. - Structural painted – Parapets	80	4
	STRUCTURES VERTICAL - Steel – Piers	80	4
	STAIRS - Steel - Stringers and treads - Solid steps or stairs	80	4
PLATFORMS (Model)	DRAINAGE - Surface water – ACO	40	2
	SURFACES – Tarmacadam	20	2
	COPERS - PCC slabs	60	6
	SUPPORTS - Brick riser	80	4
	TACTILES – Concrete	20	2
LMD DEPOT SHED (Model)	STRUCTURES HORIZONTAL - Steel - Beams, girders, joists and purlins	100	5
	STRUCTURES VERTICAL - Steel – Columns	100	5
	DRAINAGE - Gutters - Cast iron lined	60	3
	STRUCTURES HORIZONTAL - Steel - Lattice trusses	100	5
	STRUCTURES ROOF - Coverings – Glass	40	2
	STRUCTURES VERTICAL - Walls - Masonry	100	5
LMD BUILDING (Model)	EXTERNAL JOINERY - Windows and doors – Generally	35	7
	BUILDING - EXTERNAL JOINERY - Joinery - Ext. fascia board	35	7
	BUILDING - EXTERNAL JOINERY - Joinery - Ext. soffit or ceiling boarding	35	7
	STRUCTURES ROOF - Coverings – Slates	70	2
	STRUCTURES ROOF - Coverings – Tiles	70	2
	STRUCTURES VERTICAL - Walls - Masonry	100	3
TRAIN SHEDS (Model)	STRUCTURES HORIZONTAL - Steel - Beams, girders, joists and purlins	100	5
	STRUCTURES VERTICAL - Steel – Columns	100	5
	DRAINAGE - Gutters - Cast iron lined	60	3
	STRUCTURES HORIZONTAL - Steel - Lattice trusses	100	5
	STRUCTURES ROOF - Coverings – Glass	40	2
	STRUCTURES VERTICAL - Walls – Masonry	100	5

8.6 Asset Cost Data

8.6.1 As part of the development of the Policy, and linked to the Tier 2 model, NR have built up national rates for use in the modelling to determine the most cost effective interventions and the lowest overall WLCC to comply with the required outputs. The detail of this is contained in the related report 'Network Rail Unit Costs Used for SBP' [Ref. Arup 2013c].

8.6.2 The development of the costs used in the WLCC analysis has been stated by NR as being built up from first principles. That is, the activities were broken down to the core labour, plant and materials elements and developed as a national average. The rates were developed by Franklin and Andrews. These were subsequently validated by Investment Projects (IP) and their cost consultant Faithful and Gould.

8.6.3 Within the Policy, the determination of the most cost effective intervention scenario has been identified taking a balance between the outputs in terms of the asset condition long-term and the associated costs.

8.6.4 For the purposes of evaluation within the modelling framework, and as a means to test various scenarios, these rates are considered to be adequate as a tool to optimise the intervention scenarios. However, given the likely variations in accessibility to sites and other regional factors the rates will be unlikely to be directly accepted in the costing of the workbanks without some adjustment. Based on the meetings with the Routes we understand that a series of 'structural' factors have been added to these national rates in determining what may be applicable to cost actual work items in the Routes.

8.6.5 We note that these rates will only have applied in the development of the policy models where these have been built up from the degradation / intervention curves in the Tier 2 model. In effect this means that such rates, to develop optimum whole life cycle costs, do not apply to those building types whose SBP development has been independent of the detailed modelling.

8.6.6 It has been stated by NR that further work is in progress to develop a bespoke 'Measurement of Unit Costs by Operational Property' document which will be rolled out by NR to the Routes in due course.

8.6.7 We have reviewed the cost information that has been applied at the Route level and we believe that it is uncertain whether these are appropriate given the level of supporting information which has been provided.

Civil Engineering Framework Agreement (CEFA)

8.6.8 Inspection of the building portfolio is undertaken by the CEFA contractor. This team deliver the annual and five yearly inspections of the assets and are currently understood to be working to populate OPAS with inventory and condition data from the wider buildings portfolio in order to have OPAS completely populated by the end of CP4.

8.6.9 As stated previously in Section 4.8.8 the CEFA arrangements are now considered by NR to be covered under OPEX costs. We have not seen a breakdown of the CEFA figures to determine what proportion applies to the building portfolio.

8.7 Policy Selection and Preferred Lifecycle Options

8.7.1 The variations in approach between the various building types have been described earlier in this section of the report.

Franchised Stations

8.7.2 For the critical blocks at franchised stations the optimum intervention strategy has been considered at block level and a comparison made of costs and impact in terms of long-term PARL against a range of threshold for the ARS (safety and performance) and PARL (condition) values. As indicated previously this analysis has been based on the work undertaken by BRE to define the intervention curves and intervention strategies. These were then used to determine which combination provides the most appropriate regime for the individual asset type.

8.7.3 In assessing the optimum outcome, and hence recommended policy, typically a range of ten options has been considered amongst which will be options that:-

- Reduce Expenditure;
- Improve Condition; and
- (typically lying between these) the Recommended Policy.

8.7.4 These options seek to balance the costs of the intervention regime against the impact on PARL in the long term linked to the deliverability of the selected option (for example, is it practical to allow an asset to reach a PARL of 0%?).

8.7.5 In each case, the intervention regimes have been applied to the asset and the costs and impact analysed by the models. Figure 8-11shows an extract from the Policy covering station footbridges.

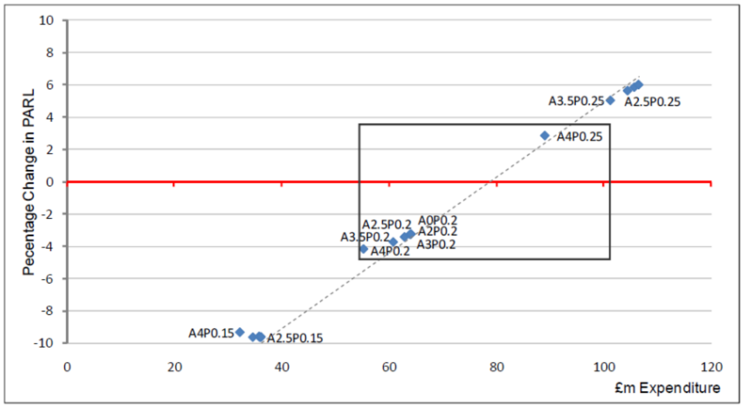


Figure 9.4 Indicative Cost vs. Percentage Change in PARL for franchised station critical blocks – footbridges

Scenario Code	ARS	PARL	CP5 Expenditure (£m)	% Change in PARL	Note
A4P0	4	0%	£ 16.35	-14.2	
A4P0.05	4	5%	£ 16.87	-14.0	
A4P0.1	4	10%	£ 20.89	-12.8	
A4P0.15	4	15%	£ 34.00	-9.3	
A4P0.2	4	20%	£ 58.33	-4.2	Reduced Expenditure Option
A3.5P0.2	3.5	20%	£ 64.18	-3.7	
A3P0.2	**3**	**20%**	**£ 66.40**	**-3.4**	**NR Policy**
A2.5P0.2	2.5	20%	£ 67.47	-3.3	
A2P0.2	2	20%	£ 67.66	-3.2	
A4P0.25	4	25%	£ 94.03	2.9	Improved Condition Option

Figure 8-11: Option Selection for Station Footbridges

8.7.6 Whilst there is considerable logic in this approach, based as it is on the foundation of the asset knowledge and then the optimisation of the intervention through a WLCC approach, there are some inconsistencies in the practice.

8.7.7 The majority of the Policy levels of intervention forecast that the PARL for those blocks will deteriorate over time despite the planned levels of intervention. Whilst most of these variances are of the order of 5-6%, for trainsheds the forecast is for a drop of 14%. In response to questions regarding this, NR have stated that trainsheds are in some ways a special case given their limited number and the current asset age profile whereby this level of degradation will have only a limited impact over the course of CP5. From this it is clear that Policy and thresholds would be reviewed in the future based on developing condition scores.

8.7.8 The approach to the segregation of the Policy into the asset blocks appears to be sensible and we support this approach; however, there does appear to be some inconsistency here which raises uncertainty.

Light Maintenance Depots

8.7.9 The means of option selection related to the critical elements within the LMDs is similar to that employed for franchised stations.

8.7.10 For key items of plant within the depots – for example train washers or wheel lathes – an assumed asset life has been applied. In addition, statutory and manufacturer requirements in terms of safety certification and regular inspection and maintenance have been included.

Other Building Types

8.7.11 Whilst the foregoing relates to the most significant building types, there is little evidence of alternative options being developed for the other groups. The Policy approach is based on local knowledge, the rolling forward of current intervention regimes and the outcome of the sampling of the national lineside building portfolio. These are stated to be assumed to deliver the required outputs. NR claim to have undertaken a back-check on the bottom-up volumes for managed stations to demonstrate sustainability. The evidence for this was not part of NR's SBP submission but has been provided following the meeting on 12 April 2013. We have not had the opportunity to fully consider this documentation.

8.7.12 We recognise the issue with the lack of detailed asset condition information with regard to these building groups. However, the lack of evidence of delivery of outputs creates a degree of uncertainty.

Link to Route Plans

8.7.13 The key linkages between the Policy and the Route Plans come through the individual Route inputs.

8.7.14 The approach undertaken by the Routes varies depending on a number of local factors relating to the maturity of the teams and their views on the quality of the data held in OPAS. In general however there is evidence that the majority of the Routes have adopted the Policy and recognise the thresholds and their application in the validation of works.

Scotland

8.7.15 There is no specific variation to the above means of deriving policy for Scottish assets.

8.8 Overall Planning Process

Top-Down Process

8.8.1 NR have confirmed in the various meetings that the work which was undertaken centrally was effectively an iterative process between the development of the Tier 2 buildings model and the drafting of the policy documentation. The Policy document itself, in its outcomes, was largely a product of the modelling to varying degrees. In effect, the optimised model outputs based on the delivery of the requirements were built into the Policy.

8.8.2 As described previously the model contained a number of elements or varying degrees of sophistication depending on the quality and coverage of the asset data. These were:

- Reliant on OPAS data and the developed degradation / intervention curves; or
- The roll forward of historical volumes; or
- The extrapolation of sampling.

8.8.3 Based on the above level of central analysis the top-down models were disaggregated to the Routes.

8.8.4 For the franchised station critical blocks the top-down model provided a high level of detail including individual schemes which could then be married directly to the workbank. For other building types, where the asset data is of lesser quality, volumes were developed at activity level, for example, inspection, domestic re-wiring etc. Block allocations were also made with regard to those building types where a roll-forward of previous year's activity was dictated by policy.

8.8.5 As a result of the modelling, there is an acknowledged shift in the profile of work to be undertaken during the course of CP5. The effect of the degradation / intervention modelling has resulted in a greater focus on maintenance and less on renewal. This is confirmed in the breakdown of the planned expenditure and acknowledged both centrally and in the Routes. It is fair to say that this change in approach contained in the policy has propagated through to volumes of activities in the workbanks.

8.8.6 For the more generic policy statements relating to the non-station buildings the impact on the types of activity undertaken and the associated volumes would appear to be much less since it is based on the rolling forward of previous activity levels.

Bottom-Up Process

8.8.7 As described previously the bottom-up process was largely reliant on the asset knowledge held at local level supported where applicable by the condition data and defect reports held in OPAS.

8.8.8 The differing level of maturity in the Routes meant that the bottom-up process varied considerably. At the extremes a mature workbank was already available (an effectively unconstrained workbank) which could be utilised, and at the other end of the scale there was extremely limited confidence in the asset data already held which could generate a workbank. It was therefore necessary for the Route team to visit individual sites to generate a list of schemes.

8.8.9 In generating the bottom-up workbanks there was general acknowledgement of the Policy and the need for compliance, for example in terms of the proposed works at franchised stations where ARS or PARL thresholds are to be considered.

8.8.10 Individual schemes within the local plans were spread across the years of CP5 based on priority and consequences using local judgement.

Generation of the Plan

8.8.11 Routes were provided with the modelled volumes ahead of their submissions. This in effect gave them an indication of their potential levels of spend, in some cases ahead of any development of works items. The Routes then created their workbanks which were informed with the unitised rates developed centrally to provide a costed plan.

8.8.12 From this initial meeting of top-down and bottom-up figures a period of dialogue between the Route and the Centre regarding the volumes and expenditure took place. These challenge sessions were essentially structured around the Centre seeking justification from the Route over their proposed plans. This challenge focussed on linkage to Policy and justification of deviations from Policy and modelled spend levels where sought by the Route.

8.8.13 For the managed station portfolio, NR claimed that a review was undertaken on the outputs of the bottom-up workbank volumes by running this through the Tier 1 model. This was claimed to validate the sustainability of the plan. It was not provided as part of the SBP submission and has not been reviewed as part of this study.

8.9 Systems Approach

8.9.1 There is only limited reference in the policy to other engineering disciplines and TOC involvement in the process of setting policy and the development of the workbanks.

Train Operators

8.9.2 In challenging the degree of interaction with the train operators, NR stated that there had been no direct involvement of the TOCs in the development of the policy and since its drafting, there has been no attempt to circulate it for comment to the operators. It was however acknowledged that there had been some discussions at Industry Strategic Planning (ISP) level regarding the policy and its implications.

8.9.3 The means of linking the TOCs into the process was seen by NR as being done through the direct contact that the RAMs have with their counterparts in the TOCs. These dialogues are used as the forum to identify plans coming forward from the operators and as a forum for NR to share their significant planned works. As such interaction with the TOC will feature in the plan through the generated workbank.

8.9.4 It was noted that at the managed stations there are monthly liaison sessions with the relevant TOCs to share plans regarding the individual locations.

Other Asset Disciplines

8.9.5 No evidence has been seen or offered to demonstrate the linkage from the Buildings Policy [Ref. SBPT3016] to other asset disciplines and vice versa. There is clearly a potential interface between the activities undertaken by various disciplines. The direct impact of enhancement works on individual station blocks, for example the introduction of overhead line equipment masts and their interface with a station canopy, are not specifically dealt with in the Policy. However, it has been acknowledged by NR that in general the work associated with buildings has potentially less impact on the wider rail infrastructure than would say an underbridge renewal. Despite this, enhancement works affecting, for example, the rationalisation of signalling control, will have an impact on the quantum of buildings and this is acknowledged in the plan but not specifically in the Policy.

8.10 Risk

8.10.1 The risks associated with the building elements of the SBP operate at various levels, namely:

- Risk of failure;
- Risk of delivery (see Section 7.11 of this report); and
- Risk of pricing (see report Ref. Arup 2013d).

8.10.2 For the purposes of this section of the report consideration has only been given to the risks associated with the failure of the assets and the linkage to policy.

Franchised Stations

8.10.3 As described previously for franchised stations, the means of developing the optimised Policy has taken account of a measure of safety and its potential impact in the use of the ARS. ARS is calculated from data in OPAS and takes account of the safety critical nature of the asset and the impact of its failure. It is used as one of the thresholds triggering intervention (along with PARL). These are taken into account when considering all of the safety critical blocks at the franchised stations. Their applicability to these blocks is a further prioritisation in terms of the relevance to passenger safety. With the policy a judgement is made between the level of ARS at which intervention is triggered, the cost and the impact on PARL.

8.10.4 In developing the intervention regimes which demonstrate the most efficient levels of intervention and best value for money, the levels at which intervention takes place are at relatively low levels of PARL. This places a significant onus on the asset stewards to have sufficient knowledge of their portfolios to be able to intervene at an appropriate time. We are not clear how the proposed intervention levels proposed in the Policy relate to the current level of activity and whether there is a greater level of management input required to achieve this. However, to gain the benefits from ‘sweating the assets’ does require appropriate management systems in place since the system is operating at reduced tolerances.

Light Maintenance Depots

8.10.5 At LMDs the critical blocks are treated in a similar fashion to that for franchised stations.

Other Building Types

8.10.6 When considering the other building types and those non-critical blocks within franchised stations and LMDs no specific account has been taken of the risks of failure in the Policy. However, the reliance on the rolling forward of historical activity volumes and the reliance on a level of local knowledge of the asset portfolio could be considered as a proxy for the management of risk.

8.10.7 There is no clear account of how safety is being considered in the Policy other than to link the activity planning to risks associated with the quality of the OPAS data and structural factors associated with delivery. We believe that improving OPAS data, as promised by the end of CP4, will clearly facilitate this.

8.11 Deliverability

Policy Impact

8.11.1 The Policy applied to the building assets is not radically different to that which went before. The current version however includes a refinement in the assessment of the degradation and intervention relationships. Conversely, in a lot of the areas the Policy is merely a rolling forward of historic volumes in the absence of detailed asset information. This would tend to imply deliverability.

8.11.2 As has been identified earlier, the impact of the Policy for the franchised stations has been to move the focus activities away from large scale renewal to more emphasis on maintenance and lower levels of renewal. On the basis it is considered that more frequent lower level activities should be easier to deliver and present less of a deliverability risk.

Site Delivery

8.11.3 The responsibility for the delivery of the work associated with the buildings portfolio rests with the Routes and the RAM in particular.

8.11.4 It is claimed that there have been reviews of the volumes internally within NR to provide a degree of confidence that the plan is deliverable. This has involved teams from Asset Management and Investment Projects. In discussions with IP representatives at the Route meetings they have advised that they wish to take an overview of the Route Plan workbanks across disciplines and seek to bring synergy to their delivery. This holistic assessment is at an early stage. The general view of the Route teams is that the volumes in the programme are not radically different to the CP4 levels and thus delivery is not considered to be a risk.

8.11.5 It should also be noted that in general deliverability of the buildings works is less reliant on scarce resources than some other disciplines.

8.11.6 Information provided by the Routes indicates that there is currently little concern regarding the industry's ability to deliver the volumes which have been included in the SBP.

8.11.7 In assessing the overall deliverability of the planned volumes we have not identified any significant risks due to the foregoing and the less specialist nature of building works.

8.12 Continuous Improvement

Research and Development

8.12.1 As described earlier, NR commissioned the work by the BRE to help develop a set of degradation curves associated with the decline of the condition of various asset types. It has been stated by NR that this work is the first of its kind covering the types of assets which make up its buildings portfolio. The resulting profiles have formed the basis of the development of the volumes of activity contained in CP5 for the building types covered by the analysis.

8.12.2 Whilst this work has been applied in the Policy to the critical assets at the franchised stations and LMDs only, it is the intended to roll this out to the wider buildings portfolio once more complete asset information is gathered. In this regard, the NR stated aim of having detailed surveys for each building in the portfolio by the end of CP4 is important.

8.12.3 It has been stated earlier that the long term projection for the PARL measure shows a significant improvement. NR have stated that it is intended that this is purely because of the tolerances in the model and that it will be refined in the light of emerging results. This is likely to impact on the PARL and ARS thresholds for the various blocks in the future.

8.13 Robustness, Sustainability and Cost

8.13.1 We have been asked to consider the degree to which NR have demonstrated that the Asset Policies are robust, sustainable[24] and the degree to which the Asset Policy has been demonstrated to deliver the required outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.[25]

Targets

8.13.2 There are two key targets identified by NR in their SBP for buildings:

- The annual number of 2 and 24 hour reactive faults (robustness); and
- The maintenance of asset condition (sustainability).

8.13.3 The rate of reactive faults is specified at a level of 5,268 incidents per annum in the SBP [Ref. SBPT101, Page 69]. This is the same level of CP4.

8.13.4 The measure of sustainability is the maintenance of the level of PARL at the exit level of CP4. Modelling undertaken by NR have forecast the relevant PARL score at the start of CP5 for the critical blocks in the franchised stations. There is no clear target set for the condition of the non-station assets since whilst the overall objective of maintaining CP4 exit condition is stated this has not been forecast and therefore currently represents a moving target.

8.13.5 We consider that the articulation of the targets for both CP5 and beyond is clear. However, whilst there has been modelling to identify the CP4 exit value for a proportion of the portfolio the actual target for the remainder is not fixed and as such there is a level of uncertainty over its delivery.

Robustness

8.13.6 The Policy has been in development over some time and can be considered to be fairly mature in comparison to other Asset Policies. The Policy is characterised by the fact that there are a number of approaches relevant to each of the individual building types. This is primarily driven by the maturity of the asset knowledge held

[24] ORR letter dated 1st June 2010 (document ref. 379948)
[25] ORR-#430597-v1-20111028_ORR_PR13_Policy_review_note and Mandate AO/030.

centrally about the various building types and their relative importance in terms of the overall levels of spend.

8.13.7 The dominant building type is the franchised station which accounts for over half of the planned levels of spend. The policy in this case is based on the outputs from the Tier 2 model translated into volumes in Tier 1. The degradation / intervention regimes produced by the Tier 2 model are designed to maintain asset condition. Forecasts produced by NR demonstrate that over CP5 the critical assets covered by the modelling will largely maintain their PARL.

8.13.8 Whilst there is merit in the franchised station approach which has been adopted there remains some uncertainty associated with the composition of the degradation curves which form the basis of the modelling. We have commented on this previously under Mandate AO/017 in the IIP 2011 Review Summary Report – Observations and Conclusions [Arup 2011]. We believe that the volumes generated as a result of the modelling are more than are required leading to improved asset condition over the course of CP5. Following a review meeting on 12 April 2013 NR provided further information to support their modelling approach. We have been unable to fully consider this information as part of this review.

8.13.9 It should be noted that such modelling work is stated to apply to the critical blocks at the LMDs and this has been confirmed from our review.

8.13.10 Based on the discussions with the Routes we note that there has been a strong bottom-up element to the development of the LMD plan. In addition, the use of the degradation curve modelling for the critical elements of the LMD plan leads to our view that it is robust given our earlier comments on the modelling in 8.13.8.

8.13.11 NR consider that the limited number of managed stations means that they are able to directly monitor the rates of degradation and intervene as necessary to maintain condition. Thus, there is a reliance on a bottom-up approach to the generation of activity volumes which do not appear to have been constrained by 'top down' direction. We believe this approach may lead to more work being undertaken than otherwise would have been planned, maintaining the asset to a higher level of service than may be required. It is our view that there is some uncertainty with CP5 volumes.

8.13.12 The findings of a NR surveyed sample of the lineside buildings portfolio have been evaluated in order to determine activity and develop the Policy. This has then been extrapolated across the national portfolio. This approach would appear to be reasonable given the lack of asset data; however, the impact on the condition of this regime cannot be determined from available information. Therefore there is some uncertainty over the delivery of the outputs with respect to lineside buildings.

8.13.13 The remaining building types rely on historic spend levels. With these buildings there is a lack of credible evidence to support the outcomes of the steady-state funding during CP4 resulting in some uncertainty regarding how this level of activity will impact on condition in CP5 in order to maintain the CP4 exit asset condition.

Sustainability

8.13.14 NR recognise that their current levels of asset data, particularly for the non-station building types, require enhancement and have committed to populate OPAS with detailed survey data for all of the building types by the end of CP4.

8.13.15 We consider that the improvement of buildings asset data will considerably enhance the potential to forecast building condition in the long-term if an appropriate model is applied.

8.13.16 We are of the opinion that the management approach proposed for station buildings (franchised and managed) is likely to be sustainable. Again the policy approach we believe provides for significant maintenance intervention and the long term performance of the assets should be ensured. For managed stations, NR claim that the sustainability is proved by a back-check of the bottom-up workbank they have carried out using the Tier 1 model. Evidence to support this was received following the review meeting on 12 April 2013 but we have not had the opportunity to consider this as part of the review.

8.13.17 For NR's other building assets (lineside buildings, MDUs) the lack of information on condition and impact of maintenance make the long term performance of the Policy less clear. The level of information on the performance and value of maintenance expenditure needs to be improved in the next Control Period to fully understand the effect of the management approach to these assets.

Whole System Cost

8.13.18 It has been mentioned previously that we have concerns regarding the way in which the Tier 2 model considers benefits. This is in regard to the fact that it operates as a net present cost (NPC) rather than a net present value (NPV) model. The impact of this is that renewals are deferred leading to the potential overall decline in asset condition over time and greater reliance on management intervention.

8.13.19 We do not consider the use of NPC to be appropriate in the Tier 2 model since the benefits of renewal are not fully taken into account; however, it is acknowledged that the Tier 1 model has a role in this.

8.13.20 The use of a greater number of minor interventions to push renewals further into the future means that it is likely that the whole system costs of these critical assets will not be optimised. We have not been able to validate this whilst cost breakdown data is not available.

8.13.21 In addition, the current Policy associated with the non-station assets offers no demonstration of long-term delivery of the objectives. We therefore have moderately high uncertainty that the Policy for these assets will deliver lowest whole life, whole system cost. We acknowledge however that this approach may be replaced as a result of the improved asset information.

Efficiency

8.13.22 Delivery efficiency is claimed from:

- Further development of OPAS;
- Improved planning of works taking account of improved packaging;
- Economies of scale when work is packaged;
- Adoption of Performance Specifications for tendered works;
- Reduction in overhead costs;
- Closer working relationship with TOCs; and
- Innovation.

8.13.23 NR forecast that these will deliver a 16% efficiency gain over the course of the Control Period.

8.13.24 At Route meetings the Routes' ability to deliver the stated efficiencies was tested. The individual Route efficiency profiles varied considerably. A commentary on the deliverability of the efficiencies is contained in accompanying report [AO/035 Arup 2013d].

Embedded Efficiency

8.13.25 NR have indicated [Ref. SBPT220, Table 2] that they expect to save £66m as a result of embedded efficiencies. This is forecast to come from *"significantly improved asset data and modelling"*. No further detail has been provided as part of the SBP submission on how this has been calculated.

8.13.26 As part of our IIP review, NR shared a brief paper, 'Embedded Efficiencies Report Buildings' [Ref. NR December 2011] which provided an account of the means by which the embedded efficiencies of £66m were calculated.

8.13.27 We have uncertainties regarding the process by which these embedded efficiencies have been calculated based on the information provided in the paper. Principal amongst these concerns is a lack of objective evidence that the process which has been adopted is credible. The description of the process adopted lacks detail and does not provide objective evidence to validate the approach. There is a lack of clarity on the baseline adopted, the datasets used in the exercise, and the challenge and review process adopted. We are unclear about which new practices are being introduced to generate the efficiencies. Finally, the paper describing the process is over a year old and has clearly not taken account of the recent versions of the Building Policy volumes.

8.14 References

Ref	Document Title	Version / Date
Arup 2011a	Mandate AO/017: Initial Industry Plan (IIP) 2011 Review Summary Report Observations and Conclusions	Issue 1 16 December 2011
Arup 2012a	Data Assurance 2011-2012 Station and Depot Stewardship	Final May 2012
Arup 2012b	Mandate AO/028 Asset Data Quality	Draft Final 7 December 2012
Arup 2013a	Mandate AO/030 Buildings WLCC Model Review – AO/030/2C	Draft A
Arup 2013b	Mandate AO/030 Buildings Tier 1 Model Review – AO/030/3D	Draft A
Arup 2013c	Mandate AO/034 Costs	Draft A
Arup 2013d	Mandate AO/035 Efficiency	Draft A
BRE 271-023	BRE Support to Network Rail CP5 Submission - Executive Summary	14 June 2011
SBPT220	Efficiency Summary	Version 2
SBPT223	Renewals Expenditure Summary	Version 1.0
SBPT3016-1	Buildings Asset Policy Volume 1 – (Fabric Policy)	Final – November 2012
SBPT3016-2	Buildings Asset Policy Volume 2 – (Mechanical and Electrical Asset Policy)	
NR 2013a	SSM and LMDSM CP5 Forecast	
NR 2013b	Remit for Condition Surveys and Data Capture on lineside Buildings for CP5 Submission	

9 Drainage Asset Policy

9.1 Performance Requirements / Outputs

9.1.1 The NR SBP submission includes a CP5 Drainage Asset Policy [Ref. SBPT3017] which explains NR's proposed management approach for drainage including earthworks, track and tunnel drainage assets. Drainage is intimately linked to these assets. This linkage is discussed in the Track and Earthworks sections.

9.1.2 The Drainage Policy document concentrates on the track and earthworks drainage, as this forms the majority of the drainage asset and is where the majority of drainage maintenance and renewals monies are currently spent. Further details of these assets are given in the Track Asset Policy [SBPT3010] and CP5 Earthworks Asset Policy [SBPT3015a].

9.1.3 Tunnel drainage is part of the earthworks asset portfolio, although the tunnels themselves are within the structures asset portfolio. Culverts are considered within the Structures Asset Policy [SBPT3013]. NR note that all other drainage assets are considered within the relevant parent asset Policy – for example station drainage is part of the Buildings Asset.

9.1.4 In terms of 'performance' the Drainage Asset is considered by NR as a 'servant' asset such that it supports the reliable delivery of other asset types, primarily Track and Earthworks.

9.1.5 The NR Earthworks Asset Policy [Ref. SBPT3015a] summarises earthworks reliability trends and NR have analysed earthworks failure data between 2004 and 2012, a summary plot is presented in Figure 9-1 below.

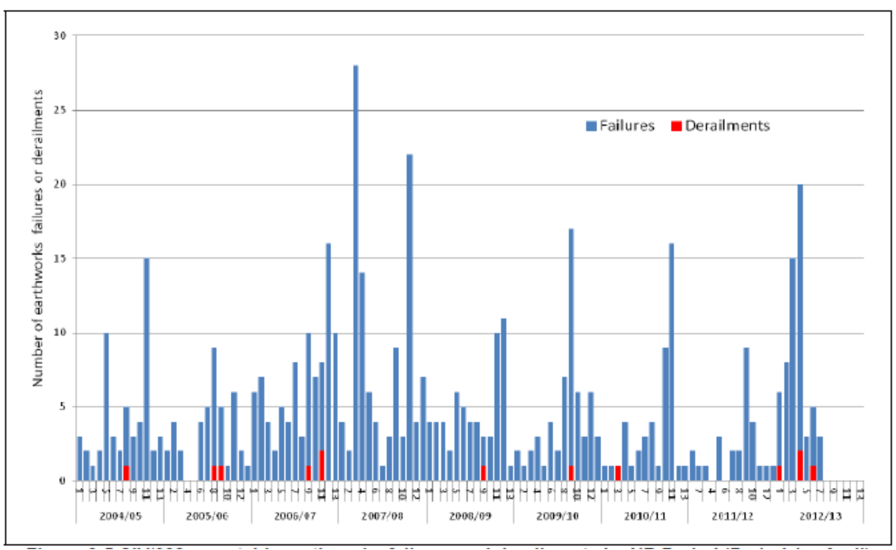


Figure 9-1: Reportable Earthworks Failures and Derailments 2004-2012

9.1.6 NR note that 80% of failures are related to high rainfall. They also note that for derailments between 2007 and 2012, it is estimated that 50% were directly attributable to inadequate earthworks drainage.

9.1.7 No national data on track formation failures due to poor or inadequate drainage is presented in the Policy. However, one Route – Western, in their Route Plan [Ref. SBPT219] does set out historic drainage performance and associated costs – see Figure 9-2 below. This is very useful as it provides evidence as to the potential benefit from drainage works.

Drainage performance – flooding incidents

Year	No. of Flooding Incidents	Delay Minutes	Schedule 8 Costs
2009/10	24	5,084	£239,318
2010/11	16	11,361	£762,140
2011/12	8	2,549	£189,399
2012/13 (as at 12/09/2012)	32	8,724	£642,808

Drainage performance – wet beds

Year	No. of Recorded Wet Beds (Closed Out)	Cost (Manual Removal)	Cost (Mechanical Removal)
2009/10	1,536	£1,239,785	£469,518
2010/11	1,627		
2011/12	1,534		
2012/13 (as at 11/09/2012)	909		

Figure 9-2: Drainage Performance – Western Route 2009-2012 [Ref. SBPT219]

9.1.8 There are no specific drainage related measures reported in the NR Annual Return. However, in the 2012 Annual Return, NR included volumes for drainage renewals for the first time.

Table 4.30: Expenditure on drainage renewals

£ million	*2009/10*	*2010/11*	*2011/12*
England & Wales	5.04	9.20	11.26
Scotland	0.42	1.07	2.26
Network Total	**5.46**	**10.27**	**13.52**

Table 4.31: Volumes of drainage renewals

	Volume of Drainage renewals undertaken (yds)	*Volume of drainage pipes cleaned (yds)*	*Volume of catchpits cleaned out (number)*
England & Wales	34,033	182,747	72,837
Scotland	11,489	36,771	12,247
Network Total	**45,522**	**219,518**	**85,084**

Figure 9-3: Drainage Renewals, Expenditure and Volumes [Ref. Network Rail Annual Return 2012]

9.1.9 The Renewals Expenditure Summary document [Ref. SBPT223] indicates (Figure 9-4) that in the last year of CP4 approximately £30m will be spent on Track Drainage and £20m on Earthworks Drainage. The plot shows this rising to approximately £40m and £30m per annum respectively in CP5.

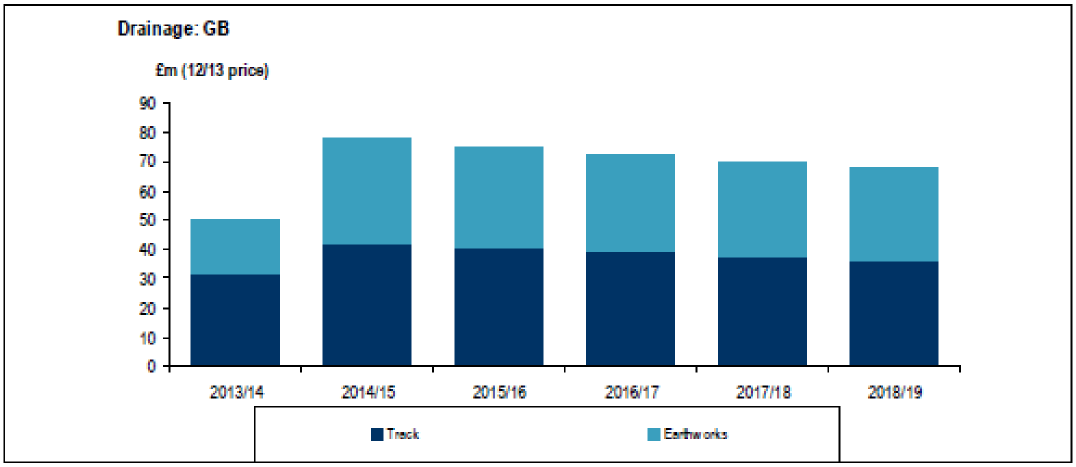


Figure 9-4: Drainage Renewals Expenditure Summary [Ref. SBPT223]

9.1.10 NR note that historically the drainage asset has been renewed and maintained as an integral part of the renewal and maintenance of the track, earthworks, structures and buildings assets. Furthermore they note that with current NR accounting practices it has not been possible to reliably disaggregate the costs or volumes of drainage works to obtain historic total drainage expenditure.

9.1.11 NR note that further work is required to establish new procedures within NR's existing processes that will provide more visibility and granularity of drainage costs and volumes for the future.

9.1.12 NR have proposed a list of Earthworks Drainage Measures as Key Performance Indicators for the drainage asset in CP5 – see Figure 9-5. These comprise proposed performance measures for high level outputs, capability, safety and availability. These ‘piggy back’ on the earthworks measures detailed in the Earthworks Asset Policy [Ref. SBPT3015a].

9.1.13 It is noted that there are currently no regulatory targets set for the volume of renewal activity and that any CP5 targets (regulated or otherwise) have yet to be defined.

9.1.14 In the SBP documentation that we have reviewed, we have not identified a clear summary of outputs / activities that are to be undertaken in CP5 based on the Drainage Policy. A number of Routes (e.g. Sussex) have identified specific large drainage projects to be undertaken in CP5 (e.g. drainage renewal of 1km of track drainage to alleviate formation and track geometry problems).

Measure type	Measure	Measure definition	Lead / lag	Reporting	CP5 target
High level output - short term measure	Geotechnical Stewardship Indicator (GSI) - Earthworks drainage condition measure	The percentage of serviceable, marginal and poor 1/8th mile sections of those that have earthworks drainage, where the condition of each 1/8th of a mile is determined by the overall condition (ie combination of service and structural condition) of the single worst earthworks drainage asset in that 1/8th of a mile.	Lead	Periodically	To be defined
Capability	Earthworks drainage condition	a) Percentage of earthworks drainage assets in each of structural grade 1 to 5. b) Percentage of earthworks drainage assets in each of service grade 1 to 5.	Lead	Periodically	Measure only
Safety	Track & earthworks drainage inspections progress	% of 1/8th of a mile drainage sections (track and earthworks drainage) inspected for the year to date		Tracked periodically Reported annually	Measure only
Safety	Track & earthworks drainage surveys progress	% of drainage assets (track and earthworks drainage) surveyed for the year to date against the annual target		Tracked periodically Reported annually	Measure only
Safety	Earthworks reporting confidence factor	The quality of dynamic data from earthworks drainage inspections and surveys, and earthworks examinations complies with the requirements of the Asset Data Quality Measures (currently being developed)	Lag	Periodically	Measure only
Availability	Flooding delay minutes	Number of delay minutes caused by flooding (TRUST code 110) per year	Lag	Tracked periodically Reported annually	Measure only
Availability	Flooding CaSL	% of trains arriving 30+ minutes late or cancelled due to flooding (TRUST code 110)	Lag	Tracked periodically Reported annually	Measure only

Figure 9-5: Earthworks Drainage Measures [Ref. SBPT3017, Table 10.2]

9.2 Line of Sight

9.2.1 As set out in the Strategic Business Plans for England & Wales and the Strategic Business Plan for Scotland [Ref. SBPT101, SBPT102], NR have developed a series of asset output measures for the major asset disciplines (track, signalling, electrical power, buildings, structures and earthworks). These measures have been proposed by NR to assess:

- "Robustness: whether our assets will deliver the required outputs;
- Sustainability: whether our asset policies continue to deliver the outputs over the longer term."

9.2.2 There are no specific high level asset measures for Drainage as it is seen as a 'servant' asset supporting delivery of the earthworks and track. The specific high level earthworks and track measures for 'robustness' and 'sustainability' are set out below.

Robustness measures	CP4	CP5
Track		
Failures > 10 mins	9,364	9,451
Signalling		
Failures > 10 mins	12,053	12,053
Telecoms		
Failures > 10 mins	519	519
Electrification and Plant		
Failures > 10 mins	671	736
Buildings		
2 and 24 hour reactive faults	5,268	5,268
Structures		
Open risk items with risk score >20	291	218
Earthworks		
Robustness	Under development	

Figure 9-6: Robustness Measures [Ref. SBPT101, 102, 232]

Asset	Sustainability measure
Track	Used life (%)
Signalling	Remaining life (years)
Telecoms	Remaining life (%)
E&P	Remaining life (%)
Buildings	Remaining life (%)
Structures	Condition score for principal load bearing elements (bridges)
Earthworks (GB total)	Earthworks Risk Index

Figure 9-7: Sustainability Measures [Ref. SBPT101, 102, 232]

9.2.3 For earthworks the 'robustness' measure is noted as being 'under development'. In terms of earthworks 'sustainability' NR are proposing to adopt a 'Risk Index'. This is discussed in Section 7 of this report.

9.2.4 The track measures relate to *'Failures > 10 mins'* and *'Used life (%)'* for robustness and sustainability respectively. These are discussed in Section 5 above.

9.2.5 The cross-asset impacts of drainage are shown in Figure 9-8 below.

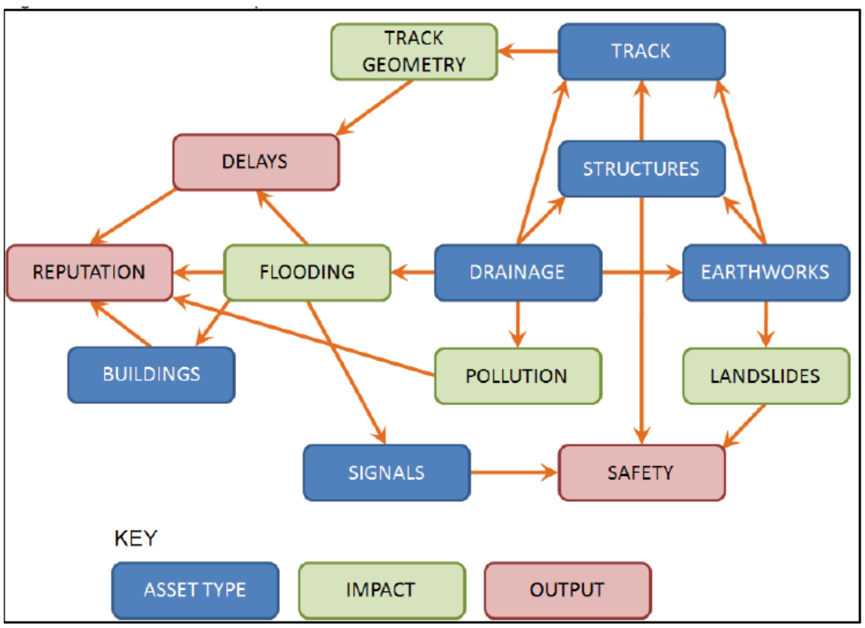


Figure 9-8: Cross Asset Impacts [Ref. SBPT3017]

9.2.6 We note that NR have evaluated a number of drainage studies to try to obtain quantitative evidence of the cost benefits of drainage works in reducing the volume and cost of track renewals and maintenance. Key findings from these studies include:

- On average, track with inadequate drainage has 4.5 times more wet beds per mile than track with good drainage;

- Track with inadequate drainage requires three times more tamping than sites with good drainage;
- Track with inadequate drainage requires three times more stone blowing than track with good drainage;
- Track with inadequate drainage requires on average twice as much manual lifting and packing as track with good drainage; and
- Track with inadequate drainage has 50% more twist faults than track with good drainage.

9.2.7 There is no quantitative data in the Drainage Policy that gives any indication of the exact improvement that will be accrued in CP5 from the drainage expenditure. Accordingly, our opinion is that it is highly uncertain what exactly the targets are for the Drainage Asset in CP5.

9.2.8 However, we consider it very likely that the implementation of the proposed Drainage Policy will help reduce the number of track failures and earthworks risk index in the medium to long-term.

9.3 Asset Knowledge

9.3.1 NR defines the railway drainage asset as:

"including all components designed to collect surface and groundwater which runs towards, falls onto or issues from the railway asset, and deliver it to a suitable outfall, whether that be a river or stream, a public sewer or a soakaway. The drainage asset includes all of the following:

- *Earthworks drainage (of both surface and groundwater)*
- *Track drainage (of both surface and groundwater)*
- *Tunnels drainage (of groundwater)*
- *Structures drainage (of both surface and groundwater)*
- *Stations, depots and other buildings drainage (the surface and subsurface drainage components, including foul and waste water disposal but excluding above ground gutters and downpipes)*
- *Third party connections to and from the NR drainage asset are identified and the associated risks are managed as part of the asset drainage system to which they are connected"*

9.3.2 Since IIP, NR have undertaken the Integrated Drainage Project (IDP) to improve their drainage asset knowledge. This included:

- A review of available drainage data held centrally and with the routes. This identified that there was acceptable drainage asset data for about 35% of the NR network from previous surveys (JBA Data and Western Data);
- A national walkover survey of the remaining 65% of the network (termed ADAS data);

- Establish a national drainage database within the Ellipse maintenance system to hold the asset inventory and condition information;
- Migrate the data from the previous JBA and Western databases into Ellipse; and
- Prepare plans for each ten chain section of the NR network showing the above information on the drainage asset.

9.3.3 SBP analysis has been based on a data cut taken from the Ellipse database on 23 August 2012. At that time, NR note that not all the existing data had been migrated into Ellipse and not all the ADAS data was in Ellipse. The drainage data coverage at 23 August 2012 is shown in Figure 9-9 below.

9.3.4 We understand that the SBP was based on extrapolation of the data for sections of the network not in Ellipse at time of the data cut – this is referred to as the 'virtual inventory' and is summarised in Figure 9-10 below.

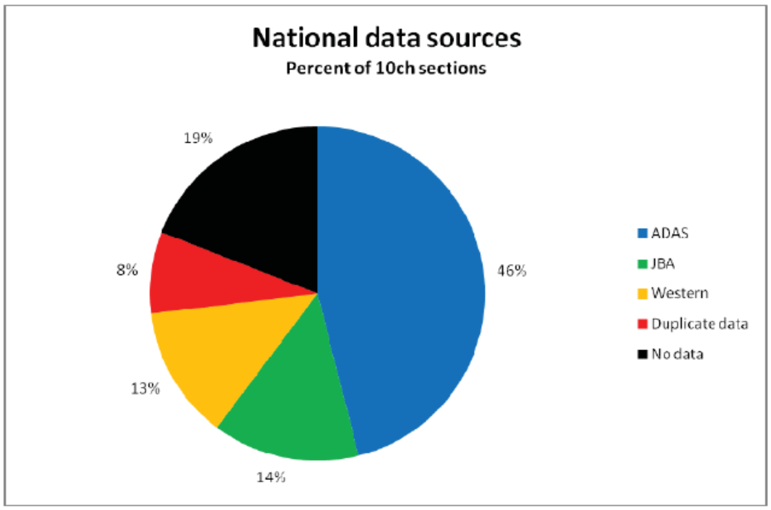


Figure 9-9: Drainage Inventory Data Coverage (at 23/08/12) [Ref. SBPT3017]

Owner	Inventory item	Units	Number	Length (km)
Earthworks	Chamber	Number	10,048	
	Channel or ditch	Length		1,641.4
	Granular drain	Length		19.4
	Inlet or outlet	Number	17,106	
	Outfall	Number	5,150	
	Pipe	Length		299.7
	Pond	Number	323	
	Pumping station	Number	18	
	Small culvert	Number	958	
	Soakaway	Number	541	
	Virtual node	Number	25,446	
Structures	Large culvert or syphon	Number	12,160	
Track	Chamber	Number	145,759	
	Channel or ditch	Length		1,557.0
	Granular drain	Length		9.8
	Inlet or outlet	Number	3,704	
	Outfall	Number	1,534	
	Pipe	Length		3,502.7
	Pond	Number	21	
	Pumping station	Number	41	
	Small culvert	Number	3,177	
	Soakaway	Number	262	
	Virtual node	Number	21,463	

Figure 9-10: SBP National Virtual Drainage Inventory (at 23/08/12) [Ref. SBPT3017]

9.3.5 A comparison between the SBP and IIP virtual inventories is shown in Figure 9-10, which clearly shows the significant discrepancies and the importance of the IDP survey work in more clearly understanding the railway drainage assets. It is noted that the IDP survey resulted in much fewer underground drainage assets than was assumed at IIP stage.

9.3.6 *Redacted*

9.3.7 Since our IIP Review in December 2011 [Ref. Arup 2011a], NR have continued to improve their asset knowledge. Specifically they have undertaken a national walkover survey of the remaining 65% of the network which has no data. This has allowed NR to have a much more reliable inventory including minor assets (inlets and outlets, ponds, pumping stations and soakaways) that were unknown at IIP.

9.3.8 However, there is still some uncertainty associated with the quality of the drainage asset inventory.

9.3.9 NR have assessed both the Structural Condition and the Service Condition of their drainage assets. These are defined as:

- Structural Condition: relates to the fabric of the asset and the severity of the structural defects that affect its integrity. Structural defects are addressed by repairing or replacing the asset.

- Service Condition: relates to the water carrying capacity of the asset and the severity of the defects that reduce its capacity below its original design level, but is independent of the structural condition. Service defects are addressed by maintenance of the asset such as cleansing or vegetation clearance.

9.3.10 For pipework a 1-5 grading system has been adopted by NR based on CCTV survey guidance with grade 1 being 'as new' and grade 5 being 'failed, blocked, not fit for purpose or unsafe'. NR have extended the 1-5 grading system to all of their drainage assets. NR note that the system adopted is compatible with CIRIA RP941[26].

9.3.11 The performance of the drainage asset (amount of water it can carry) is also linked to size, gradient and roughness. All these can be affected by condition factors.

9.3.12 The ADAS surveys included assessment of the condition of all surface visible drainage assets identified (but typically the condition of pipes will not be assessed). Accordingly, NR note that condition could not be assessed for a significant proportion of the surveyed assets (just over 40%).

9.3.13 In the future NR intend to determine pipework condition over a period of years through the cycle of detailed defect surveys using CCTV, or equivalent technology.

9.3.14 Based on data available, NR have assessed that the service condition profile is significantly worse than the structural condition profile:

- For the structural condition 83% of assets are serviceable (grades 1 or 2), 14% are marginal (grade 3) and 3% are poor (grades 4 or 5); and
- For the service condition 63% of assets are serviceable (grades 1 or 2), 21% are marginal (grade 3) and 16% are poor (grades 4 or 5).

9.3.15 The NR 'drainage panel of experts' have combined structural condition and service condition as shown in Figure 9-11 below.

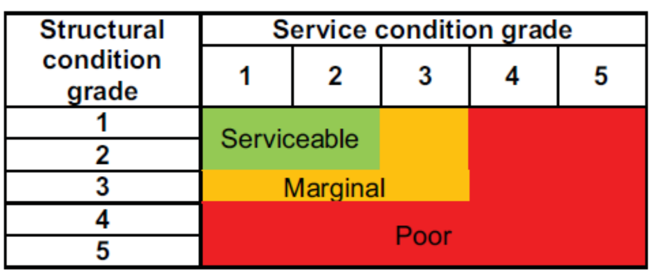


Figure 9-11: Overall Condition Calculation [Ref. SBPT3017]

9.3.16 Based on that combination the overall condition of the twelve drainage inventory groups has been calculated by NR as shown in Figure 9-12 below.

[26] CIRIA RP941 (2013 in press) Transport infrastructure drainage: condition appraisal and remedial treatment.

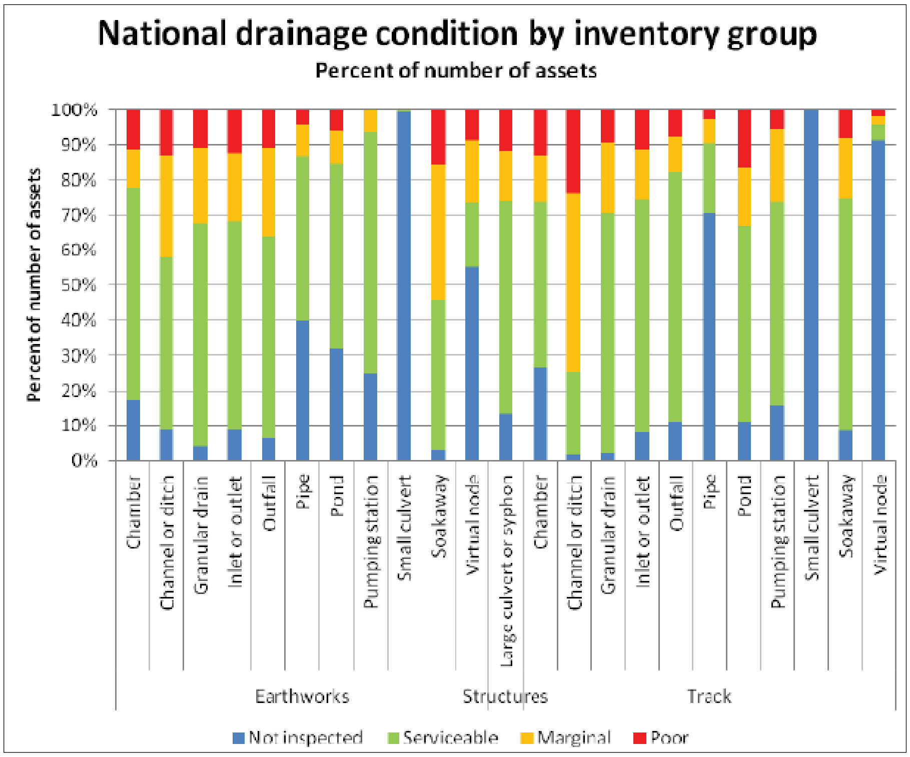


Figure 9-12: National Drainage Condition [Ref. SBPT3017]

9.3.17 We understand from the Policy [Ref. SBPT3017, Page 26] that at the time of preparing the SBP there was no overall condition data for Western and very little for Wales. Accordingly, they have omitted these Routes from Figure 9-12.

9.3.18 Although NR seem to have made good progress with drainage surveys since IIP we note that much of the condition of the drainage asset (over 70% of pipework for example) has yet to be determined. Our opinion is that there is high uncertainty associated with NR's understanding of drainage condition.

9.4 Asset Behaviour, Degradation and Criticality

9.4.1 The relationship between condition, capacity and performance of the drainage asset is clearly and logically set out in the Drainage Asset Policy in qualitative terms. Degradation is similarly explained qualitatively. The modelling work to date (see below) does not attempt to consider these factors quantitatively. This is not unreasonable given the state of knowledge of the drainage inventory and condition.

9.4.2 At the current time the NR drainage decision support tool (Drainage SCAnNeR) has been designed to derive volumes and costs only for CP5 and does not consider deterioration of assets in the longer term.

9.4.3 It is the intention that development of a drainage modelling capability integral within the track and earthworks WLCC models will replace drainage SCAnNeR and address this shortfall.

9.4.4 NR have adopted the same Track SRS Asset Criticality Bands as used in the Track Asset Policy when segmenting track drainage. These track criticality bands are shown in Figure 9-13 below.

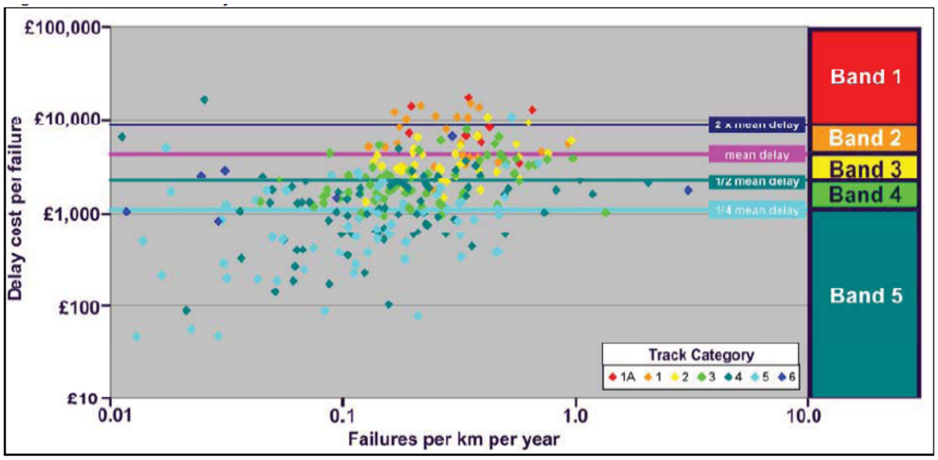


Figure 9-13: Track SRS Criticality Bands [Ref. SBPT3017]

9.5 Renewal and Maintenance interventions

9.5.1 As noted above in the 2012 Annual Return, NR included volumes for drainage renewals for the first time. The volumes are reproduced below (Figure 9-15) together with the expenditure.

9.5.2 NR have identified six generic intervention categories, namely:

- Inspect;
- Survey;
- Maintain;
- Refurbish;
- Renew; and
- New build.

Intervention category	Definition
Inspect	Routine inspection of the asset to assess its performance and identify locations requiring further intervention
Survey	Periodic detailed surveying of the asset to assess its condition (including the details of specific defects), capacity, inventory and physical attributes.
Maintain	Maintaining the performance of the asset by cleaning (de-silting, vegetation removal, root cutting etc) and minor repairs
Refurbish	Restoring the performance of the asset by major repair, local replacement or reprofiling
Renew	Wholesale replacement of the asset. May also include an element of asset improvement, for example to increase capacity to take account of future climate change.
New build	Installation of new assets to address a shortfall in drainage performance where there is currently no or insufficient drainage.

Figure 9-14: Drainage Intervention Categories [Ref. SBPT3017]

9.5.3 NR have qualitatively assessed the impact of intervention options on asset condition. This appears to have been derived from expert judgement.

9.5.4 As noted above, NR have a specific 'Maintenance Strategy' [SPBT 3169] and a development plan for optimising maintenance regimes [SBPT3004]. In relation to Civils assets the NR maintenance documents only relate to inspections and examinations (as these are treated as included within the maintenance funding provided in the control period pricing reviews). Other aspects of 'maintenance' such as planned preventative maintenance work are treated as 'renewals' by NR.

9.5.5 NR have assessed Drainage to be currently at 'Stage 1 – Historic regimes – intuitive consideration of Parameters of Risk' on the five stage 'Maintenance Regime' development scale [SBPT 3004]. Stage 1 for Drainage is described as *'Historically insufficient asset information to adopt risk-based approach'*.

9.5.6 NR are planning to reach Stage 3 by the end of CP4 and Stage 4 by the end of CP5. It is unclear what development is planned in this area in CP4/ CP5; however, as there is currently incomplete condition data for drainage (condition of over 70% of pipework has yet to be determined), we would consider it highly uncertain whether this trajectory can be achieved by NR.

9.5.7 For the Drainage asset it is highly uncertain what the impact of the proposed maintenance optimisation during CP5 will entail and its potential impact on the effectiveness of the Drainage inspections and surveys.

9.6 Asset Cost Data

9.6.1 Since the IIP submission, NR have undertaken much more detailed analysis of drainage and derived updated unit costs for the SBP submission. This work is summarised in the Control Period 5 Drainage Unit Costs Submission [Ref. SBPT3076b]. The analysis is comprehensive and considers various historic datasets including CAF, Monitor and Ellipse.

9.6.2 Two key areas of uncertainty are highlighted in the Asset Policy, namely uncertainties from the reliability and accuracy of the historic data sets and their treatment, and the applicability of the data analysis to future NR costs. Recommendations for further improvement are also presented.

9.6.3 The methodology in the pricebook regarding process and scope included with the rates appears logical and consistent. In meetings with NR they have demonstrated how these rates were derived from the historical data. However, at the time of writing the database has not yet been provided to enable a desktop study / check.

9.6.4 The CP5 Drainage Unit Costs document [Ref. SBPT3076b] notes that unit costs from historic data have had to be supplemented by costs from other sources including Highways Agency data. A NR 'drainage panel of experts' was also used to assess costs for some items where little or no data was available.

9.6.5 NR note that although a review of regional cost variations was undertaken, no consistent patterns were identified and national unit costs were adopted for drainage asset interventions.

9.6.6 NR have presented drainage unit costs as a range of figures, namely "best estimate", "minimum credible" and "maximum credible" – see Figure 9-15. These costs are accompanied by a relatively detailed explanation as to where the rates were derived from and what is covered in the rates. This is very positive.

9.6.7 It is noted that there is a high dependency on a small number of unit rates (e.g. for track drainage 96% of CAPEX value is based on just 3 out of the 59 different rates) and therefore there is a large dependency on the accuracy of these items.

9.6.8 The ranges given for these items between the 'Best', 'Minimum' and 'Maximum' values highlights that the actual costs for these works can vary considerably. For example the rate for renewing a pipe varies from £72.80/m to £1329/m with a quoted 'Best' figure of £414/m (note that 61% of the CAPEX spend for track drainage is associated with this item).

9.6.9 Accordingly we consider that there is moderately high uncertainty associated with the unit rates.

9.6.10 An initial review of the costs used in the Tier 1 Drainage SCAnNeR Model and the Tier 1 Earthworks SCAnNeR Model indicates that the drainage unit costs set out in Figure 9-15 seem to have been adopted.

Asset type	Unit	Inspect				Survey				Maintain				Refurbish				Renew				New build			
		IIP best	Best	Min	Max	IIP best	Best	Min	Max	IIP best	Best	Min	Max	IIP best	Best	Min	Max	IIP best	Best	Min	Max	IIP best	Best	Min	Max
Inspection	Route km	£445	£204	£204	£1,400	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Pipe	m	n/a	n/a	n/a	n/a	£2.00	£20.00	£1.00	£20.00	£3.45	£4.25	£3.81	£26.30	£207	£86	£72.80	£414	£207	£414	£72.80	£1,329	£207	£414	£72.80	£1,329
Catchpit	nr	n/a	n/a	n/a	n/a	[1]	[1]	[1]	£1,840	£16.85	£16.26	£5.36	£77.40	[1]	£1,073	£500	£1,077	[1]	£1,297	£1,091	£1,793	[1]	£1,297	£1,091	£1,793
Ditch or channel	m	n/a	n/a	n/a	n/a	£0.20	£0.20	£0.10	£0.30	£8.51	£9.54	£5.82	£34.01	£324	£356	£7.60	£356	£324	£289	£15	£289	£324	£289	£15	£289
Gravel drain	m	n/a	n/a	n/a	n/a	£0.20	£0.20	£0.10	£0.30	£3.80	£3.80	£0.03	£3.80	£324	£356	£40	£356	£324	£306	£40	£306	£324	£306	£40	£306
Small culvert (<0.45m)	nr [3]	n/a	n/a	n/a	n/a	£100	£100	£44.00	£250	£607	£247	£56	£1,669	£3,500	£3,500	£1,100	£10,500	£3,500	£3,500	£1,100	£10,500	£33,000	£33,000	£25,000	£50,000
Large culvert (0.45-1.8m)	nr [4]	n/a	n/a	n/a	n/a	£500	£7,663	£500.00	£7,663	£11,500	£333	£333	£11,500	£8,000	£26,079	£3,040	£56,401	£170,000	£140,534	£10,907	£220,000	£170,000	£140,534	£10,907	£220,000
Outfall	nr	n/a	n/a	n/a	n/a	£50	£50.00	£25.00	£4,685	£100	£100	£50	£500	£860	£4,773	£2,746	£14,907	£5,000	£4,923	£675	£10,000	£5,000	£4,923	£675	£10,000
Inlet	nr	n/a	n/a	n/a	n/a	£50	£50.00	£25.00	£4,685	£100	£100	£50	£500	£860	£4,773	£2,746	£14,907	£5,000	£4,923	£675	£10,000	£5,000	£4,923	£675	£10,000
Soakaway	nr	n/a	n/a	n/a	n/a	No data	£500	£500	£1,840	No data	£220	£220	£2,000	No data	£1,073	£500	£1,077	No data	£1,297	£1,091	£1,793	No data	£1,297	£1,091	£1,793
Pond	nr	n/a	n/a	n/a	n/a	No data	£1,500	£500	£3,000	No data	£35,000	£10,000	£100,000	No data	£2,000	£1,500	£50,000	No data	£100,000	£50,000	£250,000	No data	£100,000	£50,000	£250,000
Pollution mitigation device	nr	n/a	n/a	n/a	n/a	£50	£50	£25.00	£4,685	£110	£110	£110	£1,000	£500	£500	£250	£1,000	£3,000	£3,000	£1,350	£6,000	£3,000	£3,000	£1,350	£6,000
Pumped system	nr	n/a	n/a	n/a	n/a	No data	[2]	[2]	[2]	No data	£3,000	£2,000	£5,000	No data	£3,750	£2,000	£7,500	No data	£100,000	£50,000	£150,000	No data	£100,000	£50,000	£150,000
Other	nr	No data – ignored at this time																							

[1] assumed to be included in rates for pipe interventions
[2] assumed to be included in regular maintenance visits
[3] average small culvert length assumed to be 22.2m – where a unit cost per m is required, divide per culver cost by 22.2
[4] average small culvert length assumed to be 30m – where a unit cost per m is required, divide per culver cost by 30

Source:

- CP5 Drainage Asset Policy Table 6.5 (IIP)
- CAF dataset unit cost analysis
- Ellipse dataset unit cost analysis
- Monitor dataset unit cost analysis
- Combined dataset unit cost analysis
- Small / large volume unit cost analysis
- Drainage panel of experts assessment
- External benchmarking assessment (further to IIP)

Figure 9-15: Drainage Unit Costs for CP5 [Ref. SBPT3076b]

9.7 Policy Selection and Preferred Lifecycle Options

9.7.1 NR have considered five policies each being a mix of intervention options. The policies (A, B, AB, C and D) are schematically shown in Figure 9-16.

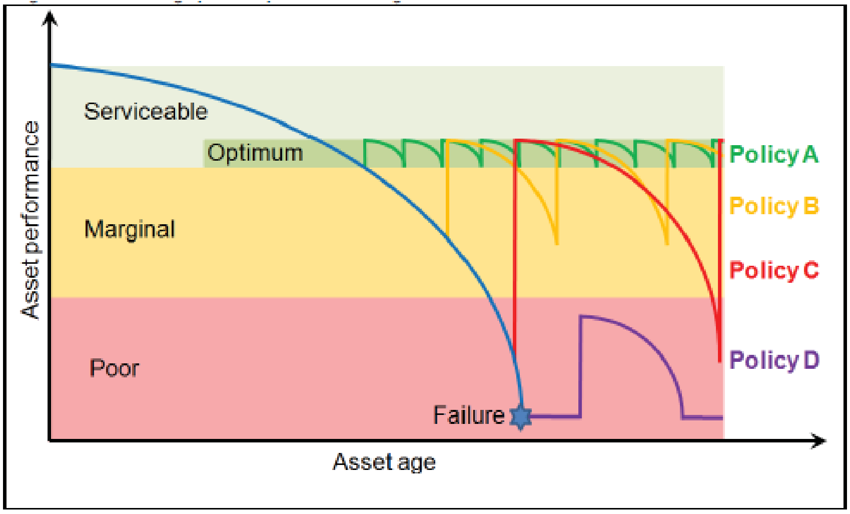


Figure 9-16: Schematic Representation of Drainage Policies [Ref. SBPT3017]

9.7.2 The five policies are:

- Policy A - Proactive optimum;
- Policy B - Proactive minimum;
- Policy AB - Proactive;
- Policy C - Reactive, operational safety and performance driven; and
- Policy D - Reactive, non-operational safety driven.

9.7.3 NR have then considered applying using various combinations of the Policies to the different SRS Criticality Bands. Ten investment options (plans) have been considered as shown in Figure 9-17 below.

<table>
<tr><th></th><th colspan="10">Plan</th></tr>
<tr><th>SRS Criticality Band</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th></tr>
<tr><td>1</td><td rowspan="5">C</td><td>B</td><td rowspan="2">B</td><td>A</td><td>A</td><td>A</td><td rowspan="2">A</td><td rowspan="3">A</td><td rowspan="4">A</td><td rowspan="5">A</td></tr>
<tr><td>2</td><td rowspan="4">C</td><td>B</td><td rowspan="2">B</td><td rowspan="3">B</td></tr>
<tr><td>3</td><td rowspan="3">C</td><td rowspan="3">C</td><td rowspan="3">B</td></tr>
<tr><td>4</td><td rowspan="2">C</td><td rowspan="2">B</td></tr>
<tr><td>5</td><td>C</td><td>B</td></tr>
<tr><td>Closed lines & sidings</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td></tr>
</table>

Figure 9-17: Investment Option Plans 1-10 [Ref. SBPT3017]

9.7.4 NR note that their current approach to drainage management approximates to 'Plan 2', bring predominantly reactive with local elements of pro-active works (albeit distributed across the network not focussed by SRS Criticality Band).

Whole Life Cycle Cost Modelling

9.7.5 NR have not developed a Tier 2 WLCC model specifically for drainage assets and do not as yet appear to have undertaken a quantitative whole life cost analysis to identify lowest WLCC interventions.

9.7.6 The Drainage Policy states that the drainage components of the earthworks and track WLCC models are not yet operational, requiring further development and/or calibration. NR note that it is therefore currently only possible to subjectively assess the outcomes from the preferred Plan 5, and any other option.

9.7.7 NR have not yet undertaken a quantitative WLCC analysis to identify lowest WLCC interventions. We note that this is part of NR's planned development.

Derivation of Costs and Volumes

9.7.8 The following figure sets out how the Drainage Policy [Ref. SBPT3017] describes the use of models to derive volumes and costs for the SBP.

Figure 8.1: Drainage modelling for SBP

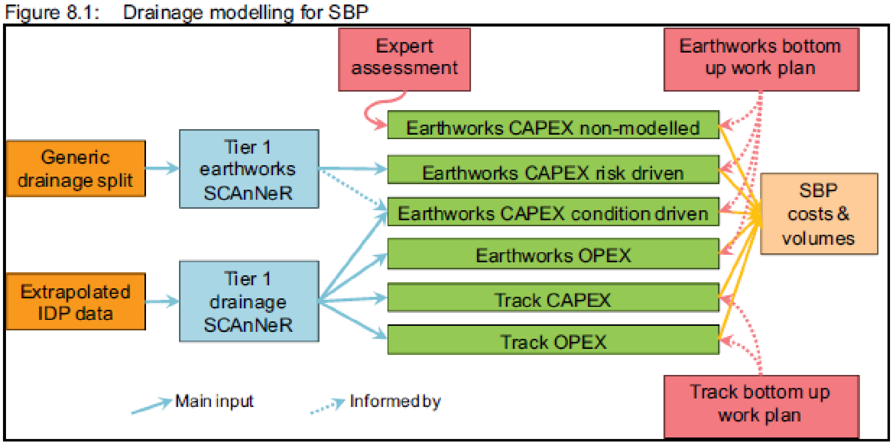


Figure 9-18: Drainage Modelling for SBP [Ref. SBPT3017 Figure 8.1]

9.7.9 We note that Figure 9-18 indicates that SBP costs and volumes have been calculated from the two SCAnNeR models. Whilst we have been able to understand the general derivation of these in the SCAnNeR models we have had difficulty in 'tracing' these forward to the costs in the SBP submission. The following paragraphs set out the extent of our understanding.

9.7.10 NR have used two separate decision support tools to calculate the drainage asset costs associated with Earthworks and Track CAPEX and OPEX costs, namely Earthworks SCAnNeR and Drainage SCAnNeR.

Earthworks SCAnNeR

9.7.11 NR have used a 'Tier 1/ 2' earthworks model – 'Earthworks SCAnNeR' (Strategic Cost Analysis for Network Rail) to investigate the relationship between performance, cost and risk for earthworks. The 'risk driven' and 'condition driven' CAPEX drainage interventions associated with earthworks have been derived from a 'generic split' of the intervention works between drainage and non-drainage. Earthworks SCAnNeR is discussed further in our Tier 1 model report [AO/030/3C].

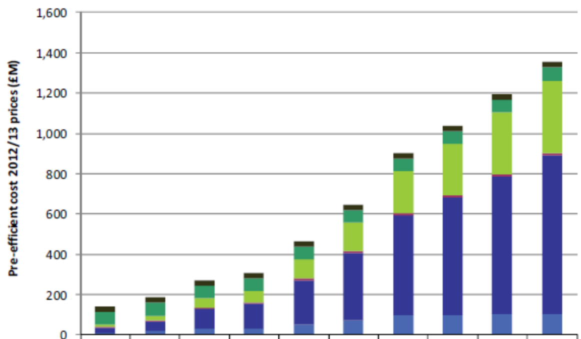
9.7.12 Recently (March 2013) we understand from NR that Drainage SCAnNeR does not in fact contribute towards the Earthwork asset CAPEX condition driven volumes or costs (i.e. Figure 8.1 from SBPT3017 is incorrect).

Drainage SCAnNeR

9.7.13 The Drainage SCAnNeR is a Tier 1 top-down spreadsheet model that takes the national virtual drainage inventory and condition profile and applies a defined set of rules to implement a range of interventions at given frequencies over the analysis period to determine overall costs and volumes for CP5. Drainage SCAnNeR is discussed further in the Track/Off-Track Tier 1 Model Review report [Ref. AO/030/3A].

9.7.14 NR have recently (March 2013) clarified to us that the model only derives Track Drainage OPEX and CAPEX volumes and costs in to the SBP (i.e. Figure 8.1 from SBPT3017 is incorrect).

9.7.15 NR have calculated the expenditures for the ten Investment Option Plans as summarised in Figure 9-19 below



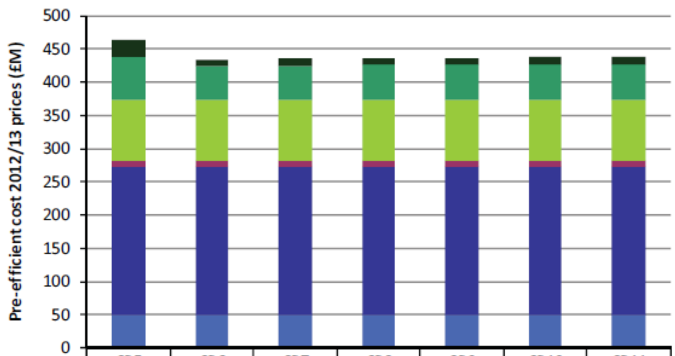
	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6	Plan 7	Plan 8	Plan 9	Plan 10
Earthworks CAPEX non-modelled	26	26	26	26	26	26	26	26	26	26
Earthworks CAPEX risk driven	64	64	64	64	64	64	64	64	64	64
Earthworks CAPEX condition driven	11	22	42	55	93	137	208	254	308	362
Earthworks OPEX	7	7	8	8	9	10	12	12	12	12
Track CAPEX	22	48	101	124	222	334	496	581	682	783
Track OPEX	13	18	29	30	50	73	99	101	104	106
Total	143	185	270	307	464	646	904	1,037	1,194	1,354

Figure 9-19: CP5 Investment Options Plans 1-10 [Ref. SBPT3017]

Policy Option Selection

9.7.16 At IIP stage the Drainage Policy was based on a continuation of the CP4 Drainage Policy – equivalent to Plan 2.

9.7.17 NR have adopted Plan 5 as the preferred plan for CP5. This is summarised in Figure 9-20 below.



	CP5	CP6	CP7	CP8	CP9	CP10	CP11
Earthwork CAPEX non-modelled	26	10	10	10	10	10	10
Earthwork CAPEX risk driven	64	49	51	52	53	53	54
Earthwork CAPEX condition driven	93	93	93	93	93	93	93
Earthwork OPEX	9	9	9	9	9	9	9
Track CAPEX	222	222	222	222	222	222	222
Track OPEX	50	50	50	50	50	50	50
Total	464	433	435	436	437	437	437

Figure 9-20: Selected Investment Option - Plan 5 [Ref. SBPT3017]

9.7.18 We have not been able to reconcile the CAPEX figures presented in Figure 9.20 (£405m for CP5) with the overall CAPEX figures presented in the Drainage Renewals Expenditure Summary [Ref. SBPT223] – see Figure 9-4.

9.7.19 We have not been able to understand what in terms of physical drainage related activities are to be delivered in CP5 associated with the proposed Plan 5.

9.7.20 At the time of writing we are unclear where volumes of drainage works are set out in the SBP documentation. Specifically we have not been able to find:

- Costs and volumes for Earthworks OPEX (e.g. drainage inspections and surveys);
- Costs and volumes for Track OPEX; and
- Volumes for Track CAPEX.

9.7.21 All these factors mean that we consider it is highly uncertain as to what is being proposed in the way of drainage works in CP5.

9.8 Overall Planning Process

9.8.1 The Asset Policy indicates that the majority of work to date has been undertaken by the NR central drainage asset management team, supported by an ‘expert panel’.

9.8.2 We have not seen specific evidence of discussion with the Routes regarding deliverability of the Policy but our discussions with the Routes do indicate that for earthworks they are planning to undertake significantly more drainage interventions.

9.8.3 A review of the Route Plans makes mention of 'Drainage Maintenance Plans[27]' (DMPs) - for example the Wessex Route Plan states:

*"**CP5 Activity***

The Wessex drainage submission is based on Plan 5 of the policy, which has an element of proactive remediation of poor drainage on the critical routes (policy B), maintenance for all drainage assets on the not so critical routes (Policy C), and inspecting of all other drainage assets. Allocation has been made to maintain about 930 miles, renew about 720 miles of drainage assets (including Earthworks and Track).

Drainage Maintenance Plans (DMP) are included within the CP5 submission and will assist in managing drainage systems; it is foreseen that for Wessex there will be one DMP for each area (Eastleigh, Woking and Clapham), each divided into Strategic Route Sections (17No).

The Route will manage drainage as one system, so no longer applying a traditional definition of track or earthwork drainage and it will be brought together under one post in the Buildings and Civils Asset Management team liaising closely with the track team. This will lead to total system decision making and risk management."

9.8.4 Although we have not found it to be explicitly stated in the SBP documents, our understanding is that these DMPs will be produced by all Routes in CP5. We assume that these will be key in 'rolling-out' the drainage policy at Route level. DMPs were not mentioned by the Routes in our meetings with them regarding earthworks / drainage.

9.8.5 From a review of the Route Plans there seems to be significantly different maturities in drainage management between the Routes. A number of Routes (e.g. East Midlands and Scotland) seem to be still at a planning stage and are expecting to be developing their Drainage Asset Management Plans (DAMPs) into CP5. Other Routes such as Kent are intending to complete their DMPs by the end of CP4.

9.8.6 We also note that there are also differences as to how Routes are managing their drainage, with Kent Track Maintenance Engineers owning DMPs. Others are appointing a dedicated RAM to be responsible for all elements of drainage including track, geotechnical and structures. (e.g. LNW).

9.8.7 The principle of managing the route drainage as a single system with improved liaison with the Track and Earthworks teams is very positive. However, at the time of writing we have not seen details of these DMPs. It is unclear whether each Route will be producing these in CP5, when in CP5 and what exactly each will comprise. We also note that the Routes seem to be at very different maturity stages with their

[27] We note that in some Route Plans they refer to 'Drainage Maintenance Plans' (e.g. Wessex) and some to Drainage Asset Management Plans (e.g. East Midlands) – we have assumed that these are the same documents.

drainage asset management.

9.9 Systems Approach

9.9.1 As noted above it is very positive that earthworks, track and drainage are being considered as a system and that the division of responsibilities has been explicitly set out in the Drainage Policy.

9.10 Risk and Review

9.10.1 As noted above, NR have adopted SRS Criticality Bands as a 'proxy' for consequence when assigning Policies A-D which will mean that more 'pro-active' policies will potentially be assigned to high criticality track sections.

9.10.2 In addition, NR have adopted an explicit risk based approach in their Earthworks Policy which to some extent (through the 'generic split' of earthworks CAPEX) will mean that drainage works start to be targeted towards higher risk earthworks sites.

9.11 Deliverability

9.11.1 As noted above, the Route Plans make mention of DMPs / DAMPs which we assume will be the primary means for 'rolling-out' the Drainage Policy - we are unclear as to their content, status and timing.

9.11.2 NR discusses deliverability in their Renewals Expenditure Summary [Ref. SBPT223]. Their view is that the work type activities utilise tried and tested techniques and no delivery supply chain issues are anticipated. We would agree with this.

9.11.3 NR state that the increase in earthworks drainage maintenance and refurbishment work types have been discussed in detail with the routes and work volumes are considered to be deliverable with changes to process and planning. This is broadly consistent with our own discussions with Routes.

9.12 Continuous Improvement

9.12.1 It is noted that the Drainage Policy explicitly includes an outline Roadmap to asset Policy maturity setting out a comprehensive range of aspects to be developed between now and CP6 – see Figure 9-21 below. This is very positive.

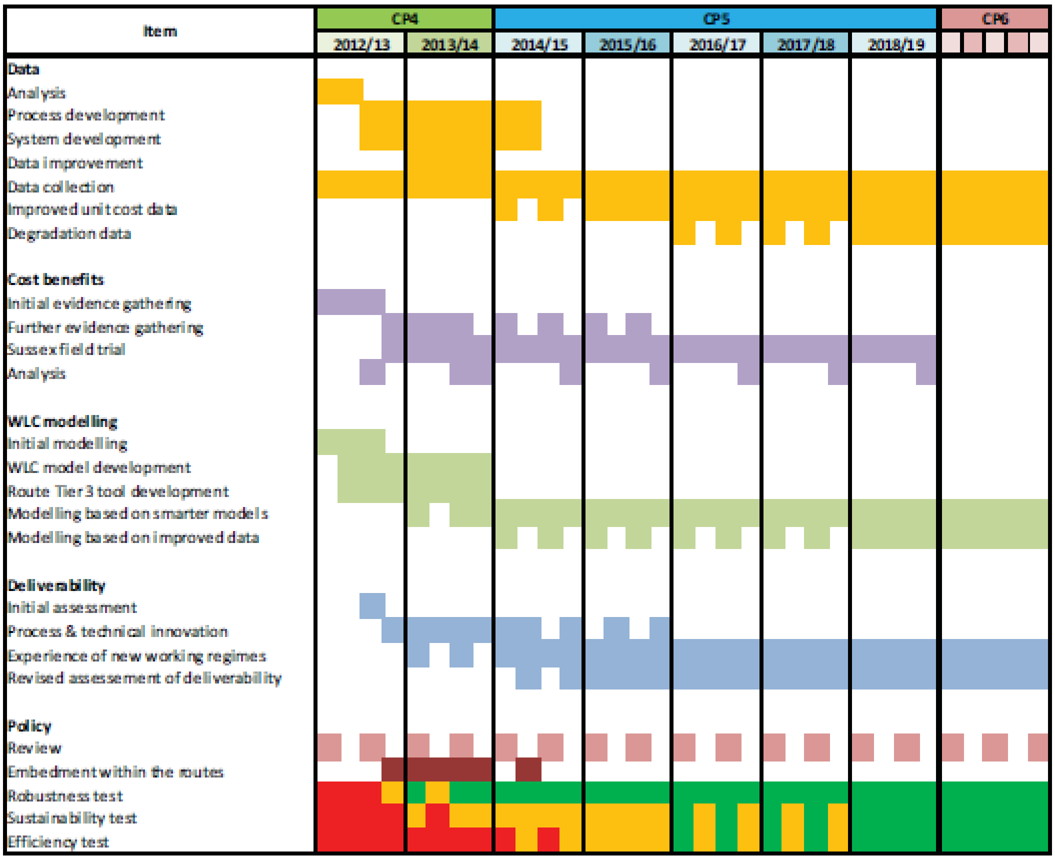


Figure 9-21: Road Map to Drainage Policy Maturity [Ref. SBPT3017]

9.12.2 The Road Map does not include mention of the proposed DMPs / DAMPs. As noted above we are unclear as to their content, status and timing.

9.12.3 Whilst some Routes (e.g. Western) seem to be already measuring track drainage performance, no explicit mention is made of reviewing the performance improvement (e.g. reduced failures) achieved by implementing the new Policy and reviewing whether it is delivering the benefits sought.

9.13 Robustness, Sustainability and Cost

9.13.1 As Independent Reporter we have been asked to consider the degree to which NR have demonstrated that the asset policies are robust, sustainable[28] and the degree to which the asset policy been demonstrated to deliver the required outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.[29]

Robustness

9.13.2 NR have made significant progress with the development of their Drainage Asset Policy since IIP in September 2011.

9.13.3 The Drainage Policy is clearly developed and logically constructed.

[28] ORR letter dated 1st June 2010 (document ref. 379948)
[29] Mandate AO/030 PR13 M&R review of asset policies and their application in planning: progressive assurance and SBP submission.

9.13.4 We are supportive of the principle of investment in the maintenance and renewal of the drainage asset.

9.13.5 We note that NR do not themselves consider that the CP5 Drainage Policy is yet robust. Specifically it is stated:

9.13.6 [Ref. SBPT3017]

".....Each of the above will contribute to achieving full asset Policy maturity as assessed by the robustness, sustainability and efficiency tests. The roadmap in Figure (10.19) shows Policy robustness (RAG status 'green') being achieved by the end of CP4 with the availability of asset data, more extensive cost benefits data and whole life cost models.

Full asset Policy maturity will be achieved in the final year of CP5 when degradation data becomes available; the results of the Sussex field trial will be known, the whole life cost models will be able to utilise the improved data; and there will be experience of delivering the CP5 works regime, with confidence in the efficiencies that can be achieved and better predictions of future efficiency gains."

9.13.7 [Ref. SBPT223]

"Our own assessment of the maturity of the new policy, following the approach adopted by other assets, is as follows:

Robustness (RAG status AMBER)

Sustainability (RAG status RED)

Efficiency (RAG status RED)

The robustness assessment reflects the significant improvements that have been made in our understanding of the drainage asset inventory and condition. We have begun to incorporate drainage as an integral component of our track and earthworks models, and these will become operational in 2013. However, it will be necessary to collect condition information and work records over several years before we are properly able to model degradation and the effectiveness of interventions, which are needed to demonstrate that our policy is sustainable and efficient."

9.13.8 We have a number of concerns as set out above, the key aspects being:

- In the SBP documentation that we have reviewed, we have not identified a clear summary of outputs / activities that are to be undertaken in CP5 based on the Drainage Policy. For example Drainage activity such as volume of drainage renewals, drainage pipes cleaned, catchpits cleaned. It is also unclear as to how the Drainage Asset Policy will be implemented – for example no details of the DMPs / DAMPs.
- There is no quantitative data in the Drainage Policy that gives any indication of the exact improvement that will be accrued in CP5 from the drainage expenditure.

9.13.9 Due to uncertainty associated with inventory and condition, together with specific outputs, we consider there is still uncertain whether the Drainage Asset Policy is robust.

Sustainability

9.13.10 We note that NR do not themselves yet consider the Drainage Asset Policy can be demonstrated to be sustainable until WLCC modelling is available.

9.13.11 Due to uncertainty associated with whole life cycle costing, together with specific outputs, we consider that it is still highly uncertain whether the Drainage Asset Policy is sustainable.

Whole System Cost

9.13.12 As noted previously it is very positive that the Drainage Asset Policy considers earthworks, track and drainage as a whole system. Investment in drainage works will undoubtedly contribute to improving the earthworks condition, reducing failures and improving track performance.

9.13.13 We consider it very positive that NR are undertaking a full scale drainage field trial in Sussex to more quantitatively assess the cost / benefit of drainage works.

9.13.14 We note that NR do not themselves yet consider the Drainage Asset Policy can be demonstrated to be efficient – see text below:

> *"Full asset Policy maturity will not be achieved until the final year of CP5 when degradation data becomes available; the results of the Sussex field trial will be known, the whole life cost models will be able to utilise the improved data; and there will be experience of delivering the CP5 works regime, with confidence in the efficiencies that can be achieved and better predictions of future efficiency gains."* [Ref. SBPT3017, Page 85]

9.13.15 Due to uncertainty associated with various aspects of the Policy, in particular the linkage between cost / outputs and WLCC, we consider that it is still highly uncertain whether the current Policy represents lowest whole life, whole system cost.

Embedded Efficiency

9.13.16 As noted above, a detailed review of efficiencies has not been undertaken as part of this mandate.

9.13.17 For the drainage asset no renewals 'embedded efficiency' has been assumed by NR. This reflects NR's view that although the Civils policies have been revised, '*the elevated level of uncertainty related to this asset makes it impossible at this* *time for us to assess any level of embedded efficiency that may result from the new asset policies.'* [SBPT220].

9.14 References

Ref	Document Title	Version / Date
Arup 2011a	Mandate A0/017: Initial Industry Plan (IIP) 2011 Review :- Summary Report – Observations and Conclusions	Issue 1 16 December 2011
Arup 2013	Mandate AO/030 Summary Report	Ref AO/030/1 Draft A
Arup 2013a	Mandate AO/030 Tier 1 Report	Ref AO/030/3 Draft A
Arup 2013b	Mandate AO/030 Policy and Tier 2 Report	Ref AO/030/2 Draft A
Arup 2013c	Mandate AO/030 Addendum Report	Ref AO/030/4 Draft A
Arup 2013d	Mandate AO.034 Costs	Draft A
Arup 2013e	Mandate AO/035 Efficiencies	Draft A
SBPT3010	Track Asset Policy	Dec 2012 Final V1
SBPT3015a	CP5 Earthworks Asset Policy	Rev 08 Final 14 Dec 2012
SBPT 3169	Infrastructure Maintenance Strategy	December 2012 v0.4
SBPT 3004	Optimising Maintenance Regimes	December 2012
SBPT3017	CP5 Drainage Asset Policy	18 Dec 2012
SBPT218	Wessex Route Plan	8 Jan 2013
SBPT3076a	CP 5 Earthworks Unit Rates Submission	V2.1 13/12/12
SBPT3076b	CP5 Drainage Unit Costs Submission	Issue 02 13/09/12

10 Off Track Asset Policy

10.1 Performance Requirements / Outputs

10.1.1 The off track assets are the vegetation that lies either side of the tracks up to the railway boundary and the physically fenced railway boundary.

10.1.2 The Policy defines how the vegetation must be proactively managed to prevent it having a negative influence on railway performance by physically obstructing the efficient management of other infrastructure assets and the running of trains. The principal role of fencing is to prevent encroachment onto the operating railway by others, including trespassers and animals.

10.1.3 A lack of good management will be displayed by leaves on the line, trees blown across tracks and vegetation obstructing signals leading to performance impacts resulting Schedule 4 and 8 charges.

10.1.4 Poor boundary fencing can have implications in terms of trespass incidents, theft of railway assets, suicides and animals on the line, again leading to performance issues.

10.1.5 No performance targets are set for off track asset performance and management in the Policy. Asset condition and associated risk to performance is used to influence policy and management planning. Objectives are set to remove poor condition assets or maintenance backlog over time but we are not clear how these are linked to overall asset management objectives.

10.2 Line of Sight

10.2.1 The Policy describes the particular and growing influence that the condition of off track assets can have on train performance by the following chart which compares trees on the line and livestock incursion with other track wrong-side failures.

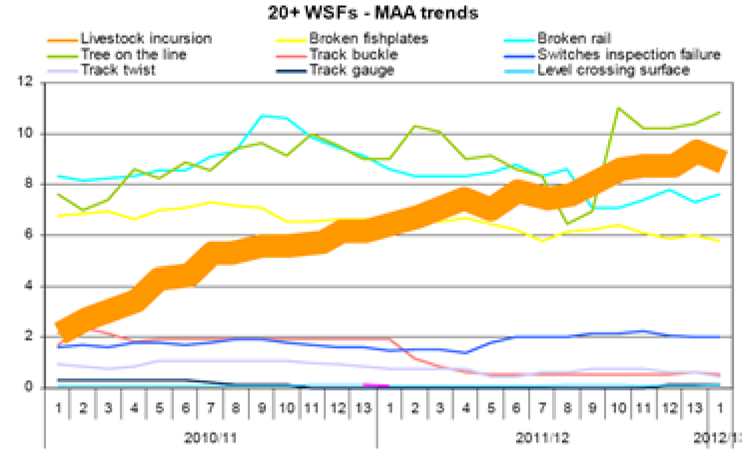


Figure 2.3 Wrongside failures due to livestock incursion highlighted in comparison with other track and off track wrongside failures

Figure 10-1: Off-track Asset Policy [Ref. SBPT3020, Figure 2.3]

10.3 Asset Knowledge

Boundary Measures

10.3.1 Boundary measures (lineside fencing) are placed into three classification groupings and the population is defined in the Policy by the following chart:

Asset description	Track category / electrification [1]	Quantity
Class I	1A / DC [2]	879 km
	1 / 2	1,511 km
	3 / 4	1,728 km
	5 / 6	853 km
	SUBTOTAL	**4,971 km**
Class II	1A / DC	2,239 km
	1 / 2	1,118 km
	3 / 4	1,546 km
	5 / 6	672 km
	SUBTOTAL	**5,574 km**
Class III	1A / DC	1,876 km
	1 / 2	4,608 km
	3 / 4	7,344 km
	5 / 6	3,897 km
	SUBTOTAL	**17,725 km**
	TOTAL	**28,270 km**

Table1.3 Volumes by boundary measure class; [1]Subdivisions of fencing risk assessment – track categories 1A, 1, 2, 3, 4, 5 & 6; DC third rail electrification: [2]DC electrification aligned with Track Category 1A due to the dangers of electrification at ground level

Figure 10-3: Classification of Lineside Fencing from Off-Track Asset Policy [Ref. SBPT3020, Table 1.3]

Vegetation

10.3.2 During the period 2009 to 2011 NR surveyed their vegetation and reported the following:

Asset description	Quantity	
Tagged trees requiring mitigation (inspection or work)	20,139no.	
High leaf fall risk (1/8 route mile sections)	1,465no.	2%
Moderate leaf fall risk (1/8 route mile sections)	7,193no.	10%
Low leaf fall risk (1/8 route mile sections)	22,045no.	30%
Negligible leaf fall risk (1/8 route mile sections)	42,481no.	58%
Overhanging 4', 6', or cess (1/8 route mile sections)	12,291no.	17%

Figure 10-2: Vegetation Asset Volumes from Off-Track Asset Policy [Ref. SBPT3020, Table 1.2]

10.3.3 From the evidence of the foregoing tables we believe this asset knowledge to be good.

10.4 Asset Behaviour, Degradation and Criticality

Boundary Measures

10.4.1 NR's current judgement of their fencing condition is shown in the Policy by the following chart (Figure 10-4):

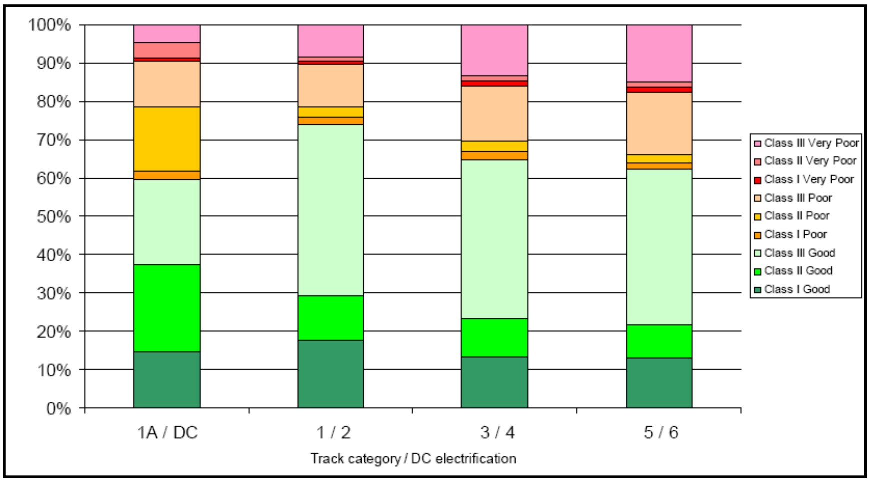


Figure 10-4: Fencing Asset Condition from Off-Track Asset Policy [Ref. SBPT3020, Figure 2.8]

10.4.2 Currently 25-40% of the boundary measures are in 'Poor' to 'Very Poor' condition depending on track category classification. It is estimated that 10%

of the fencing assets alongside D.C. electrified lines and track category 1A, 1 and 2 lines are in very poor condition and due for renewal.

10.4.3 Route criticality has no impact on boundary measures, as NR have a statutory duty across the whole network.

Vegetation

10.4.4 The criticality of vegetation to the performance of the network is judged by its proximity to the running lines and using data from the survey in 2009-11 is shown by the following chart:

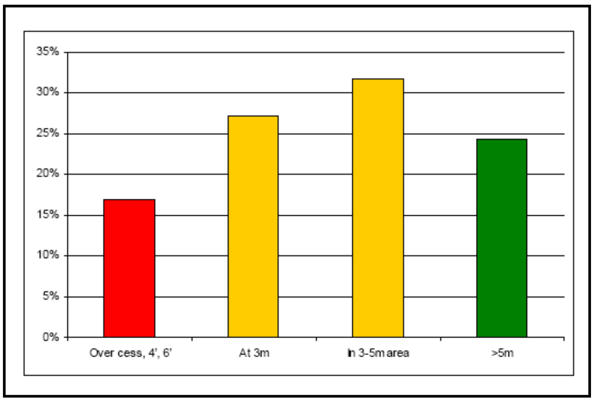


Figure 10-5: Vegetation Asset Performance from Off-Track Asset Policy [Ref. SBPT3020, Figure 2.9]

10.4.5 The information indicates that around 17% of the network has a significant amount of encroachment over the track.

10.4.6 The high volume of non-compliance to the vegetation standard provides an indication of the annual workload caused by vegetation growth. To this must be added the annual workload defined as leaf fall.

10.4.7 As a result of measures put in place over recent years to mitigate the safety impact on train performance by leaf fall each autumn, the policy identifies an on-going but reducing workload in this area.

10.4.8 Route criticality is likely to be a factor since the distance to be cleared of vegetation increases with line speed.

10.5 Renewal and Maintenance Interventions

10.5.1 Expenditure on lineside assets since the end of CP3 are shown in the policy by the following chart (Figure 10-6):

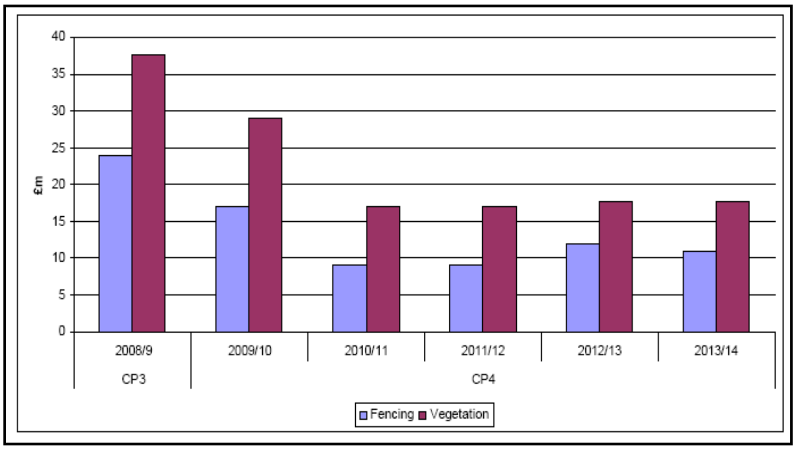


Figure 10-6: CP4 Expenditure on Lineside Assets from Off-Track Asset Policy [Ref. SBPT3020, Figure 2.11]

Boundary Measures

10.5.2 Boundary measures rely initially on an inspection regime that not only reports on the condition of the asset, but on adjacent land use changes as these may well have an influence on the on-going asset condition; particularly for the Class III country boundary.

10.5.3 The Class I and II boundary asset types tend not to lend themselves to refurbishment due to the materials used in their construction. Class III assets (post and wire livestock fencing) are more suited to refurbishment.

Vegetation

10.5.4 Vegetation management is centred on an inspection regime and appropriate mitigation to both cut back growth and where possible, prevent its return. NR consider that much of the required management of trees and shrubs along the lineside is as a result of previous management regimes not having been followed up and the vegetation being allowed to recover. For example, cut stumps from broadleaved species rapidly produce coppice shoots in an attempt to feed the surviving root system. This results in re-growth rates of up to two metres per year.

10.5.5 The Policy describes how NR have looked at how other railway infrastructure managers manage vegetation and have been trialling and using new techniques and equipment to manage vegetation growth.

10.6 Asset Cost Data

Boundary Measures

10.6.1 The following costs are given in the policy:

Table 10-1: Costs Provided in the Policy [Ref. SBPT3020]

Boundary Asset Costs £'s			
	Class I	Class II	Class III
Refurbish per metre	26	12	7
Renew per metre	56	35	17

Vegetation

10.6.2 For vegetation asset management costs are more relevant to the particular work necessary. The policy states the following:

"From a cost and efficiency point of view, the maintenance of vegetation is several orders of magnitude cheaper than the initial management to create the lineside that can be maintained:

- *Cost to annually maintain sites of woody vegetation; ~ £1,000 per cess mile*
- *Cost to clear sites of woody vegetation; ~ £30,000 per cess mile"*

10.7 Policy Selection and Preferred Lifecycle Options

Boundary Measures

10.7.1 For boundary measures, three investment options have been considered.

- Option 1: This option looks to repair all 'Poor' condition boundary measures and renew all 'Very Poor' condition measures by the end of CP5. It will also introduce a steady state renewal of those measures based upon the volume that will life expire during any one year.
- Option 2: This option is the same as Option 1 but the period of time to achieve the renewal of all measures is extended to the end of CP6.
- Option 3: This option sees the steady state renewal delayed until the start of CP6

10.7.2 For England and Wales, Option 1 has been adopted. For Scotland, Option 2 has been selected as there are more Class III boundary measures in Scotland.

10.7.3 We consider that the NR approach to boundary measures is driven by security and safety but that the policy leads to an increased level of expenditure in CP5.

Vegetation

10.7.4 For vegetation management the Policy states that there are four key management regimes to maintain the vegetation in the area immediately next to the rails (up to five metres away), create a desired structure of vegetation and thereby achieve compliance with standards and reduce risk to the operational railway. These are:

- Vegetation already >5m from rails; chemical maintenance;
- Vegetation in 3-5m area; mechanical then chemical;
- Vegetation at 3m; mechanical and manual; and
- Vegetation overhanging cess, 4' or 6'; manual and mechanical.

10.7.5 There are only two options considered. Option 1 is to adopt a planned preventative approach; Option 2 is to adopt a reactive approach.

10.7.6 Of the two options presented, NR have selected Option 1 which we consider to be preferable.

10.7.7 We consider that the Policy appears to advance high volumes of vegetation management in CP5 leading to uncertainty regarding whether the proposed level of expenditure gives value. We question whether the adoption of the policy unilaterally has been assessed by Routes prior to its implementation. We would have expected to see a reference NR/L2/TRK/5201 Management of Lineside Vegetation in the Policy.

10.8 Overall Planning Process

10.8.1 In order to derive top down volumes and budgets for consideration by Routes, a Tier 1 model has been developed for boundary measures.

10.8.2 The Policy document describes the methodology used to establish and populate each model with data.

10.8.3 The Policy states, and this review concurs, that the derived top down plan for CP5 has been possible with more asset knowledge that for any previous Control Period.

10.8.4 Routes have prepared their bottom-up business plans for boundary measures and vegetation management as part of their overall track RAMP process.

10.8.5 There has been some confusion over the definition of “off track” in our review. The Policy is clear, however, other documents enlarge the content of “off track”. For example, [Ref. SBP 3004] “optimising maintenance regimes” contains the following table:

Off-track	Vegetation	Vegetation management (manual)
		Vegetation management (mechanised)
		Vegetation management (spray)
		Vegetation management by train
		Vegetation - removal of boundary trees
		Inspections (fencing, vegetation, drainage)*
	Boundaries	Maintain fences and boundary walls
		Inspections (fencing, vegetation, drainage)*
	Level crossings	Inspections (level crossing - access points)
		Maintain level crossing
	Other off-track	Spoil and debris clearance outside station area
		P. Way other*

Figure 10-7: Mapping of Off-Track Maintenance Activities to Major Components [Ref. SBPT3004]

10.8.6 A further example occurred in Route meetings, where “off track” included lineside drainage and slab track.

10.9 Systems Approach

10.9.1 The Policy identifies those railway infrastructure assets that interface with boundary measures and vegetation. As the requirements for off track asset management is primarily to prevent trespass or interference with the running of trains, a systems engineering approach appears unnecessary.

10.10 Risk and Review

10.10.1 For boundary measures the risks of not having a secure fence in DC electrified areas or in areas of known trespass have been considered in formulating the planned volumes for CP5.

10.10.2 In summary the policy prioritises assets based on condition and assessed risk together with, in some situations, legal obligations and defines different interventions for different conditions.

10.10.3 We consider this approach to be acceptable; however, question the possibility of delivering the policy requirements with reduced volumes.

10.10.4 Within vegetation the Policy highlights the risk that the spread of ash dieback may require an increased volume of tree felling as there may be over 200,000 ash trees within the railway boundary. There is no contingency in the CP5 Policy to account for ash dieback. NR have advised that such work will be determined by Government policy at the time.

10.11 Deliverability

10.11.1 The inspection and some maintenance is undertaken by NR staff, however, the majority of the delivery responsibility falls on suppliers for whom this work is not rail industry specific.

10.11.2 We consider that the Policy is deliverable given the reliance on competent third-party contractors to undertake the work.

10.12 Continuous Improvement

10.12.1 For boundary measures, adoption of the planned volumes in CP5 will result in the known defects being cleared and also begin a process of steady state renewal such that by the end of CP5, expenditure can drop to a lower level of renewals funding.

10.12.2 NR believe that maintenance activity can then be used to manage all boundary measures and in so doing push out the service life of all types and classes thereby improving the whole life cycle cost of the boundary assets.

10.12.3 For vegetation management in CP5, NR's policy is to use better asset information and introduce novel technologies to the railway that will lead to safer and more efficient working practices.

10.13 Robustness, Sustainability and Cost

Robustness

10.13.1 It is likely that the Policy will deliver robustness for both boundary measures and vegetation management as a result of the volumes included in the plan. However, some uncertainty remains in the absence of clear asset management or performance targets.

Sustainability

10.13.2 The movement from a reactive to a pro-active approach to the assets promotes sustainability in the long term. There is, though, some uncertainty on what precise outputs will be delivered by the Policy.

Costs

10.13.3 We believe that the overall costs which are included in the plan may be above the levels necessary to deliver the policy requirements.

10.14 References

Ref	Document Title	Version / Date
SBPT3020	Off Track Asset Policy	December 2012

11 Fleet Asset Policy

11.1 Performance Requirements / Outputs

11.1.1 The NR SBP submission includes a CP5 Fleet Asset Policy [Ref. SBPT3018] which explains NR's proposed management approach for NR owned Traction and Rolling Stock Fleets, On-Track machines and plant with rail wheels.

11.1.2 NR have broken their owned fleet of into five functional groupings as follows:

- Incident Response;
- Monitoring / Recording / Testing;
- General Maintenance / Support;
- Maintaining / Renewing; and
- Planned Treatment.

11.1.3 The fleet asset represents a diverse range of plant that in part supports the delivery of maintenance and renewal activities. Our review of the fleet asset has focussed on the intervention and materials delivery fleets as these are the more critical in terms of delivery of the maintenance and renewals works on the wider NR assets, including track.

11.1.4 The Fleet Asset Policy deals principally with NR owned Traction and Rolling Stock Fleets, On-Track Machines and Plant with rail wheels, which are specialised assets central to maintaining and renewing the railway infrastructure or for supporting operational effectiveness. Some sections deal additionally with the road fleet (cars and vans).

11.1.5 The Policy identifies how the asset management of the NR owned fleets will be undertaken. The Policy excludes plant owned by Infrastructure Renewals Contractors and other external organisations. The Policy notes that capacity for the combination of the market and NR's own plant to deliver the requirements of other asset policies (especially track) is handled in those individual asset policies.

11.1.6 The overall fleet assets required to deliver the defined CP5 outputs will be made up of NR owned and supply chain owned assets.

11.1.7 There will be competing demands at peak times for limited resources to deliver the full programme of infrastructure maintenance, renewals and enhancements. Also, several suppliers are likely to have railway infrastructure fleet demands from contracted work with other rail infrastructure owners such as HS1 and TfL.

11.1.8 NR have attempted to define their overall requirements in the appendices to the Fleet Asset Policy [Ref. SBPT3018] from which conclusions are drawn on the ability of NR's Supply Chain to provide the balance of Fleet resources to deliver the CP5 Business Plan.

11.1.9 The Policy states that the NR owned fleet inventory and future changes to that inventory have been defined independently of the outputs of any other CP5 asset models.

11.2 Line of Sight

11.2.1 The alignment of the Fleet Asset Policy [Ref. SBPT3018] to the NR business plan is summarised as follows:

Table 11-1: Fleet Business Plan Summary

Type of Plant	Aligned to Business Plan
Seasonal and Incident Response	Yes
Intervention Fleets (these vehicles are described in the main policy document and also referred to in Appendix 3, pages 8 and 9)	Broadly, but not to sufficient detail to demonstrate delivery of the SBP
Materials Delivery Fleets	Not to sufficient detail to demonstrate delivery of the SBP
Infrastructure monitoring fleet	Yes
On Track Plant	Yes
Locomotives	Yes
Seasonal Treatment Train	Yes
Road Vehicles	Yes

11.2.2 There are three important subsets to the intervention fleets that are not defined to a level of detail to give confidence that the quantum of resource will be available to deliver the Business Plan. These are fleets to deliver the PL heavy refurbishment programme, the S&C heavy refurbishment programme and fleets to deliver the S&C tamping programme for maintenance, renewals and enhancements.

11.2.3 NR IP state in Appendix 3 to the Policy that there is a potential shortfall in:

- S&C tilting wagons and the associated turnaround facility throughput;
- Medium Output Ballast Cleaners (MOBCs) and other ballasting plant and a significant portion of the current fleet will become life expired within CP5;
- Stoneblowers;
- Grinders; and
- MPVs.

11.2.4 It is not clear that this potential shortfall has taken account of the large programme of work included in the full enhancement programme, for example, Crossrail (on NR infrastructure); Thameslink; Northern Hub; etc. Whilst any shortfall identified in the future can be resolved by a procurement programme and leasing, it can take up to three years from identifying the need to actually have new large bespoke equipment delivered. We therefore conclude that even taking into account the planned overhauls and procurement there is a risk to CP5 delivery caused by a current shortage of NR owned and supplier owned fleet resources.

11.2.5 The CP5 Track Asset Policy [Ref. SBPT3010] with its mid-life ballast replacement for PL and S&C, increases the demand for tampers and haulage. NR's capacity study suggests that there is adequate capacity in the network as long as a healthy balance between weekend and midweek delivery of the programme is achieved.

11.2.6 We consider that a predominantly weekend operation will require further investment on tampers, wagons and locomotives and will result in midweek under-utilisation.

11.2.7 It is not clear that adequate wagon load resources are available to support the heavy refurbishment of PL and S&C (reballasting), once other demands are taken into account.

11.2.8 The policy requires a new design of on track plant (road-rail vehicles) to meet safety requirements.

11.2.9 The policy for road vehicles in CP5 is a total change from CP4, moving from leasing to ownership.

11.3 Asset Knowledge

11.3.1 Asset knowledge alone is not the driver for fleet volume as there are other factors that may constrain the environment in which fleet resources need to operate and contribute to achieve corporate goals.

11.3.2 Machine capability (in terms of output) is not the greatest constraint on the capacity of the fleet, especially for assets which work in possessions. The greatest constraint on the fleet's capacity to deliver work is the access pattern available, and particularly the balance between midweek and weekend working. This affects S&C treatment in particular, where access may be limited or only available at weekends, meaning that vehicles see low midweek utilisation that consequently drives a much higher than average unit cost.

11.3.3 We have been advised by NR that producing an optimised spread of work across week nights and weekends is key to the delivery of SBP volumes and efficiency. We agree with this approach - see Section 11.2.5 above.

11.4 Asset Behaviour, Degradation and Criticality

11.4.1 Establishing a clear policy for machine availability and reliability, from owned fleet and bought in fleet is key to understanding the risk to SBP output delivery. NR have advised that tamping and stoneblowing contracts require 95% machine availability.

11.4.2 It is not clear what sub fleet by sub fleet reliability and availability targets have been set. This is a key driver of fleet size and on-going preventative maintenance costs.

11.4.3 From the Policy [Ref. SBPT3018, Section 2.5]:

"The diverse procurement, contracting and operational history of the fleets means that there is not yet a homogeneous approach to asset performance recording and analysis; performance analysis generally concentrates on the service as seen by the customer, which includes operational factors as well as fleet stewardship factors. A programme to normalise fleet asset data is on-going. Sufficient data has now been gathered to generate information to indicate rates of degradation on some fleets, although the data quality and short time range dictates that these can in most cases be only a guide to possible trends, and are insufficient to draw firm conclusions. It is estimated that a minimum of 2-3 years' data will be required to generate this data."

11.4.4 Based on the foregoing, we conclude that there is not yet a full understanding of fleet asset degradation.

11.4.5 The role of fleet in the delivery of the SBP M&R volumes for track and electrification is highly critical. We believe that this is so highly critical that NR may find that to deliver exceptionally high levels of intervention fleet availability and reliability may be worth incurring increased levels of expenditure to improve the delivery performance of these asset groups.

11.4.6 This principle of investment to raise the levels of availability and reliability may also apply to those intervention fleets required to deliver CP5 volumes and procured through contracts.

11.5 Renewal and Maintenance Interventions

11.5.1 The Policy would appear to have considered renewal interventions. The maintenance interventions are not clearly linked to availability and reliability targets.

11.5.2 Reference to Figure 2.8 in the Policy, reproduced below, seems to suggest that failures are an accepted way of life, and the customer just has to re-plan work. The High Output failures in particular would be totally unacceptable for many rail infrastructure managers. It is not clear that NR have the right policy in place for the maintenance of these critical machine systems.

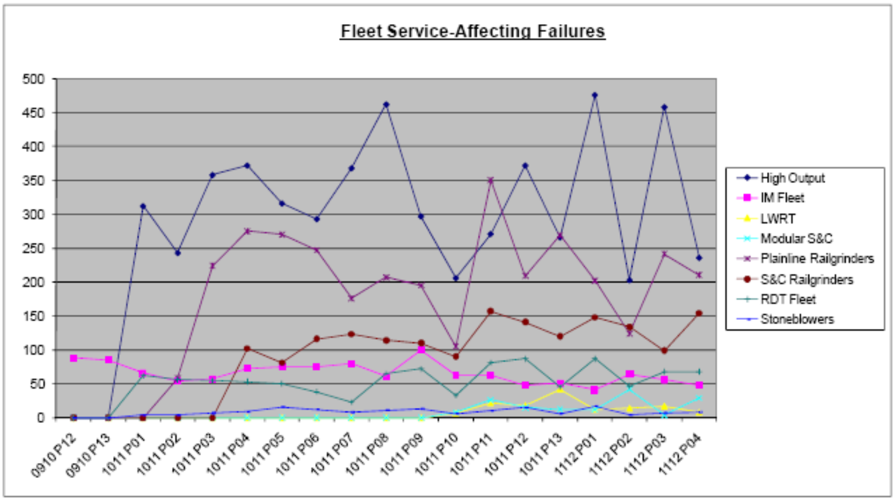


Figure 11-1: Reported Machine Failures

11.5.3 The above graph is accompanied with the following text:

"The High Output and Plain Line Grinders exhibit the most significant issue in terms of failures which adversely affect the output of the fleet in question, and subsequent effect on the maintenance or renewal of the track."

11.5.4 NR have said that the failures shown in the graph reflect machine reliability and may not all have affected planned volumes if the machines could have been repaired during track possessions. Nevertheless, they are a measure of reliability and show areas for improvement in CP5.

Tamping Machines and Stoneblowers

11.5.5 It is unclear whether there is a clear policy on ownership or contract supply. NR appear to have developed a Stoneblower fleet to meet their particular needs through ownership, yet with Tamping machines have left development to be met through their contracting strategy. The Track Policy is very clear in that it requires the track geometry quality of S&C to be improved by greater interventions and the adoption of tandem tamping for through bearer units. This is where two machines of similar design work on adjacent tracks on a master / slave basis to improve the geometry quality of S&C layouts. Also the Track Policy sets out a strategy for more PL and S&C track to be reballasted.

11.5.6 Whilst there are plans in the Fleet Policy to procure new support machinery for the increase in PL reballasting, there are none to develop and procure similar support machinery for S&C to compliment the three ballast vacuum machines listed in the Policy [Ref. SBPT3018, Page 66].

Road Vehicles

11.5.7 There is a new policy to own road vehicles with an average renewal every four years, reviewed annually.

11.5.8 We have challenged NR to demonstrate that this is an optimal policy, particularly a four year renewal cycle.

11.6 Asset Cost Data

11.6.1 Detailed cost data has been made available for the Tier 1 review.

11.6.2 For certain items, such as the intervention fleet, where there are few manufacturers of bespoke rail equipment in the world; accurate renewal costs are difficult to calculate and the manufacturers are reluctant to disclose cost data.

11.6.3 The SBP submission does not describe the process for deriving unit rates, the scope of what is included within the rates or the assumptions and inclusions associated with them.

11.6.4 The Wheeled Plant section of the Renewals Expenditure Summary documents [Ref. SBPT223] includes the following regarding deviation of unit costs:

"Unit rates are estimated by using previous costs, market intelligence, industry exhibitions/conferences and off the shelf costs overseas factored for redesign to W6A gauge."

11.6.5 NR have highlighted that there is a high level uncertainty within their rates and within the same part of the SBP submission. The reasons given for this are:

"Plant is not purchased off the shelf; all purchases involve some element of design work, so unit rates cannot be accurate, especially for novel assets, until the OJEU process is in progress"

"MPV life extension costs are estimated. Costs will not be known until vehicles are stripped for fatigue inspections"

Road Vehicles

11.6.6 NR have not included any allowance in renewal rates for the redundant asset. The reason for this is that the redundant asset generally has no significant value and is often donated or used as donor parts. This is considered reasonable for larger more bespoke type items and especially technology driven equipment. However part of the wheeled plant policy is to replace road vehicles every four years and does not consider the residual value for the previous asset. Significant road vehicle items make up £114m in CP5 and between £114m and £118m in each Control Period CP6 - CP11.

11.7 Policy Selection and Preferred Life Cycle Options

11.7.1 The Fleet Asset Management Lifecycle was designed during CP4. It embraces a process to challenging the Original Equipment Manufacturer (OEM) overhaul and maintenance instructions, and design life to reduce whole life costs whilst maintaining safety, reliability and availability. It will be used to reduce, or lengthen the intervals between maintenance interventions.

11.7.2 There are no plans to use this process to challenge service activities or intervals for road vehicles.

11.7.3 The traction and rolling stock fleet, together with on track plant must be considered uniquely to infrastructure assets.

11.7.4 Inspection, maintenance and overhaul interventions are derived from embedded component knowledge and industry practice, and initially are mandated by the OEM, in a suite of documents which form the basis of each asset's Vehicle Conformance Certificate. This Certificate is required by Railway Group Standards (GM/RT2004) and issued by an independent Vehicle Acceptance Body.

11.7.5 The Maintenance and Overhaul plans are designed to maintain the asset at a standard whereby it is capable of operating at capacity to the end of its design life, and failure to undertake the activities required within a defined time frame results in mandatory withdrawal from service.

11.7.6 Life extension vs. replacement. These options are described in the Fleet Asset Policy [Ref. SBPT3018, Section 6.3].

11.7.7 The application of modelling to determine life extension vs. replacement is not viable due to the diversity of the fleet.

11.7.8 Sensitivity testing has not been applied.

11.7.9 We consider that the Fleet Policy may be applicable to certain fleet vehicles. However we do not consider it to be appropriate to certain key items associated with the delivery of track maintenance and renewal volumes where the financial cost implications of the failure of a machine during operations far outweigh the cost of appropriate maintenance.

11.8 Overall Planning Process

11.8.1 The Fleet Policy describes the modelling approach taken to determine the optimum fleet size for rail grinders and stoneblowers.

11.8.2 The fleet size cannot be determined by annual demand, it must consider the number of critical shifts to be undertaken simultaneously due to external factors driving demand such as available track access.

11.8.3 A further factor to be considered when determining fleet size is the location, capacity and availability of operational tracks (sidings, depots) where vehicles can be stabled. These may impact on the cost and availability of wheeled plant fleet, in particular the operation of the High Output Track systems.

11.8.4 Routes were therefore asked to provide annual volumes of work; assumed percentage of week night vs. weekend work times and finally volumes of work in km or point ends per shift.

11.8.5 A number of additional factors were applied to the model including an historic availability % and transit shifts.

11.8.6 Three shift patterns were modelled by NR and the results are reproduced below:

	Model 1 Highest	Model 2 Highest	Model 3 Highest	IIP CAPACITY	% GAP (LOWEST)	COMMENTS
SB PL	19.06	25.41	30.50			
SB S&C	3.11	3.89	4.67			
All SB	21.85	29.14	34.96	18	21.40	Within acceptable levels given modelling assumptions and coarse level of calculations. Planning efficiencies will be possible as a result of new machine design.
Grinder PL	4.56	6.08	7.30			
Grinder S&C	4.07	5.42	6.51			
All Grinders	8.63	11.51	13.81	12	-28.09	Model does not account for different machine designs, or different PL vs S&C outputs, so may be underestimated. The CP5 capacity is within the range identified by the model and is within acceptable levels.

Figure 11-2: Results of the Volume Demand Modelling for Stoneblowers and Grinders

11.8.7 For stoneblowers, the model appears to show that availability is slightly below the modelled fleet size and for grinders it appears to show a fit. However, the policy states clearly that the assumptions and coarseness of the calculations make the results acceptable.

11.8.8 The full and detailed maintenance philosophy for fleet is described in the policy [Ref. SBPT3018, Table 10.1].

	TIME BASED (SCHEDULED) MAINTENANCE	BALANCED MAINTENANCE	RELIABILITY CENTRED MAINTENANCE	CONDITION BASED MAINTENANCE
Stoneblowers	Stoneblowers are currently maintained on a Scheduled Maintenance Regime. New Stoneblowers purchased in CP5 to replace the life expired machines would remain on Scheduled Maintenance during the OEM warranty period.	Stoneblowers will move to Balanced maintenance during CP4 and CP5, in order to reduce protracted overhaul periods, and increase availability and achieve more yardage with fewer machines.	Enhanced performance data will be collected during the latter part of CP4 in order to identify root causes of failures and improve CP5 decision making for maintenance.	The new stoneblowers to be purchased in CP5 will be specified with in-line condition monitoring already fitted.
Wiring Train	The wiring train is currently maintained on a Scheduled Maintenance Regime	The wiring train will move to Balanced maintenance during CP4 and CP5, in order to reduce protracted overhaul periods, and increase availability. Maintenance will be balanced to fit with the 'campaign' nature of the wiring train operation.	Enhanced performance data will be collected during the latter part of CP4 in order to identify root causes of failures and improve CP5 decision making for maintenance.	If additional capacity is purchased to satisfy the Government Electrification Programme, these assets will be specified with in-line condition monitoring already fitted.
EM-Sats	EM-Sats are maintained on a Scheduled maintenance regime. The utilisation pattern for these machines indicates no commercial or operational benefit to changing this policy.	The EM-Sats were originally specified with no overhaul programme. An Overhaul Programme is being developed.		No commercial benefit
High Output	The High Output Fleet is currently maintained on a Scheduled Maintenance Regime. New assets purchased in CP5 to replace the life expired machines would remain on Scheduled Maintenance during the OEM warranty period.	The High Output Fleet was originally specified with no overhaul programme. An Overhaul Programme is being developed in response to declining condition and performance issues, and this will be designed on a Balanced Maintenance basis.	Enhanced performance data will be collected during the latter part of CP4 in order to identify root causes of failures and improve CP5 decision making for maintenance.	The new High Output equipment to be purchased in CP5 will be specified with in-line condition monitoring already fitted.
Materials Delivery Fleet	Currently maintained on a Scheduled Maintenance regime. If demand remains static, there is sufficient redundancy in the fleet to continue under a scheduled maintenance regime.		Enhanced performance data will be collected during the latter part of CP4 in order to identify root causes of failures and improve CP5 decision making for maintenance.	No commercial benefit
Modular S&C Delivery	Currently maintained on a Scheduled Maintenance regime.	Maintenance will be balanced away from critical periods (eg Bank Holiday weekends) in order to maximise reliability and availability.	Enhanced performance data will be collected during the latter part of CP4 in order to identify root causes of failures and improve CP5 decision making for maintenance.	No commercial benefit

Figure 11.3: Example of Maintenance Philosophy [Ref. SBPT3018, Table 10.1]

11.8.9 Renewal options are described in the Policy [Ref. SBPT3018, Table 10.2].

	RENEWAL ON TIME-BASIS (SCHEDULED REPLACEMENT)	RENEWAL ON CONDITION BASIS	RENEWAL ON COST BASIS	RENEWAL ON TECHNOLOGY BASIS	INCREASE IN FLEET POPULATION	REDUCTION IN FLEET POPULATION
Stoneblowers		7 Plain Line Stoneblowers will be replaced on a combination of age and fatigue life condition in CP5. Timings are assumed to be consistent with design life but this will be subject to a market capability review, which will be part of the OJEU process. These will be renewed with multipurpose stoneblowers, to increase flexibility and utilisation for treating both plain line and S&C, representing a **renewal with enhanced capability**			Modelling by our customers identifies the use of stoneblowers to replace tamping activity, creating a more durable track quality and extending intervention intervals particularly on S&C. This drives an **increase in the population of multipurpose machines by 3, representing an enhanced capability** Climate change increasing the number of non-work days may require a change in shift patterns or a greater number of assets to satisfy demand (low risk for CP5)	6 Plain Line Stoneblowers will be mothballed, representing a **reduction in total fleet population.**

Figure 11-4: Example of Renewal Policy [Ref. SBPT3018, Table 10.2]

11.8.10 In reviewing the possibility of increasing the stoneblower fleet size, consideration should not only be taken of customer (Route) demand, but also the respective asset policy under which the machine will be employed. In the debate between tamping track and stoneblowing track (both intervention techniques seek to improved track geometry quality) the Track Policy states that tamping is the preferred method of track geometry maintenance [Ref. SBPT3010, Section 10, Policy Statement No. 51]

11.9 Systems Approach

11.9.1 It is noted that a sub-fleet by sub-fleet approach has been adopted.

11.10 Risk

11.10.1 The risks associated with fleet are discussed in the Policy [Ref. SBPT3018, Section 10.4].

> 11.10.2 We question whether NR are confident that they can obtain the specification of new machines that will deliver the sustainability targets of the Track Policy, through the retendering of tamping contracts during CP5.

Deliverability of New Machines

11.10.3 Whilst the plan for the procurement of new machines required to support delivery of the CP5 maintenance and renewal volumes has considered testing, approvals, commissioning, supply contracts and staff training, as certain machines may be first of type, there is a risk of delay which would impact on delivery of volumes towards the end of the control period. This may apply in particular to the new equipment required to deliver the S&C heavy refurbishment programme.

11.11 Deliverability

11.11.1 It is not clear where the accountabilities for delivery sit between fleet (NDS) and IP. Ultimately, together, they provide services to meet the infrastructure renewal and maintenance plans defined by Routes and enhancements. If fleet simply provides the equipment, then the accountability falls to IP to ensure that fit for purpose contracts with fully trained and competent operators will be in place to meet the expectations of Routes and Projects. This is particularly the case for the electrification programme, the Route's track renewal programme and their track geometry maintenance programme.

11.11.2 The IP delivery programme is defined in Appendix 3 page 17 of the Fleet policy. It states that there is a high probability, over 90%, that the CP5 workbank can be delivered as required.

11.12 Continuous Improvement

11.12.1 Inventory management is an area that NR intend to improve in CP5.

11.12.2 There is a need to improve the design of road rail vehicles to meet safety needs. This is a key area where to meet new safety requirements agreed with ORR, NR are investing in new vehicles even though the existing fleet is not due for renewal.

11.12.3 The policy states an intention to improve data collection that will lead to improvements in the modelling of fleet asset maintenance, refurbishment and renewal.

11.12.4 We consider that all of the foregoing continuous improvement measures are sensible actions.

11.13 Robustness, Sustainability and Cost

11.13.1 As Independent Reporter we have been asked to consider the degree to which NR have demonstrated that the asset policies are robust, sustainable[30] and the degree to which the asset policy been demonstrated to deliver the required outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets.[31]

[30] ORR letter dated 1st June 2010 (document ref. 379948)
[31] ORR-#430597-v1-20111028_ORR_PR13_Policy_review_note and Mandate AO/030.

Robustness

11.13.2 For the NR owned fleet, the Policy appears robust, and is an improvement on that produced in 2011 for the IIP.

11.13.3 We have concerns that NR may not have done enough work to date, such that they can be confident that the overall bespoke fleet (plant) resources that are required to deliver the SBP outputs for asset management, including enhancements, are available at the cost levels required to deliver the SBP.

Sustainability

11.13.4 Fleet assets vary in scope and cost in their support to the principal deliverables of the SBP. Therefore, it is difficult to respond to the ORR sustainability question for this Policy. As such we are not able to come to a view on the sustainability of the Policy.

Whole System Cost

11.13.5 NR have not undertaken any WLCC modelling for fleet. Accordingly there is no WLCC report for fleet.

11.13.6 We consider that delivering a minimum whole life cycle cost for the many and varied types of the mechanised wheeled fleet may not be optimal in terms of delivering the high levels of availability and reliability required to deliver the SBP.

11.14 References

Ref	Document Title	Version / Date
SBPT3018	Fleet Asset Policy	v 5.1, 12th December 2012 with Appendices on 03.02.2013
SBPT3010	Track Asset Policy	December 2012

Appendix A

Independent Reporter Part A - Mandate AO/030

Mandate for Independent Reporter Part A

Audit Title:	PR13 M&R review of asset policies and their application in planning: progressive assurance and SBP submission.
Mandate Ref:	[to be added by Network Rail]
Document version:	Draft A
Date:	08/05/2012
Draft prepared by:	Richard Coates
Remit prepared by:	
Network Rail reviewer:	Dan Boyde

Authorisation to proceed

ORR		
Network Rail		

Background

Network Rail submitted proposed updates to its asset policies in September 2011. These gave Network Rail's best view of efficient policy at the time, and were the policies used in developing its contribution to the IIP submission. The asset policy documents and supporting evidence were reviewed by the ORR, supported by the independent reporters, AMCL and Arup. Their reports are published on the ORR website.[32]

Network Rail will carry out further work on its policies in the lead up to submission of its Strategic Business Plan (SBP). Network Rail must submit evidence to ORR to demonstrate that it is making sufficient progress in developing a robust SBP submission. This is termed progressive assurance. Network Rail and ORR have agreed high level milestones at which Network Rail must submit this evidence.

Network Rail will submit its SBP and all supporting information in January 2013.

Scope

Under this mandate the reporter will assess:

- The evidence supplied by Network Rail under progressive assurance relating to its proposed CP5 asset policies and their application;
- The final CP5 asset policies submitted by Network Rail in support of its SBP; and
- The application of its asset policies in developing SBP cost, volume, output and efficiency projections.

In doing so it will consider:

- Compliance with the Network Licence, particularly section 1 relating to Network Management; and
- Our tests of robustness, sustainability and minimum whole lifecycle, whole system cost and further criteria for assessing asset policy as shared with Network Rail.

The Independent Reporter Part A will carry out the review for:

[32] http://www.rail-reg.gov.uk/pr13/PDF/amcl-iip-2011-review.pdf
http://www.rail-reg.gov.uk/pr13/PDF/arup-asset-policies-2011-review.pdf

- Track;
- Off-track;
- Buildings;
- Drainage;
- Civils; and
- Fleet.

This includes review of:

- Asset policy documents;
- Strategic planning tools;
- Whole lifecycle cost analysis tools;
- RAMPs documentation; and
- SBP documentation including costs, volumes and outputs tables.

The reporter will also review whole lifecycle cost analysis tools for signalling and telecoms.

The reporter will review the progress that Network Rail has made in development of its asset policies, strategic planning tools, whole lifecycle cost analysis tools and key network and asset sustainability and performance measures through a rolling programme of evidence submission and review meetings. Network Rail will submit its progressive assurance evidence for these areas by 31 July 2012 at the latest. The reporter will provide an interim progressive assurance report and feedback to ORR and Network Rail by 07 September 2012.

The reporter will review the progress that Network Rail has made in development of its plans by operating route through challenge meetings and review of submitted evidence. This is likely to include review of Network Rail's strategic framework / process mapping, RAMP template, RAMP guidance documentation and other communications with routes. Network Rail will submit its progressive assurance evidence by 30 April 2012 at the latest. The reporter will provide an interim progressive assurance report and feedback to ORR and Network Rail by 30 May 2012.

The reporter will review Network Rail's submitted SBP policies, models and data tables, and all supporting evidence. Network Rail will submit finalised supporting evidence in advance of SBP as it becomes available.

Asset policy documents

The review will build on the findings of the reporter mandate AO/017: Initial Industry Plan (IIP) 2011 Review. It will include an assessment of the extent to which recommendations in AO/017 have been addressed.

Policy will be assessed against the criteria of robustness, sustainability and lowest whole life, whole system cost and the further indicators of good asset stewardship as detailed in Appendix 1. The review will include understanding how Network Rail has used the outputs of tier 2, minimum whole lifecycle cost modelling, in its development of policy.

The reporter will assess the quality of Network Rail's projections of efficiencies embedded within the proposed asset policies. It will assess Network Rail's projections of further scope efficiencies to be delivered in CP5.

Minimum whole lifecycle cost analysis tools

The reporter will review the efficiency / minimum whole life and whole system cost of the proposed policy against the criteria in Appendix 1. In doing so it will assess the application of the tier 2 models in justifying this policy, bearing in mind the existing evaluation of these models against the criteria in Appendix 2. It will assess the extent to which recommendations made under mandate AO/017 have been addressed.
Strategic planning tools
The reporter will consider whether the proposed policies have been accurately modelled in the tier 1 strategic planning models. This will include:

- Modelling principles: Do the models accurately model asset policy as set out in the asset policy documents?
- Degradation: Are the degradation assumptions used consistent with those used in tier 2 modelling?
- Input data: Are asset input data (including number, criticality, condition, age, used life etc.) consistent with Network Rail's asset registers? Are these correctly disaggregated by operating route?
- Unit costs: are unit costs used consistent with tier 2 modelling? N.B. A separate mandate will address CP4 exit unit costs
- Recommendations: have recommendations from mandate AO/017 been addressed?

The review of computational accuracy of the models is not included within this mandate.

RAMPs
The reporter is to review the format, process for populating, and the content of the final Route Asset Management Plans (RAMPs) submitted as part of the SBP against the criteria in Appendix 3.
SBP costs, volumes and outputs tables
The reporter is to review the process through which the SBP [pre-efficient] costs, volumes and output tables have been compiled from tier 1 model outputs and route based plans (workbanks and RAMPs).

- Is the process robust?
- Are these data tables consistent with delivering required outputs at minimum industry whole lifecycle cost?
- Are these data tables robust by operating route?
- Are the tables fully populated, from CP4 to CP11?
- Does the profile of historical and projected costs appear reasonable, in line with policy and have apparent anomalies been explained by Network Rail?
- Has a QRA been carried out and what is the quality of it?
- Are projected scope efficiencies reasonable? Can further scope efficiencies be delivered through further refinement of policy? N.B. A separate mandate will cover efficiencies in greater detail.

Methodology

As part of this workstream the reporter will undertake the following activities:

1. Attend all relevant progressive assurance, policy presentation and policy challenge meetings;
2. Attend monthly quadripartite coordination meetings (Network Rail / ORR / AMCL / Arup);
3. Undertake a review of draft and final asset policy and policy justification documents;
4. Undertake a review of any other relevant supporting and information including bases and assumptions, documentation, models, presentations etc.;
5. Prepare and submit draft and final reports following each of the progressive assurance high level milestones to both ORR and Network Rail, setting out the main observations and conclusions arising from the review process;

6. Prepare and submit draft and final reports following the submission of SBP and supporting documentation.

The reporter will produce a detailed methodology in presenting its proposals.

As far as possible, it is intended that the reporters shall co-ordinate their activities with the analysis being carried out by the ORR in order to avoid duplication of work.

The Reporters shall also avoid duplicating activity already undertaken – or in progress - under various mandates reviewing asset policy development to the IIP, tier 1 and tier 2 modelling tools and asset data inputs.

Deliverables

1. Minutes of meetings and a summary of the reporters' views of the challenge workshops.
2. Progressive assurance review of RAMP process - presentation of findings to ORR and Network Rail by 30 May 2012.
3. Progressive assurance review of asset policy and its justification – presentation of findings to ORR and Network Rail by 7 September 2012.
4. SBP Draft Report - 1 March 2013.
5. SBP Final Report – 29 March 2013.

Timescales

The key milestones for the work are as follows:

- Kick-off meeting with ORR and Network Rail in May 2012.
- Network Rail to provide evidence relating to the production of robust plans by operating route, including RAMPs, by 30 April 2012.
- Reporter to produce progressive assurance review of production of robust plans by operating route report by 30 May 2012.
- Network Rail to provide evidence relating to the ongoing development of asset policy, planning models (tiers 0, 1 and 2), output and performance measures by 31 July 2012.
- Reporter to produce progressive assurance review of the development of asset policy, planning models (tiers 0, 1 and 2), output and performance measures by 7 September 2012.
- Network Rail to submit SBP and all supporting documentation by 7 January 2013.
- SBP draft report by 1 March 2013.
- Final reports by 29 March 2013.

Independent Reporter proposal

The Reporter shall prepare a remit for review and approval by the ORR and Network Rail on the basis of this mandate. The approved remit will form part of the mandate and shall be attached to this document.

The remit will detail methodology, tasks, programme, deliverables, resources and costs.

Given the importance of this review, the Reporter shall provide qualified personnel with direct experience in the respective disciplines to be approved by the ORR. The contractor is asked to submit details of the previous experience and qualifications of such personnel as part of their proposal.

Appendix 1 – Policy review

The review will consider asset policies against three high level criteria:

1. **Robustness: Is it reasonable to believe that the policy can deliver the required outputs, for England & Wales and Scotland?** In testing the robustness of the policy the reporter should consider whether the policy and plans have been demonstrated to be capable of delivering the outputs required for CP5 (2014-2019). This includes consideration of outputs, KPIs and condition measures as disaggregated by operating route.
2. Sustainability: If demand on the network were to remain steady, would application of the asset policy continue to deliver the outputs specified indefinitely? A sustainable asset policy is one which delivers (at least) the agreed outputs for the final year of the control period in the long term (to at least end of CP11) if demand on the system remains within the capacity limits of the current network and any enhancement schemes already committed to by industry. The demonstration of compliance with this test is likely to involve forecasting and modelling as part of the submission. This test is to ensure that, in managing within CP4 funding, Network Rail is making genuine efficiencies and is not deferring essential work at the cost of inefficiently higher expenditure in later control periods.
3. Lowest whole life, whole system cost: Has asset policy been demonstrated to deliver the required outputs both in the short and long-term at lowest possible whole system cost over the lifetime of the assets? In demonstrating minimum whole life cost Network Rail must demonstrate that both scope and unit cost efficiencies have been fully considered.

In assessing against these high level criteria the reporter will also consider the 'Indicators of Good Asset Stewardship' as set out below. They will assess whether comprehensive and convincing rationales have been provided demonstrating good asset stewardship in compliance with Network Rail's licence obligations.

The reporter will assess against the following key tests (i.e. not an exhaustive list) as a sub-set of the overall asset management capability, that are generally associated with good asset stewardship and that are likely to give rise to compliance with the Licence obligations relating to asset management policies and plans.

1. **Performance Requirements / Outputs** – have these been defined at system and individual asset group level taking into account strategic objectives? How are these influenced by demand? What level of risk can be tolerated for each performance requirement? What level of system resilience etc.?
2. **Line of sight** – is there a clear relationship from business objectives (performance, demand, capacity etc.), policy/strategy down to specific outputs defined in the route asset management plans and route delivery plans.
3. **Asset Knowledge** – is there adequate accuracy and completeness of asset inventory data, capability, capability, including structure and critical component / element details, age, condition, maintenance history, failure modes, service life etc.
4. **Asset Behaviour and Criticality** – is there an adequate understanding of asset behaviour, criticality, critical components, and failure modes

5. **Asset Degradation** – is there an adequate understanding of deterioration rates of critical components and materials?
6. **Renewal and Maintenance interventions -** Has a suitable range of intervention options been considered taking into account any enhancement requirements due to interoperability, asset system interfaces etc.? Do these interventions simply reflect current / historic practice or have materials and techniques used by others (e.g. identified from benchmarking activity) and other future developments / techniques been considered?
7. **Asset Cost Data** – is there adequate maintenance and renewal cost data for the identified maintenance and renewal interventions to enable suitably accurate lifecycle cost estimation? Are suitable unit rates available for calculating the works and other costs (e.g. access, possession costs, mobilisation etc.)?
8. **Lifecycle Option Preparation** – have a suitable range of alternative lifecycle management options been considered for the critical asset types and components, based on adequate asset knowledge an understanding of asset behaviour, maintenance and renewal options? How has resilience been considered? Have any Scotland specific issues been identified and considered? How have sub- options been rationalised and optimised?
9. **Lifecycle Option Selection and Strategies** – have clear alternative lifecycle strategies been considered? Typical strategies may be:
   - "Do Minimum" Strategy – the minimum required to sustain safety across the analysis period, e.g. infrequent/irregular but major interventions to satisfy/meet the minimum safety and performance targets.
   - Preventative Strategy – regular and frequent minor interventions to maintain the condition of the asset by slowing down the rate of deterioration.
   - Targeted Strategies – with interventions aimed towards:
     - Minimising Whole Life Costs while satisfying safety/performance targets;
     - Minimising network disruption; satisfying the disruption targets;
     - Delivering a required condition score;
     - Etc.

Where asset policies deviate from lowest whole lifecycle, whole system cost, has the inefficiency caused by funding constraints been quantified to understand the long-term cost and risk implications?

10. **Preferred Lifecycle Option -** How are the preferred lifecycle options for different asset types reflected in the asset policies and plans?
11. **Sensitivity testing** – Has sensitivity testing been carried out to understand levels of uncertainty within confidence limits, both for underlying asset information and in the decision support tools used in the development of asset policy?
12. **Overall Planning Process** – is it clear how 'top-down' decisions will be used in practice to influence local asset maintenance and renewal choices? How are 'bottom-up' unconstrained asset needs evaluated against 'top-down' asset policies and a planned workbank produced (e.g. how a workbank at an SRS level is derived)?
13. **Systems Approach** – has the policy adopted a systems engineering approach which considers cross-asset groups and cross-industry requirements? Has interaction between asset types/ overall

system been considered? (e.g. if head hardened rails are specified has the impact on wheels been considered).

14. **Risk and Review** – is it clear how asset risks will be managed and reviewed? Is there definition of tolerable risks and is this applied in practice? What level of resilience is required, has a RAMS (reliability, availability, maintainability and safety) approach been adopted?
15. **Deliverability** – is it clear how the proposed asset management approach will be delivered? – is it feasible that the policy can be delivered given known constraints e.g. technology, supply chain, training, experience etc. (e.g. Maintenance – does the policy adequately consider the maintenance implications in terms of numbers of staff, skills, training, and equipment?) Are roles and responsibilities defined?
16. **Continuous Improvement** – research and development, feedback and efficiency improvements.

Appendix 2 – Minimum whole lifecycle cost analysis tools review

i. Input data – what is the robustness of input data?:
   - understanding of degradation - elicitation vs evidence of actual degradation. Quality of information and elicitation techniques
   - unit costs - are unit costs derived from actuals in an auditable way? Are unit costs considered accurate? (Ref. Arup's unit cost audits - 2010/11 reg accounts)
   - modelling of appropriate intervention options
   - understanding of effect of intervention
   - sensitivity analysis - comment on the sensitivity of outputs to uncertainty in model inputs

ii. Robustness of cost modelling:
   - Comment on extent of costs considered - e.g. is the cost of safety and performance risk fully considered?
   - Verification - are the outputs plausible based on expert engineering knowledge? Have the model outputs been checked considering their application to on-the-ground assets?
   - Assurance - has the integrity of the coding been tested?
   - How has modelling been tested to ensure that it is delivering required outputs?

iii. Assessment of extent to which WLCC model outputs are used in both policy and tier 1 planning models:
   - Do they support policy?
   - Do they support proposed volume, expenditure and output forecasts?

iv. Coverage of WLCC models:
   - what assets are included in the WLCC models?
   - are these appropriate? i.e. Have they been prioritised correctly (by associated spend / criticality etc.)?

v. Scenarios:
   - Has a suitable number of scenarios been tested?
   - Are they a sensible representation of intervention options?
   - To what extent do they help to understand minimum whole life cost?
   - Is current policy included for comparison?

vi. Best practice:
   - Has WLCC modelling best practice been fully considered and adopted? Has NR considered models and degradation information available externally?

Appendix 3 – Route Asset Management Plans

1. Format
   a. What do RAMPs cover? (e.g. Costs, volumes, outputs, KPIs, efficiencies)
   b. Is there information which should be included but is not?

c. Is the format consistent with strategic planning models?

d. To what extent is format controlled and is this appropriate?

- Process

  a. What level of control / autonomy is there? Is the level of control appropriate? How does the route interact with the centre?

  b. How are the RAMPs populated? By whom? At what level of detail? On what intelligence?

  c. To what extent can routes deviate from policy? How is this controlled?

  d. To what extent do routes challenge policy? How is this managed?

  e. To what extent do routes challenge CP4 exit unit costs on a route basis? How is this managed?

  f. To what extent do routes challenge central efficiency assumptions? How is this managed?

  g. How do RAMPs interact with tier 1 modelling? Over what timeframes are plans based on bottom-up workbanks? Is this appropriate?

- RAMP documents / tables

  a. Are the RAMP documents / tables complete?

  b. Are the RAMP documents / tables accurate?

  c. Are the RAMP documents / tables accurately reflected in the SBP submission?