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Transport Infrastructure Ireland

## TII Publications



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# The Use of Road Tar in Ireland and Research of Treatment Protocols

**RE-PAV-00002**  
February 2023

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## TII Publications



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# 1. Introduction

## 1.1 Background to Coal Tar

Coal Tar is a by-product of coal gas manufacturing, a process that took place in town gasworks up to the mid 1960's before the mainstream introduction of petroleum products to produce gas. Coal Tar was distilled to produce Road Tar, a product used as a binder for asphalt pavement materials.

Coal Tar is considered a hazardous material due to high levels of Polycyclic Aromatic Hydrocarbons (PAHs) and consequently, as a derivative, Road Tar may also contain high levels of PAHs. Bitumen, the alternative binder to Road Tar, is produced from crude oil and contains extremely low levels of PAHs.

The objective of the Works Package is to develop a Road Tar Treatment Protocol to manage the potential risk of discovering and dealing with Road Tar in the National primary and secondary road network. Where Road Tar is a possibility, determine investigation procedures and resultant treatment options to be followed.

## 1.2 Purpose of the Research

The purpose of this research exercise is:

- i. Development a foundational knowledge of the historical use of road tar in Irish road pavements
- ii. Develop a presence of road tar risk profile for the National Road network
- iii. Review international best practice for the screening, testing and treatment of road tar bearing materials

The information gathered as presented in this research report will be used by Transport Infrastructure Ireland (TII) as an input to the development of a guide for management of Reclaimed Asphalt (RA) materials and protocols for the screening, testing and treatment of RAP containing Road Tar.

## 1.3 Definitions

**Road Tar** was used in roadwork and prepared entirely from crude tars produced wholly or substantially as a by-product of the high temperature carbonisation of coal at above 600°C.

**Bitumen** is a virtually not volatile, adhesive and waterproofing material derived from crude petroleum, or present in natural asphalt, which is completely or nearly completely soluble in toluene, and very viscous or nearly solid at ambient temperatures.

**Polycyclic Aromatic Hydrocarbons (PAHs)** is class of organic compounds that is composed of multiple aromatic rings. PAHs occur naturally in coal, crude oil, and gasoline. They result from burning coal, oil, gas, wood, garbage, and tobacco.

## 2. Review of Historical Use of Road Tar in Ireland

### 2.1 Review of Irish Bituminous Material Specifications

The primary aim of the specification review was to establish if and when Road Tar was referenced as a component of any products used in road pavements on the road network.

The following sequentially summarises the organisations responsible for specifications used in Ireland, starting from present to former.

#### 2.1.1 Transport Infrastructure Ireland

When Transport Infrastructure Ireland (TII) was established in 2015, the existing documentation previously administered and developed by the National Roads Authority was restructured. The specification of road pavements materials is covered by CC-SPW-00900 Road Pavements - Bituminous Materials.

The Series gives general requirements for the properties of the aggregates and binders used in bituminous mixtures, surface treatments and bond coats.

Reference to Tar is confined to the following:

Clause 8.1 Low Energy Bound Mixtures utilising existing road pavement materials; tar is mentioned in the context of recycling the existing road pavement:

*'The plant used shall be capable of processing, diluting, dispersing and encapsulating hazardous tar contaminants into the recycled road structure thereby rendering them safe.'*

Clause 9. Reclaimed Asphalt for recycling into new bituminous mixtures:

*'Source asphalt containing tar shall not be permitted.'*

Hence road pavement specifications in use since 2015 do not specify Road Tar as a component whatsoever.

#### 2.1.2 National Roads Authority

The National Roads Authority (NRA) was established in 1993 with responsibility for the maintenance and construction of the National Primary and National Secondary Road network. Specifications were developed with the publication in 2000 of the NRA Manual of Contract Documents for Roadworks. The specification of road pavements materials is covered by Series 900 Road Pavements – Bituminous Bound Materials.

The Series contains general requirements for the properties of the aggregates and binders used in bituminous materials and bituminous sprays. Whilst Surface dressing is mentioned in Series 900, the specification is referenced out to a Department of the Environment document, see section 2.1.3 for further information.

For each bituminous material it is stated that 'the binder shall be petroleum bitumen' and for bituminous sprays 'the binder shall be spraying grade cationic bitumen emulsion' Series 900 does not mention Tar.

Prior to the introduction of Series 900, the NRA specified road pavement materials in accordance with Department of the Environment Specifications. See section 2.1.3 for further information.

Hence road pavement specifications in use since 2000 did not specify Road Tar as a component whatsoever.

### 2.1.3 Department of the Environment

Prior to the formation of the NRA to oversee the National Primary and National Secondary Road network, all road pavement materials were specified by the Department of the Environment (DoE). A Specification for Roadworks was published in 1978 and reprinted 1981 and 1990.

The Specification for Road Works, known colloquially as 'The Green Book' (in reference to the colour of the cover), included the specification of road pavements materials under *Series 900 Flexible Surfacing*.

The Series contains general requirements for the properties of the aggregates and binder used in bituminous materials and bituminous sprays. For each bituminous material it is stated that 'the binder shall be petroleum bitumen' and for bituminous sprays 'the binder shall be cut back bitumen or spraying grade cationic bitumen emulsion'.

Whilst Surface dressing is mentioned in Series 900, the specification is referenced out to a separate DoE document, simply called 'Surface Dressing' known colloquially as 'The Blue Book' (in reference to the colour of the cover). This document was published in 1981.

The binders for use in Surface Dressing were required to be Cutback Bitumen or Bitumen Emulsion. Road Tar is not specified.

Hence road pavement specifications in use since 1978 did not specify Road Tar as a component whatsoever.

A note at the start of the DoE Specification for Road Works states: *this specification is based on the Specification for Roads and Bridge Works published in 1976 for the UK Department of Transport, with adaptations where necessary to suit Irish conditions and materials.*

It is also worth noting that the UK specifications provided options for Road Tar and the Irish versions did not.

### 2.1.4 An Foras Forbartha Teoranta

An Foras Forbartha (An Foras) was established in 1964 as the National Institute for Physical Planning and Construction Research. Within An Foras, an advisory service tested materials for local authority engineers and according to an employee who joined in 1970, no Tar specific specifications were in use. Various research papers and publications in the field of road pavements were published by An Foras prior to the operation being dissolved in 1993, after which the operation became subsumed by the Environmental Protection Agency.

The following An Foras research papers and publications do not mention Tar in the title, however copies of the publications have not been able to be located to conduct a full review.

Mensah-Quainoo J (1973) *The National Secondary routes, rural condition ratings*

Sheedy JPM (1982) *Charts based on TRRL nomograms for estimating past and future traffic for purposes of road strengthening and pavement design*

Golden JM (1984) *A simplified rational design method for flexible road pavements*

Jamieson IL (1984) *Pavement binders and energy savings*

Jamieson IL (1988) *A review of the properties of penetration bitumens with particular reference to specifications*

In summary, the review has established that specifications in use since 1978 do not reference Road Tar as a component of any products used in road pavements on the road network.

Relevant extracts of the specifications are contained in Appendix A.

## 2.2 Interviews with Stakeholders

Organisations involved in the supply of binders for use in bituminous mixtures, surface dressing and bituminous sprays were contacted and asked to provide any historical details of Road Tar supply and use. Current and former employees of the following organisations and a summary of their response is provided below:

- i. Irish Tar & Bitumen Suppliers Ltd (ITBS)
  - a) Over 50 years since ITBS imported tar.
  - b) Anecdotally, supplies of Coal Tar ceased in the late 1960's.
- ii. Colas Teoranta / Irish Shell
  - a) Best information available indicates Colas or Irish Shell did not import Coal Tar or Road Tar since 1953.
- iii. An Foras Forbartha (entity no longer exists)
  - a) No knowledge of Road Tar specifications.
  - b) Once found Road Tar in a very deep core.

In summary, information gathered from a wide range of Stakeholders suggests that Road Tar has not been supplied as a component of products used in road pavements on the road network since the mid 1970's at the latest.

## 2.3 Coal Tar Archives

Coal Tar is a by-product of coal gas manufacturing, a process that took place in town gasworks up to the mid 1960's before the mainstream introduction of petroleum products to produce gas.

A search for historical data relating to the town gas installations resulted in an informative chronology of energy use on the Ireland 2050 website, supported by the Energy Institute. <http://ireland2050.ie/about/> but unfortunately this website has since become unavailable. However it was noted that certain elements of the website had been derived from the publication by McCabe, C. (1992). History of the Town Gas Industry in Ireland 1823-1980. Dublin Historical Record, 45(1), 28-40. from <http://www.jstor.org/stable/30100966>

The publication includes the following:

- i. Between 1823 and 1825 three gas companies were established in Dublin. There were 3,750 gas lamps in use in Dublin in 1884 and the large gas holders in Barrow Street (now residential) were built in 1871, 1885 and 1925.
- ii. Gas works were the first large scale sources of ammonia, sulphur, sulphuric acid as well as tar for roads.

- iii. After the 1939-1945 war, high coal prices resulted in the gas companies moving away from coal to produce gas due to the increased availability of cheap by-products from the petroleum industry.
- iv. Dublin Gas manufactured gas from medium fuel oil in 1962 and Naphtha in 1966. However the oil crises of 1973 and 1979 resulted in gas derived from petroleum sources becoming very expensive.
- v. The conversion to using natural gas, fuelled by the Kinsale gas field, occurred in Cork in 1979, Dublin in 1982, Limerick, Waterford and Clonmel in 1986, Carlow in 1987 and Drogheda/Dundalk in 1988.

Hence by the 1960's, petroleum products had replaced coal for the production of gas and in the 1980's natural gas had become mainstream.

## 2.4 Conclusions

The purpose of the task was to establish the historical availability of Road Tar and the historical specification of materials containing Road Tar. In terms of availability, stakeholders from various organisations suggest Road Tar has not been available on the market since the late 1960's to mid 1970's at the very latest. The operation of the town gasworks appear to concur with this timeline as gas companies had replaced coal with petroleum products in the generation of gas in the 1960's.

Available specifications also support this timeline as the Department of Environment specifications in use since 1978 do not reference Road Tar as a component of any products used in road pavements on the road network.

The objective was to determine timelines that may be used to develop risk profiles for the subnetworks in terms of the likelihood of the pavement containing Road Tar.

From the available data, it would be reasonable to conclude that conservatively, roads constructed or realigned since the late 1970's would not contain Road Tar. With respect to legacy roads, constructed prior to this time, any reconstruction element undertaken since the late 1970's could also be assumed to not contain Road Tar, however the pavement substrate below the reconstructed element may contain Road Tar.

## 3. Risk of Road Tar Presence per TII Subnetwork

### 3.1 Introduction

The National primary and secondary road network comprises over 5,300 km of pavement with subnetwork classifications of Motorway & Dual Carriageway, Engineered Pavements, Urban and Legacy Single Carriageway.

A significant proportion of the National road network has been constructed with Bitumen in parallel to the availability of Road Tar and exclusively since Road Tar production ceased.

Hence the probability of a road pavement containing Road Tar ranges from zero to possible. The purpose of this task is to determine if a construction timeline can be attributed to certain sub networks. The objective is to determine risk profiles for each subnetwork in terms of the likelihood of the pavement containing Road Tar.

Note that the task is not intended as a mapping exercise for the entire network but a key additional step to take when assessing the potential for an issue to arise when undertaking pavement renewals and repairs.

### 3.2 Subnetworks

There is significant variation across the road network in terms of pavement construction, age, width, geometric design and traffic volumes. To effectively manage the network, a series of 5 subnetwork types have been defined by TII to reduce the variation in pavement condition, traffic and construction type within each subnetwork. (TII 2020)

#### 3.2.1 Subnetwork Types

Table 3.1 presents the five subnetwork types, typical attributes, corresponding lengths and percentage of the network that each subnetwork represents.

**Table 3.1 Subnetwork Types**

Subnetwork		Typical attributes	Length km (March 2021)	Percentage of network
0	Motorways & Dual Carriageways	High speed and high volume	1245	23%
1	Engineered Pavements	Designed pavement, presence of hard shoulder	1164	22%
2	Urban Area	Within towns and cities where National roads begin and end	667	13%
3	Legacy Single Carriageway – High Traffic	No original formal design, carrying between 5,000 and 10,000 AADT	1252	24%
4	Legacy Single Carriageway – Low Traffic	No original formal design, carrying less than 5,000 AADT	983	19%

Location maps of the subnetworks are contained in Appendix B.

National Primary roads are numbered from M1 to M50 (N Inclusive) and National Secondary roads are numbered from N51 to N87.

### 3.2.2 Design Manual for Roads & Bridges

A design manual produced by An Foras Forbartha Teoranta was used as part of the road design process up to the early 1990's. This addressed rural single carriageways, but not the motorways and more complex designs that were to follow. The National Roads Authority (NRA) created a new Design Manual for Roads & Bridges (DMRB), introduced in 2000, to promote consistency of approach to the design of more complex projects.

The manual set out the technical standards for the national roads programme, including road pavements. The NRA DMRB ensured that contractors built the projects to identical specifications.

This was of critical importance when the Design-Build contract form was adopted for the motorway and dual carriageway projects constructed from 2000 on. (NRA 2011)

## 3.3 Historical Construction Programmes

Data derived from NRA and TII archives has been used to complete the following sections. Primarily the NRA publication *A decade of progress* (NRA 2011) and Annual Reports.

Over 1,200 kilometres of motorway and 400 kilometres of single carriageway and link roads were built between 2000 and 2010 accounting for 50% of the current length of subnetwork 0 and 1, with further extensive infrastructure development having taken place since.

### 3.3.1 Subnetwork 0 - Motorways and Dual Carriageways

The motorways and dual carriageways that form Subnetwork 0 comprise the major inter urban routes and a selection of other national routes. The following summarises the timeline of construction of these sections of road.

**M1 (Dublin to Border) – 91 kilometres** - Completed between 1993 and 2007 with some work commencing in the 1980's including the 10 km Dunleer Bypass (completed 1993) and 13 km Balbriggan Bypass (1998) among the earlier schemes.

**M2/N2 Dublin to Ashbourne – 17 kilometres**- Completed in 2006. Dual carriageway and 3 lane motorway.

**M3/N3 (Dublin to Kells) – 61 kilometres** - Completed between 2007 and 2010. The road comprises 51 km of motorway from Clonee to north of Kells, 10 km of type 2 dual carriageway on the N3 at the Meath/Cavan border and 4 km of 2 lane single carriageway forming the N52 Kells Bypass.

**M4/M6 (Dublin to Galway) - 194 kilometres** - Completed between and 1990 and 2009. Three bypasses built during the 1990's – Athlone Bypass (1990), Maynooth bypass (1994) and the Lucan bypass (1994). The route is mainly motorway, except near the M50, and around Athlone.

**M4/N4 Kinnegad PPP to Mullingar – 11 kilometres** - Dual carriageway, Mullingar bypass (1995), McNeads Bridge to Mullingar (2001), McNeads Bridge to Kinnegad PPP (2005)

**M7 (Dublin to Limerick) - 199 kilometres** - Completed between 1983 and 2010. The road was built as twelve road projects. Three of these date back to the 1980's and 1990's - Naas Bypass (1983), Newbridge Bypass (1993) and the Portlaoise Bypass (1997). The Dublin to Naas dual carriageway was originally completed in 1968, however in terms of Subnetwork 0, the section from the M50 to Naas has been fully reconstructed.

**M8 (Portlaoise to Cork) - 150 kilometres** - Completed between 1992 and 2010. The road was built in seven sections, with the Glanmire bypass completed in 1992 and the Cashel Bypass and Watergrasshill Bypass completed 2003.

**M9 (Kilcullen to Waterford) – 116 kilometres** - Completed between 1994 and 2010. The road was built in five sections, with the Kilcullen Bypass completed in 1994. The four other sections were constructed in the period 2000-2010.

**N25 Waterford City Bypass – 23 kilometres** - Completed between 2006 and 2009. The Bypass consists of 23 km of dual carriageway and 14 km of single carriageway.

**N25 / N30 New Ross Bypass – 15 kilometres** - Completed between 2016 and 2019. The Bypass consists of 14km of dual carriageway and 1km of single carriageway.

**M11/N11 Dublin to Wexford – 115 kilometres** - Numerous schemes completed along the N11 route, including Newtownmountkennedy Bypass (1990), Arklow Bypass (1999), Glen of the Downs upgrade (2003), Ashford-Rathnew (2004), Gorey Bypass (2007), Arklow-Rathnew (2015) and Enniscorthy Bypass (2019)

**M50 – 45 kilometres** - Constructed between 1987 and 2005. The first section on the Western Parkway was completed in 1990 and the last section, the South Eastern Motorway, opened in 2005.

**Dublin Port Tunnel – 5 kilometres** - Opened in 2006

**N18 / M18 / M17 Limerick to Tuam – 121 kilometres** - Completed between 2002 and 2017. Bypasses of Newmarket-on-Fergus (2002), Ennis (2007), Gort to Crusheen (2010), followed by the 57 km PPP scheme from Gort to Tuam (2017)

**Limerick Tunnel – 11 kilometres** - Opened in 2010

**N40 / N22 Cork South Ring Road to Ballincollig – 19 kilometres** - Ballincollig Bypass (2004), Kinsale Road Interchange (2006), Sarsfield Road and Bandon Road interchanges (2013)

**N4 Dromod to Rooskey – 11 kilometres** - Bypass completed in 2007, Type 2 dual carriageway.

**N4 Collooney / Ballysadare Bypass / Sligo Inner Relief Road– 11 kilometres** - Dual carriageway, completed in 1998 and extended in 2005. The above schemes account for 98% of subnetwork 0, with the earliest motorway project, the Naas Bypass being constructed between 1980 and 1983.

### 3.3.2 Subnetwork 1 - Engineered Pavements

Engineered pavements include single carriageway roads designed since the 1980's with hard shoulders and more recent peripheral sections of pavement adjacent to those classed as subnetwork 0.

The following, taken from the NRA publication A decade of progress (NRA 2011), summarises the level of construction of Engineered pavements in the period from 2000 to 2010 on a selection of routes.

**N2 – 28 kilometres** - Carrickmacross Bypass (2005), Monaghan Town Bypass (2006), Clontibret to Castleblayney, built as a 2+1 section (2007)

**N4 – 11 kilometres** - Rathowen (2001), Hughstown to Meera (2004) Edgeworthstown relief road (2006)

**N5 – 26 kilometres** - Strokestown to Longford (2004), Charlestown Bypass (2007)

**N6 (N65) – 13 kilometres** - Loughrea Bypass (2005) and Link Road to M6 J16 (2009)

**N10 – 6 kilometres** - Kilkenny link road to M9 (2008)

**N15 – 22 kilometres** - Clar to Barnesmore (2001), Bunduf to Drowes River (2002), Ballyshannon to Bundoran Bypass (2006)

**N17 – 16 kilometres** - Knock to Claremorris (2002)

**N20 – 16 kilometres** - Croom Bypass (2001), Rathduff to Mallow 2+1 (2005)

**N21 – 20 kilometres** - Ballycarthy to Killally (2001), Ballycarthy Tralee (2005), Castleisland Abbeyfeale (2006)

**N22 – 7 kilometres** - Bealagrellagh/Gortatlea (2002), Gortatlea Farranfore (2005)

**N24 – 12 kilometres** - Beary's Cross to Grange Cross (2001), Piltown/Fiddown (2002)

**N25 – 25 kilometres** - Kilmacthomas link (2001), Camaross (2002), Youghall Bypass (2003), Kinsalebeg (2006)

**N26 – 5 kilometres** - Ballina to Bahola Ph 1 (2004)

**N30 – 5 kilometres** - Enniscorthy to Clonroache (2006)

**N33 – 7 kilometres** - Ardee link road (2001)

**N52 – 35 kilometres** - Nenagh Bypass link (2001), Mullingar Bypass (2006), Mullingar Belvedere (2007), Tyrellspass link to M6 (2008), Tullamore Bypass (2009), Kells (2010)

**N55 – 3 kilometres** - Cavan Bypass (2006)

**N56 – 11 kilometres** - Mountcharles Bypass (2001), Letterkenny Ring Road (2006), Mountaintop to Illistrin (2007)

**N77 – 4 kilometres** - Kilkenny Ring Road extension (2007)

**N78 – 8 kilometres** - Athy to M9 J3 (2009)

**N85 – 7 kilometres** - Ennis Bypass (2008)

The above schemes account for 25% of subnetwork 1 in the 10-year period 2000 to 2010.

### **3.3.3 Subnetwork 2 - Urban Area**

Located within towns and cities, often where National roads begin and end, the Urban carriageway design is not generally engineered as the pavement must accommodate factors in the surrounding terrain. Such factors may include crossfall, underlying utilities, adjacent streets and availability of access. Subnetwork 2 generally comprises speed limits up to 60 kph and / or within the Central Statistics Office defined town boundaries.

City and Town pavements are generally legacy pavements that may have been developed and altered over many decades to accommodate local changes. It is therefore difficult to establish the pavement construction in terms of product types, thicknesses and components in a uniform manner.

The historical location of town gasworks increases the likelihood that some roads within the urban environment would have contained Road Tar at depth within the pavement.

However, roads are a prime location for the installation of public utilities including gas, electricity, water and telecommunications. With increased demand and expansion of these utilities, a great deal of the legacy network will have been replaced over time.

### **3.3.4 Subnetwork 3 - Legacy Single Carriageway – High Traffic**

Traffic levels on Subnetwork 3 carriageways typically carry between 5,000 and 10,000 Annual Average Daily Traffic (AADT) – the total two-way traffic volume passing a particular point over a full year divided by 365.

Legacy roads comprise multiple material types of variable thicknesses that may have originally been unbound and sealed with surface dressing. As traffic levels increased, the renewals and repairs undertaken would have incorporated pavement improvements and strengthening over time. Some sections will have been reconstructed and others overlaid.

As an example, the N71 Skibbereen bypass is a single carriageway opened in 2003 and is contained in subnetwork 3. Future treatment requirements would not need to consider this section of pavement in terms of Road Tar risk.

Sections of single carriageway that didn't receive strengthening may contain multiple layers of surface dressing with some of the older layers predating the 1978 Department of the Environment specifications. (See Section 2). This increases the possibility that Road Tar based surface dressings may be present somewhere in the pavement structure. However where overlays have been added to the original structure, the Road Tar may well be at a depth below which any future treatment is needed.

### **3.3.5 Subnetwork 4 - Legacy Single Carriageway – Low Traffic**

Traffic levels on Subnetwork 4 carriageways typically carry less than 5,000 AADT.

As noted for subnetwork 3, legacy roads comprise variable material types of and thicknesses that may have originally been unbound and sealed with surface dressing.

Low volume legacy roads are unlikely to have received any substantial improvements and as such have a higher probability of comprising multilayer surface dressings. Some of the older surface dressing treatments would predate the 1978 Department of the Environment specifications which increases the possibility that Road Tar based surface dressings may be present *somewhere* in the pavement structure.

## **3.4 Risk Profiles**

Determining the likelihood of the presence of Road Tar in a road pavement informs the decision process about the approach to managing the risks involved and if confirmed, what risk control measures are then required.

The subnetwork types defined by TII are a good starting point to determine the likelihood of the presence of Road Tar in a road pavement.

Section 2 concluded that conservatively, roads constructed or realigned since the late 1970's would not contain Road Tar as the Department of Environment specifications in use since 1978 do not reference Road Tar as a component of any products used in road pavements on the road network.

The motorways and dual carriageways that form subnetwork 0 comprise the major inter urban routes and a selection of other national primary routes. Section 3 of this report established that these roads have been constructed since 1980, with the majority since the 1990's. It is therefore reasonable to determine that the likelihood of subnetwork 0 road pavements containing Road Tar as impossible.

The Engineered pavements of subnetwork 1 include single carriageway roads on the national primary and secondary routes designed since the 1980's with hard shoulders or more recently as peripheral sections of pavement adjacent to subnetwork 0. The majority of subnetwork 1 pavements are new construction or realigned routes, however there is a small possibility that some sections may have been placed on the pre-existing pavement in the substrate. It is therefore reasonable to determine that the likelihood of subnetwork 1 road pavements containing Road Tar as unlikely rather than impossible.

The City and Town pavements of subnetwork 2 are generally legacy pavements developed and altered over many decades to accommodate local changes. Some of these pavements would predate the 1978 Department of the Environment specifications, which increases the possibility that Road Tar based materials may be present in the pavement structure. However, with increased urban development and the resultant expansion of utility infrastructure, much of the legacy network will have been replaced over time. It is therefore reasonable to determine that the likelihood of subnetwork 2 road pavements containing Road Tar somewhere in the pavement structure as possible.

The legacy pavements of subnetworks 3 and 4 comprise multiple material types of variable thicknesses, many would have originally been unbound and sealed with surface dressing.

Some sections will have been reconstructed and others overlaid. Some of the older surface dressing treatments would predate the 1978 Department of the Environment specifications which increases the possibility that Road Tar based surface dressings may be present in the pavement structure. It is therefore reasonable to determine that the likelihood of subnetwork 3 and 4 road pavements containing Road Tar in the pavement structure as possible.

It is important to recognise that the presence of Road Tar within the pavement only requires to be managed if the depth of proposed pavement rehabilitation encompasses the layer in which the Road Tar is present.

### 3.5 Conclusions

The purpose of the task was to determine if a construction timeline could be attributed to certain subnetworks. Data relating to the historical construction programmes for subnetworks 0 and 1 has been reviewed and considered sufficient to determine construction timelines for these two subnetworks. This is not the case for subnetworks 3, 4 and 5 as these subnetworks relate to pavements that have existed and developed over many decades.

The objective was to determine risk profiles for each subnetwork in terms of the likelihood of the pavement containing Road Tar. Risk profiles according to the knowledge of subnetwork pavement types and construction periods have been determined and presented in Table 3.2.

**Table 3.2 Subnetwork risk profiles for presence of Road Tar**

Subnetwork		Typical attributes	Likely presence of Road Tar
0	Motorways & Dual Carriageways	High speed and high volume	Never
1	Engineered Pavements	Designed pavement, presence of hard shoulder	Rarely
2	Urban Area	Within towns and cities where National roads begin and end	Sometimes
3	Legacy Single Carriageway – High Traffic	No original formal design, carrying between 5,000 and 10,000 AADT	Sometimes

Subnetwork		Typical attributes	Likely presence of Road Tar
4	Legacy Single Carriageway – Low Traffic	No original formal design, carrying less than 5,000 AADT	Sometimes

The task was not intended as a mapping exercise for the entire network but a key additional step to take when assessing the potential for an issue to arise when undertaking pavement renewals and repairs. The subnetwork types defined by TII are a good basis to determine the likelihood of the presence of Road Tar and informs the decision process about the approach to managing the risks involved.

### 3.6 References

- [1] Transport Infrastructure Ireland (2020 April) TII National Roads Network Indicators 2019. <https://www.tii.ie/tii-library/strategic-planning/tii-road-network-indicators/TII-National-Roads-Network-Indicators-2019.pdf>
- [2] National Roads Authority (2011) A Decade of Progress. <https://www.tii.ie/tii-library/policies/TII%20General%20Publications/A-Decade-of-Progress.pdf>

## 4. Review of International Best Practice

The purpose of this element of the research task is to review international best practice with respect to road tar identification and treatment, and to provide TII with a summary of practices undertaken within other jurisdictions, highlighting key components of assessment and use. Where documents are referenced, an English translation of the title is provided in the body of the text and the source language reference is contained in the Bibliography at the end of each section.

### 4.1 Germany

According to the German Asphalt Pavement Association (DAV) document 'Recycling of Asphalt, 2014' [1] the purpose of the 'German Closed Substance Cycle Management Act, 2012' [2] is to promote the circular economy to conserve natural resources and ensure the environmentally sound management of waste. Producers or owners of waste are obliged to use it for recycling, which has priority over disposal. The obligation to recycle waste must be fulfilled as far as it is technically possible and economically reasonable, especially if there is a market for a material obtained or one can be created.

In addition to the Act, the Federal working group on waste (LAGA) publication 'Requirements for the recycling of mineral-based residual materials/waste – technical rules' [3] form the basis of federal state regulations when recycling asphalt. The LAGA technical rules may be considered as a link between waste legislation and construction materials recycling.

The recycling of reclaimed road construction materials containing tar is not excluded by regulations in German States, providing the following is observed:

1. Leave materials containing tar in the pavement structure  
If road materials containing tar are integrated into the pavement, adverse effects on soil water and ground water are not expected. If preliminary investigations show that tar is present in the pavement structure, the construction design can be revised with the aim of leaving the layers containing tar in the pavement structure.
2. Removal of materials containing tar  
Leaving in place may not be an option, for example:
  - replacement of pavement in conjunction with work on utilities,
  - removal of roads,
  - realignment and gradient improvements,
  - carriageway clearances due to existing structures and other gradient constraints.

Reclaimed road construction materials containing tar must be recycled in an environmentally clean manner. Use as a construction material must satisfy legal requirements and prove to be significantly more cost-effective than consignment to landfill.

3. Identification of harmful components  
Where historical records exist for the pavements and binders used, the authorities preparing the works can verify the environmental compatibility by referring to the records. If the use of binders containing tar cannot be confirmed, the PAH and phenol content of these materials must be determined. The German terms of contract (ATV) of VOB, Part C DIN 18299 [4] place the responsibility for this testing on the client who must arrange for samples to be taken and carry the costs of analysis.

#### 4. Allocation of utilisation classes

If there is evidence that the materials to be removed and recycled contain tar, they must be evaluated in relation to occupational health and safety, soil protection and water protection. Depending on the PAH content in the solid and the phenolic index of the eluate, the material is assigned to one of three Utilisation classes.

##### 4.1.1 Guideline Document RuVA-StB 01

The German Research Society for Roads and Traffic, *Forschungsgesellschaft für Straßen- und Verkehrswesen*, (FGSV) developed a set of guidelines (RuVA-StB 01) [5]:

‘Guidelines for the environmentally compatible recycling of road construction materials with tar/pitch-type components and for the recycling of reclaimed asphalt in road construction’

The guidelines, published in 2001, revised in 2005, take into account the LAGA technical rules and requirements of the Federal Soil Protection act. The guidelines cover:

- Construction planning
- Assessment of road construction materials
- Determination of utilisation classes
- Recovery processes
- Testing
- Installation requirements

##### Construction Planning

As early as the draft design stage for construction measures on existing roads, the road construction administration must check whether layers with tar/pitch-type components are present.

Documents about the construction of the road - e.g. construction files, construction diaries, information about the construction of the road surface, test certificates for suitability or control tests - can be used to check the layers, which show which binders were used in the production of the individual layers. If there is any ambiguity about the type of binder used, investigations must be carried out on drill cores, slabs or milled material, where the layers are to be examined separately.

If layers with tar/pitch-type components are encountered, the aim should be to ensure that these layers remain in the road surface and are built over, since it is known that such layers do not pose any risk to the environment. If layers have to be removed, they should be removed separately if possible. Layers with typical tar/pitch components are to be obtained separately from layers of asphalt, provided this is technically possible.

##### Assessment of Road Construction Materials (Proposed Reclaimed Materials)

In addition to their structural suitability, the materials to be removed and recycled must be evaluated primarily with regard to occupational safety, soil and water protection if tar/pitchtype components are detected.

The levels of PAH and phenols must be considered for occupational safety. PAHs escape at higher temperatures (above 100 °C) and Phenols escape with water vapor when this is released on heating. Technical Rules for Hazardous Substances (TRGS) [6] and the recommendations of the institute for occupational safety (BG/BIA) [7] must be observed.

For soil and water protection, the quantities of PAHs and phenols that are eluted by water are important.

Since there is insufficient background for the evaluation of the PAH components that can be eluted from the materials, the evaluation is based on the constituents (content in the solid), as provided for in the technical rules of the LAGA. Phenols are evaluated by the phenol index in the eluate obtained by leaching crushed material.

Test methods are covered under the testing section below.

### **Determination of Utilisation Classes**

The PAH content in the solid and the phenol index in the eluate, determines the recycling class of the proposed materials which in turn determines the type of recycling permitted. To classify a material into one of the recycling classes, testing is undertaken unless it has been proven beyond any doubt that only bitumen or bitumen-containing binders were used.

Only Class A recycling materials may be used to produce asphalt using the hot mixing process – the method to be aimed for, as this represents the highest quality of utilisation.

Figure 4.1 in RuVA-StB 01 is a helpful flowchart that can be used to determine the recycling classes and the assignment of recycling processes. Two starting points are assumed; a procedure for road maintenance planning and a procedure for excavations.

Figure 4.1 is reproduced below, translated into English.

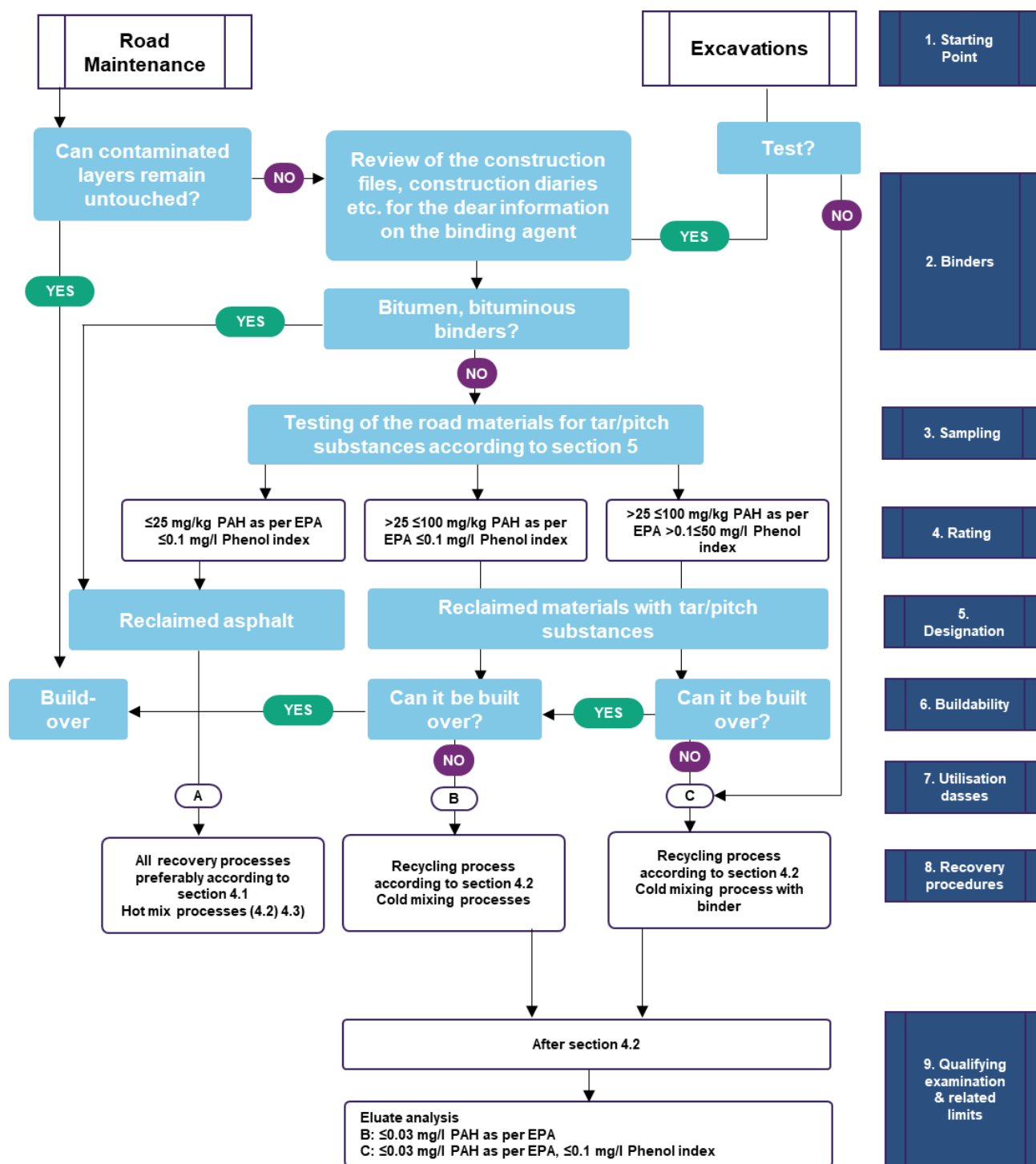


Figure 4.1 RuVA-StB 01 Diagram of the decision-making process for the recycling of road construction materials with tar/pitch-type components and recycling of reclaimed asphalt

### Recovery Processes

The recycling processes are divided into hot and cold. Cold processes are used with and without the addition of binders. The utilisation class determines which recycling process is permitted.

Table 1 in Section 4 of RuVA-StB 01 deals with the utilisation classes; the table contains the criteria for each class. In 2018, the Berlin Senate Department for the Environment, Transport and Climate Protection issued an amendment to the table with further restrictions [8]. The Table reproduced below includes the amendments of 2018.

**Table 4.1** Table Reproduced from Official Gazette for Berlin, No.: 07/2018 p. 900 (amended version of Table 1 from RuVA-StB 01)

Utilisation Class	Type of reclaimed road construction materials		Background <sup>1</sup>	Total PAH content in solids according to EPA (TS)	Phenol Index in the eluate	Recovery operations according to section <sup>2</sup>
				mg/kg	Mg/l	
A	Reclaimed Asphalt		AS, BS, GS	≤ 25 <sup>4</sup>	≤ 0.1 <sup>4</sup>	4.1 (4.2) (4.3)
B	Reclaimed materials with typical pitch/tar constituents	Predominantly hard coal tar-type	AS, BS, GS	>25 ≤ 100	≤ 0.1	None (disposal)
C		Predominantly lignite tar-type	BS, GS	>25 ≤ 100	>0.1 ≤ 50	None (disposal)

<sup>1</sup> AS = Occupational safety, BS = Soil protection, GS = Water protection  
<sup>2</sup> in brackets: only in exceptional cases, as not high-grade recycling  
<sup>3</sup> dropped (was used in a previous version of the table)  
<sup>4</sup> Verification may be omitted if it is proven beyond doubt in an individual case that only bitumen and bituminous binders were used.

The Class A value of up to 25 mg/kg PAH corresponds to a binder in the mixture that does not require labelling. The rationale is explained in the document appendix and essentially relates to the maximum level of PAH that could be found in a bitumen that is compliant with EN 12597.

The amendment published by the Berlin Senate Department for the Environment, Transport and Climate Protection imposed the maximum PAHs and Phenol levels in the above table. Reclaimed material with values above these levels is to be classified as hazardous waste (waste code 17 03 01\* bituminous mixtures containing coal tar). The material must be disposed of as a Hazardous Waste and the preferred method is thermal disposal. The material must not be recycled in road construction. Irrespective of the method of recycling, the storage of Class A materials is subject to the requirements in the 'Code of Practice for the Reuse of Asphalt' (M WA) [9].

For the interim storage of Class B and Class C materials, the requirements of the 'Code of practice for the recycling of road construction materials containing pitch and asphalt granulate in bitumen-bound base courses by cold processing in mixing plants' (M VB-K) [10] and 'Code of practice for the use of reclaimed asphalt and pitch-containing materials in base courses with hydraulic binders' [11], apply.

Class B and Class C materials may only be temporarily stored and separate from other construction materials. The stockpiles must be protected from water ingress until they are recycled.

If storage is not under roof, they may only be stored temporarily on a waterproof base and must be covered to protected against water ingress.

#### Hot Mix Process

Class A materials in Table 1 can be reused as asphalt granulate in a hot mixing process. It can be used in asphalt mixing plants and in construction site mixing processes. Asphalt granulate that is to be used for the production of mixes in asphalt mixing plants must comply with the 'Technical Delivery Conditions for Asphalt Granulate' (TL AG-StB) [12]

The procedures for recycling recovered asphalt directly on the construction site are described in the 'Additional Technical Terms and Conditions and Guidelines for the Structural Maintenance of Traffic Areas - Asphalt Construction Methods' (ZTV BEA-StB) [13]

#### *Cold Mix Process - with Binders*

Recycling with cold mix processes with binders is possible for road construction materials of all recycling classes; however, this is only permissible for Class B and Class C if the limit values in the following table are complied with for the bound mixture. Test methods are covered under the testing section.

**Table 4.2** Limit values for the elution of test specimens from bound materials of recycling classes B and C as part of the suitability test

utilization class	PAHs according to EPA	phenol index
	mg/l	mg/l
B	≤ 0.03	no verification required
C	≤ 0.03	≤ 0.1

With these processes, a distinction can be made between use in stationary and mobile mixing plants and in site mixing processes. Depending on the binder to be used, recycling must take place in accordance with one of the following codes of practice:

Code of practice for the recycling of road construction materials containing pitch and asphalt granulate in bitumen-bound base courses by cold processing in mixing plants (M VB-K) [10] Code of practice for the use of reclaimed asphalt and pitch-containing materials in base courses with hydraulic binders [11]

#### *Cold Mix Process - without Binders*

In exceptional cases, cold processing can be carried out without the addition of binders. Class A materials come into consideration for this if they are installed in base layers under waterimpermeable top layers.

In the cold mix processes, aggregates can be added if the structural properties of the mix require. The quantity added should be kept as small as possible in order not to increase the volume of the tar/pitch-type layer unnecessarily.

### **Testing**

#### *Road Construction Materials (Proposed Reclaimed Materials)*

Qualitative determination of PAH and/or elutable phenols can initially be obtained using rapid methods contained in Working document AP Nr. 27/2 [14].

The document outlines methods to detect PAH using fluorescence under UV light and phenols in environmentally relevant concentrations through colour reactions in the cores, slabs and milled material. The methods are used as a priority to carry out on-site testing and perform checks on incoming materials.

With these methods, no quantitative statement is possible, only a yes/no statement. A yes statement can initially only lead to a Class C utilisation. An exact assignment to a recycling class can only be made by quantitative analytical testing.

### Bound Construction Materials (Recycled Mixture)

The composition of the mixture is assessed in accordance with the elution limits and suitability criteria mentioned under the Cold mix process in the previous section. Test specimens are produced from the mixture specified in the suitability test and eluted after 14 days of storage. The PAH content and the phenol index are determined in the eluate.

### Eluate Preparation and Analytical Test Methods

Quantitative determination of PAH and/or elutable phenols is undertaken on samples of loose reclaimed materials and specimens manufactured in the laboratory from bound reclaimed materials. Cores must not be used for this testing.

- The elution is carried out in accordance with 'Technical test specifications for mineral materials in road construction' (TP Min-StB) Part 7.1.2 Trough method [15].
- The PAH content according to EPA in the eluate is determined in accordance with 'Technical test specifications for mineral materials in road construction' (TP Min-StB) Part 7.3 Analytical method (DIN 38407-F18) [16].
- The PAH content according to EPA in the solid is determined in accordance with TP Min-StB Part 7.3 Analytical method (DIN ISO 13877) [16] or the Gas Chromatography Mass Spectrometry method according to [17].
- The phenol index is determined using the High Performance Liquid Gas Chromatography (HPLC) method in accordance with [18] or in accordance with TP Min-StB Part 7.3 Analytical method (DIN 38409-H16-2) [16].

The US EPA comprises a set of 16 PAH types for normal analysis, i.e. PAH 16 and the German guidance refers to the PAH content as 'PAHs according to EPA'

### Installation Requirements for the Mixtures

Depending on the utilisation class of the materials, the installation of the mixtures produced from them is only permissible from the point of view of soil and water protection if the requirements contained in the following table are complied with.

These are in accordance with the technical rules of the LAGA with regard to the installation location and the required pavement superstructure.

**Table 4.3 Requirements for the installation of the mixtures from the point of view of soil and water protection**

Line	Utilisation Class	Recovery process	Location <sup>2</sup>	Construction requirements
1	A	Hot mix process	No limitation	No
2	A	Cold mix process with binder	No limitation	No
3	B, C		Excluded in water protection zones of water and medicinal spring protection areas, water priority areas, areas with frequent flooding, karst areas without sufficient cover etc.	Under waterproof layer
4	A	Cold mix process without binder		

<sup>1</sup> Omitted

<sup>2</sup> In principle, the distance to the groundwater should be >1 m, except in the case of hot mixing processes.

#### 4.1.2 German Bibliography

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- [2] Kreislaufwirtschaftsgesetz (KrWG)
- [3] Länderarbeitsgemeinschaft Abfall (LAGA): Anforderungen an die stoffliche Verwertung von mineralischen Reststoffen/Abfällen, Technische Regeln II 1.3, 1995
- [4] DIN 18299 VOB Vergabe- und Vertragsordnung für Bauleistungen - Teil C: Allgemeine Technische Vertragsbedingungen für Bauleistungen (ATV) - Allgemeine Regelungen für Bauarbeiten jeder Art, 2019
- [5] Richtlinien für die umweltverträgliche Verwertung von Ausbaustoffen mit teer-/pechtypischen Bestandteilen sowie für die Verwertung von Ausbauasphalt im Straßenbau, (RuVA-StB 01), Fassung 2005, FGSV 795
- [6.1] Technische Regeln für Gefahrstoffe: Teer und andere Pyrolyseprodukte aus organischem Material (TRGS 551), Bundesarbeitsblatt Nr. 7-8/1999
- [6.2] Technische Regeln für Gefahrstoffe: Grenzwerte in der Luft am Arbeitsplatz „Luftgrenzwerte“ (TRGS 900), Bundesarbeitsblatt Nr. 10/2000
- [6.3] Technische Regeln für Gefahrstoffe: Begründungen und Erläuterungen zu Grenzwerten in der Luft am Arbeitsplatz (TRGS 901), Bundesarbeitsblatt Nr. 10/2000
- [6.4] Technische Regeln für Gefahrstoffe: Verzeichnis krebserzeugender, erbgutverändernder oder fortpflanzungsgefährdender Stoffe (TRGS 905), Bundesarbeitsblatt Nr. 9/1999
- [7] BG/BIA-Empfehlungen für verfahrensbezogene Verarbeitung von bitumenhaltigen Baustoffen, Bau-Berufsgenossenschaft (in Vorbereitung)
- [8] Ausführungsvorschriften zu § 7 des Berliner Straßengesetzes, Lesefassung (amtliche Fassung: Amtsblatt für Berlin, Nr.: 07/2018 S. 900. Senatsverwaltung für Umwelt, Verkehr und Klimaschutz
- [9] Merkblatt für die Wiederverwendung von Asphalt, (M WA), FGSV 754
- [10] Merkblatt für die Verwertung von pechhaltigen Straßenausbaustoffen und von Asphaltgranulat in bitumengebundenen Tragschichten durch Kaltaufbereitung in Mischanlagen, (M-VB-K) FGSV 755
- [11] Merkblatt für die Verwendung von Ausbauasphalt und pechhaltigem Straßenaufbruch in Tragschichten mit hydraulischen Bindemitteln, FGSV 826
- [12] Technische Lieferbedingungen für Asphaltgranulat (TL AG-StB), FGSV 749
- [13] Zusätzliche Technische Vertragsbedingungen und Richtlinien für die Bauliche Erhaltung von Verkehrsflächen - Asphaltbauweisen (ZTV BEA-StB), FGSV 798
- [14] Prüfung von Straßenausbaumaterial auf carbostämmige Bindemittel Schnellverfahren, FGSV AP 27/2
- [15] Technische Prüfvorschriften für Mineralstoffe im Straßenbau (TP Min-StB), Teil 7.1.2 Trogverfahren, FGSV 610

- [16] Technische Prüfvorschriften für Mineralstoffe im Straßenbau (TP Min-StB), Teil 7.3 Analysenverfahren, FGSV 610
- [17] Landesumweltamt Nordrhein-Westfalen: Merkblätter Nr. 1, Bestimmung von polyzyklischen aromatischen Kohlenwasserstoffen (PAK) in Bodenproben, Abschnitt 7.2, Seite 14, Essen (1994) in Verbindung mit H. Budzikiewicz, Massenspektrometrie; VCH Verlagsgesellschaft, Weinheim 3. erw. Auflage
- [18] Heime r, K.: FE 146 1035 Verbundvorhaben des BMBF; Reststoffverwertung im Straßenbau, Schnellverfahren zur Ermittlung von phenolhaltigen Verbindungen in Straßenbaumaterial, STB Prüfinstitut, Erfurt 1998

## 4.2 Netherlands

Until 1 January 2001, tar Asphalt was a special category in the Soil Quality Decree, meaning tar Asphalt could be used in works under certain conditions, including as a bound recycled product in lower layers of road construction. As of 1 January 2001, this special category lapsed meaning that the use of tar Asphalt, in whatever form, is no longer permitted.

LAP3 is the Dutch acronym for the third National Waste Management Plan (NWMP3) [1]. The plan consists of a policy framework and sector plans that detail how specific waste materials may be processed. Sector Plan 34 deals with Asphalt and Tar Asphalt [2].

In the case of material containing tar, the policy is to remove it from the supply chain by thermal processing to destroy the PAH present.

### 4.2.1 Handling Guidelines for Reclaimed Asphalt – Selective Removal of Tar-Free and Tar Asphalt' (Publication 210), CROW

CROW is a not-for-profit organization in which government and businesses work together in pursuit of their common interests. A CROW working group developed a document 'Handling Guidelines for Reclaimed Asphalt – selective removal of tar-free and tar asphalt' (Publication 210) [3].

This guideline describes how clients and contractors should assess whether the existing asphalt contains tar or is tar free. The guideline covers preliminary investigation through to final disposal with seven steps to be followed:

- Historical administrative investigation and inspection;
- Developing a draft coring plan;
- Conducting the coring;
- Analysing cores and research results;
- Developing a milling plan;
- Removing the asphalt;
- Transport and disposal.

If all of these steps have been carried out in accordance with the guideline, asphalt plants and recycling companies accept asphalt that has been assessed as tar-free for further processing.

### Warm Reuse of Asphalt Granulate in Asphalt Mixtures

The reuse of asphalt granulate in warm asphalt mixtures is considered the highest quality use. Asphalt containing asphalt granulate generally has equivalent properties to asphalt containing 100% new raw materials.

The application of asphalt granulate in road foundations is not as high-quality compared to use in warm asphalt mixtures. The use of asphalt granulate for the paving of semi-paved roads is also less desirable, because the potential of this valuable raw material is not optimal.

### **Responsibilities of the Client**

The owner of asphalt is the natural or legal person in possession of the asphalt; this will generally be a road manager. As the owner, a road manager must investigate whether the asphalt contains tar in order to determine the correct destination for the asphalt. This investigation may form part of the tender, but preferably is carried out before the contract is tendered. In tender documents the client must state information concerning the specific site conditions, such as:

- Whether the material is clean or contaminated;
- The chance of contact with substances containing health risks;
- A safe work area can be set up on the site.

The obligations for clients are laid down in construction process provisions of the Working Conditions Decree: Chapter 2, section 5, articles 2.23 to 2.35 inclusive [4]. In integrated contracts where the contractor becomes responsible for parts of the design particular attention should be paid to regulate these obligations.

If the investigation into the material does not form part of the contract, the client must provide the results of the investigation with the tender documents, so that the contractor has sufficient information to estimate the costs and risks in the tender.

If conducting the investigation does form part of the contract, this should be treated as a separate, easily calculable, part of the tender or a provisional lump sum. The disposal of waste is referred to as a disposal chain, in the case of asphalt it is the sum of all actions up to the moment that the asphalt has been accepted by a processor, who will store, apply, reuse or thermally clean the material. The chain starts the moment that a client intends to remove the asphalt. The plans determine where and how much asphalt will be removed.

In this publication the chain is split into the seven steps that must be followed with associated mandatory protocols; as shown in Figure 4.1.

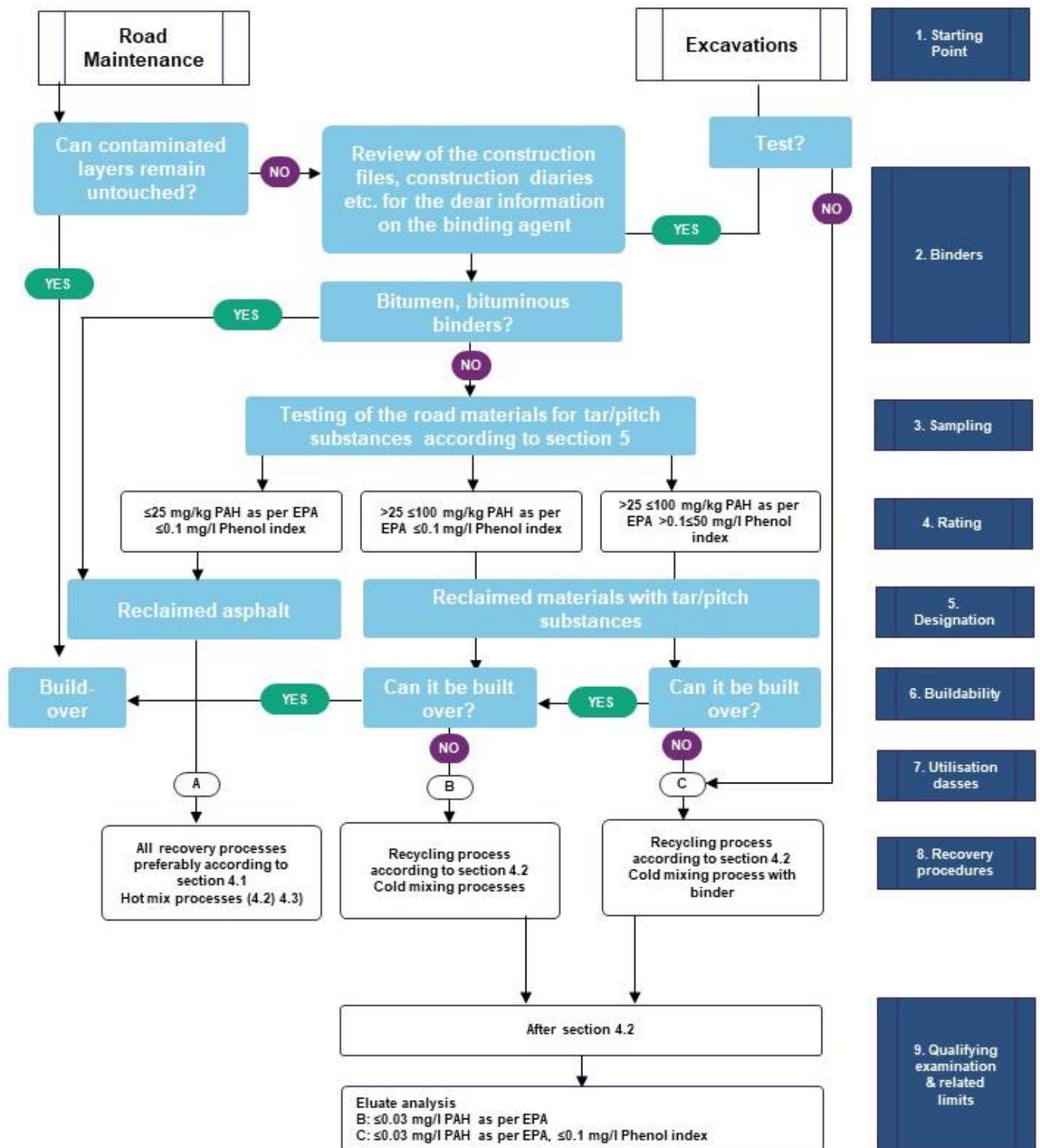


Figure 4.1 CROW 210 Main process flow including the seven stages and protocols

### Protocol 1: Historical Administrative Investigation and Inspection

This includes historical information about the structure and composition of the work, where possible this shall comprise quality data for the materials used during construction and maintenance. All data is important for assessment of the possibilities for reuse e.g. types of asphalt, reinforcement, coloured asphalt. If during the historical administrative survey, the date of construction is not determined, the materials should be considered suspicious.

A second part of this step concerns the work inspection. During this inspection it must be assessed how the work can now be performed safely and whether special features visible in the work are to be taken into account during the investigation.

This concerns, for example, rut formation, transitions, joints and any special road sections (e.g. bus stops with surface layers that may contain tar) that must be examined as a separate element.

The first step is completed with a dated report. The work is classified according to road sections with all associated data about dimensions and examination depth, if the depth to be explored is not determined in advance, it is advisable to examine the entire asphalt construction. The report also contains information about contact persons and the appropriate notifications and security measures.

The Historical Administrative Investigation and Inspection process diagram is reproduced in Figure 4.2.

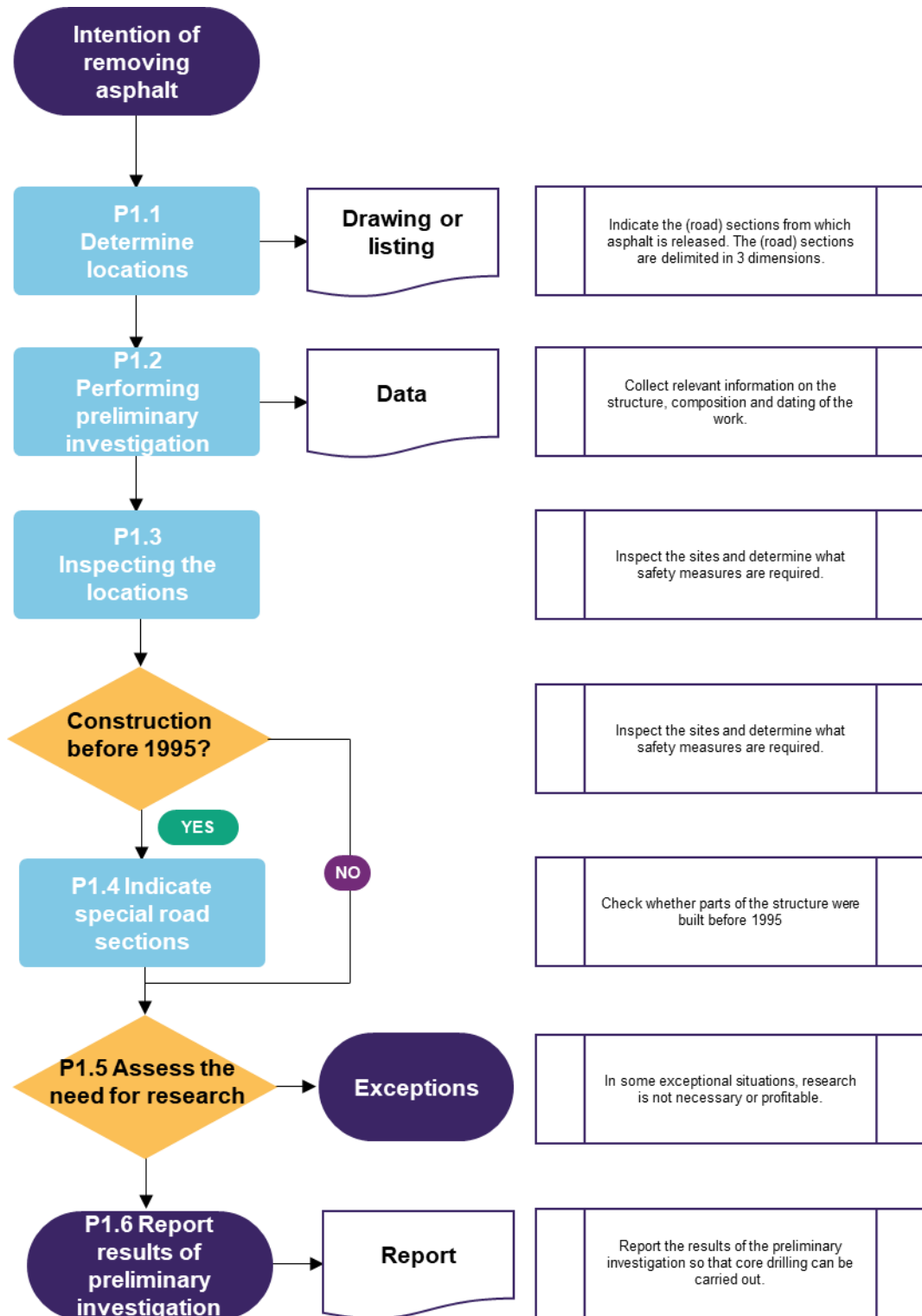


Figure 4.2 CROW 210 Protocol 1: Historical administrative investigation and inspection

### Protocol 2: Developing a Draft Coring Plan

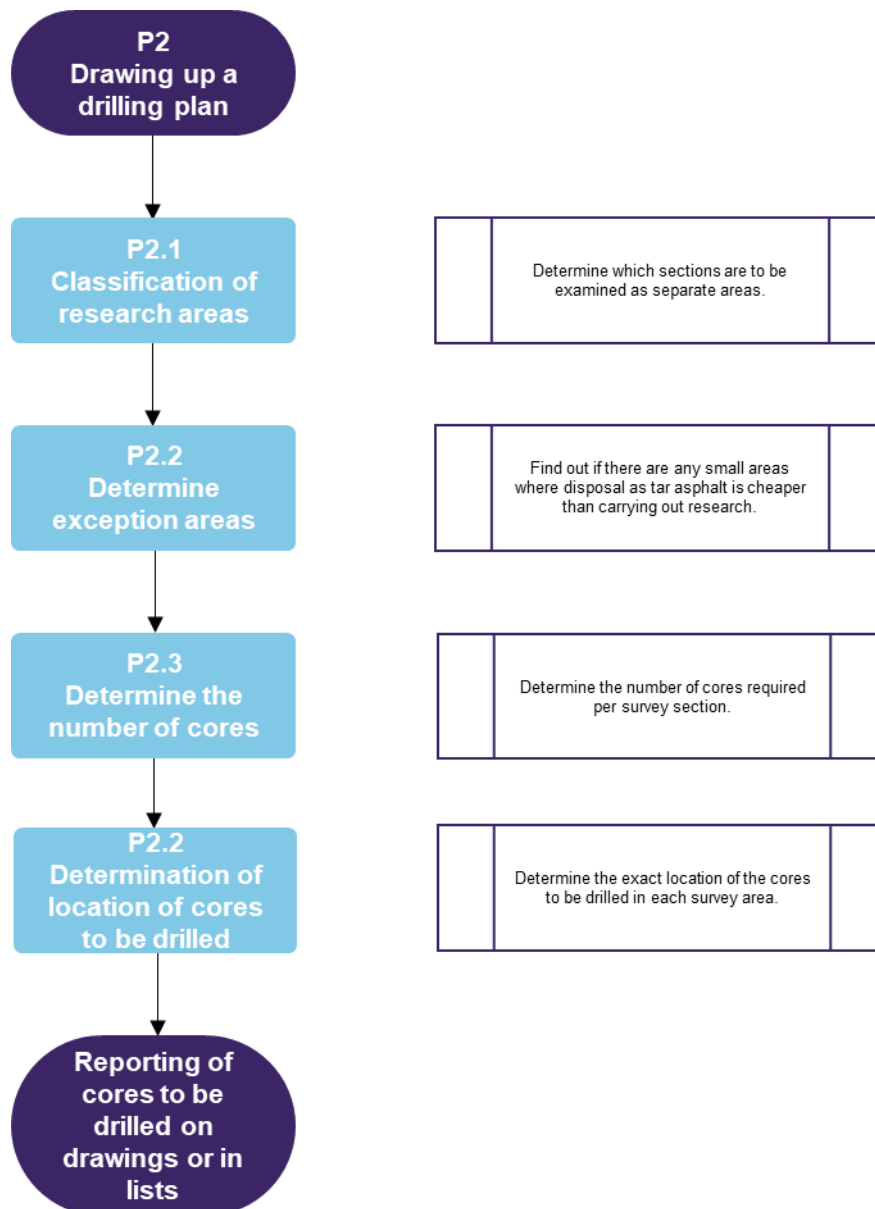
This step can be undertaken by or on behalf of the road manager or performed by a contractor. Based on the information from Protocol 1, the number and location of cores is determined. The number of cores per m<sup>2</sup> is based on the age and the surface area of the asphalt. The following table is reproduced from the document to indicate the level of testing undertaken in the Netherlands.

Situation	Minimum number of cores
<b>Constructed in whole or in part before 1995* (works considered as several research areas)</b>	
Area < 100 m <sup>2</sup>	1
Area < 500 m <sup>2</sup>	2
Area > 500 m <sup>2</sup>	1 per 500 m <sup>2</sup> + 1 extra per area
Highway or major homogenous area > 10 000 m <sup>2</sup>	1 per 1 000 m <sup>2</sup> + 1 extra per area
Very large homogenous area > 100 000 m <sup>2</sup>	1 per 10 000 m <sup>2</sup> + 1 extra per area, minimum 11 cores
<b>Constructed entirely after 1994* (works considered as one research subject)</b>	
Area < 1000 m <sup>2</sup>	2
Area > 1000 m <sup>2</sup>	1 per 1 000 m <sup>2</sup> + 1 extra per area
Highway or homogenous area > 100 000 m <sup>2</sup>	1 per 10 000 m <sup>2</sup> + 1 extra per area, minimum 11 cores

\* Tar was banned as a component of asphalt in the Netherlands from 1<sup>st</sup> January 1995

Lanes and emergency lanes must be examined separately. Experience suggests that sometimes multiple surface course layers are present at different depths. If, on the basis of data, it is possible to shown that a full-width carriageway has the same structure, a separate investigation of each lane is not necessary. If the data from step 1 is insufficient, the coring investigation must assume that the entire section is suspect for tar containing asphalt.

The Developing a Draft Coring Plan process diagram is reproduced in Figure 4.3.



**Figure 4.3 CROW 210 Protocol 2: Developing a draft coring plan**

### Protocol 3: Conducting the Coring

This step involves preparing for and performing the coring work. During the preparation, the drilling company and the client assess the safety measures and whether the necessary notifications have been made. When carrying out the work, it is important to have the correct locations, preferably GPS coordinates, and core references to enable the cores to be labelled correctly.

In some cases, the asphalt core includes tar-containing adhesives (tack coat). These layers are very thin, so there is a chance that they are not noticed during the investigation. The testing laboratory must be aware of this, because this poses a risk when delivering the asphalt to an asphalt plant.

The core must be a minimum 100mm diameter and extracted to a minimum of 100mm below the depth for investigation. The core location accuracy must be +/- 2m from the plan.

The cores must be transported and stored in the laboratory at a temperature that cannot exceed 40°C and protected from sunlight and precipitation.

The Conducting the Coring procedure diagram is reproduced in Figure 4.4.

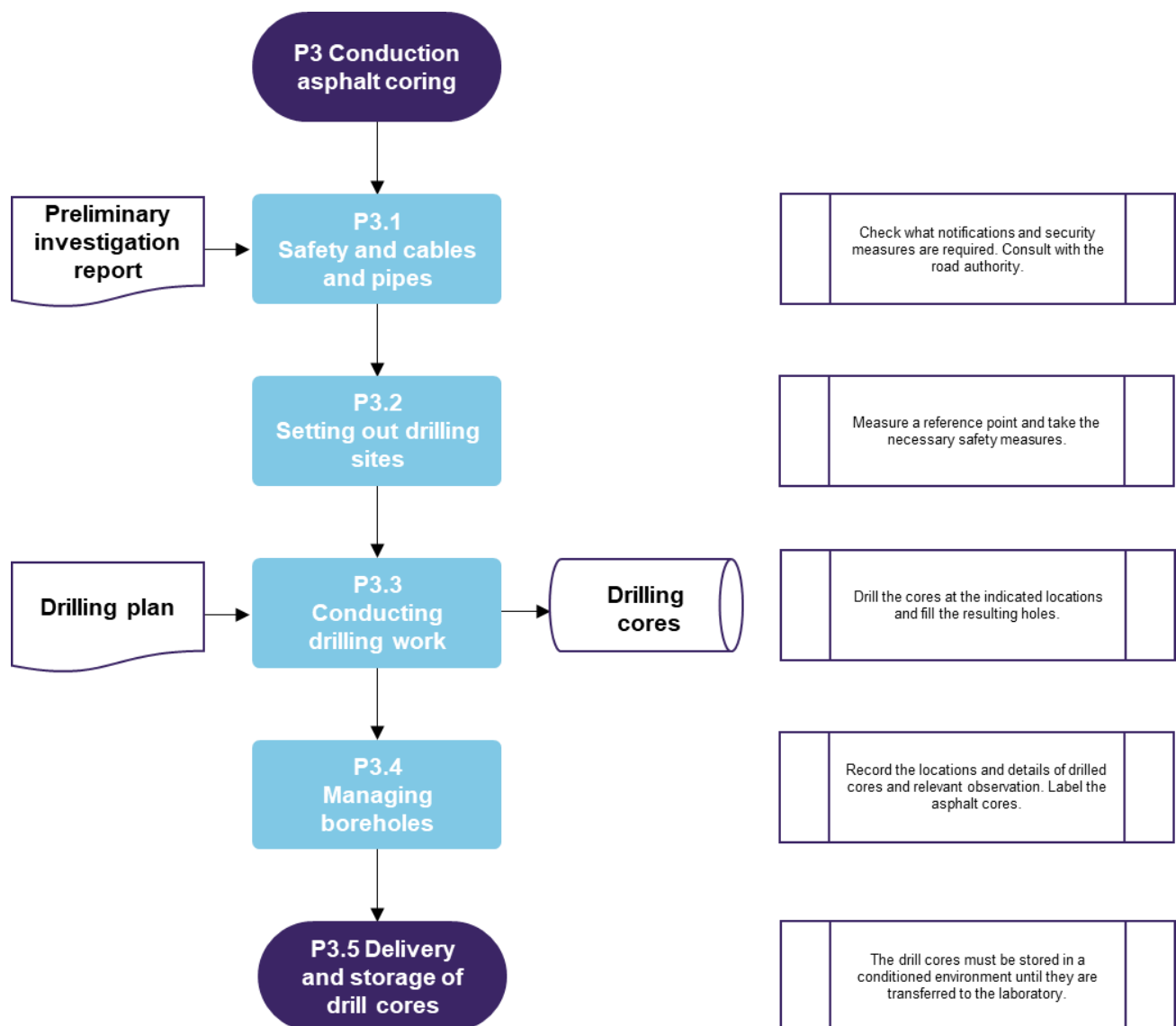


Figure 4.4 CROW 210 Protocol 3: Conducting the coring

#### Protocol 4: Analysing Cores and Research Results

This step involves examining the cores and the detection of tar in the asphalt. The investigation should be conducted by a laboratory that is competent in the relevant operations based on EN ISO/IEC 17025 and accredited for same.

The study begins with a core log, to determine layer thickness and material types and nominal sizes. The analysis is performed in accordance with the method described in test 77.1 of the Standard RAW Provisions [5]. The core is saw cut in a longitudinal direction to expose all layer of the core.

This is followed by a PAH detector study on all layers; providing a qualitative indication as to whether tar is present in each layer and at the interfaces (tack coats). The test is performed in accordance with the method described in test 77.2 of the Standard RAW Provisions [5]. The PAH detector test must be performed within 2 months of the core being saw cut.

The test involves applying a thin but opaque coating of the detector spray onto an exposed strip of the cut face of the core. The core is left to dry for 10 minutes then evaluated within 1 hour.

The evaluation takes place in a dark room using a UV light with yellow filter. The core is assessed to determine the contrast between non-fluorescent stone chips and the possible luminescent mortar around it.

If a clear discoloration (UV fluorescence) is detected in the mortar, this is an indication of the presence of tar/PAH in the asphalt. If speckles of fluorescence are observed in the mortar, they indicate fluorescent minerals in the aggregate and not the presence of tar.

The PAH detector has a qualitative detection limit of approximately 250 mg/kg PAH 10. This means that the 'fluorescent' result always has a tar-containing layer except for false positives. For asphalt layers that do not react positively in the PAH detector test (i.e. does not discolour or does not fluoresce) it cannot be stated with certainty that the asphalt is tar-free. The background concentration of PAH 10 in tar-free asphalt is normally between 5 to 10 mg/kg.

For asphalt that is considered tar free, based on the PAH detector study, a semi-quantitative analysis is carried out per homogeneous test area using a semi-quantitative method (DLC test - Thin Layer Chromatography) or quantitative method (HPLC or GCMS test - High Performance Liquid Chromatography or Gas Chromatography Mass Spectrometry) to determine the PAH 10 content of the asphalt. The tests are performed in accordance with the method described in test 77.3 of the Standard RAW Provisions [5].

The DLC test gives two possible answers, no fluorescence or fluorescence, roughly comparable to PAH 10 ranges of:

- PAH 10 < 50 mg/kg                      no fluorescence: tar-free
- PAH 10 > 50mg/kg                      fluorescence: tar suspect

All samples in which fluorescence is observed must be further examined for PAH content by GC-MS or HPLC, otherwise these samples must be classified as 'tar containing'.

If the PAH 10 content has to be determined quantitatively by means of GC-MS analysis, this can be done by presenting the preserved DLC extract to an analytical laboratory and having the content in this dichloromethane extract determined.

Note that PAH 10 is the sum of the individual contents of the following ten polycyclic aromatic hydrocarbons:

- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Chrysene
- Fluoranthene
- Indeno(1,2,3-cd)pyrene
- Naphthalene
- Phenanthrene

The US EPA list contains 16 polycyclic aromatic hydrocarbons, PAH 16, including the above types plus:

- 9H-Fluorene

- Acenaphthylene
- Acenaphthylene, 1,2-dihydro-
- Benz[e]acephenanthrylene
- Dibenz[a,h]anthracene
- Pyrene

No additional testing is required if all the asphalt to be removed has been laid since 1995 and no tar has been detected with the PAH detector. Where further examination is required, the number of tests are as follows:

**Table 4.4 Asphalt quantities and minimum number of analyses**

Quantity of each area of tar-free asphalt	Minimum number analysis
Constructed since 1995 and no tar detected with the PAH detector test	PAH detector only
0 to 25 t (if entire works comprise <25t)	PAH detector only
0 to 200t	1
200 to 1 000t	2
1 000 to 2 000t	3
Each additional 2 000t	1 extra

The core log and results are compared to the coring plan to determine homogenous areas with similar thickness and material profiles and non-homogenous areas. The quantities of each area are then calculated to determine whether it is economically viable to selectively mill or allocate all as tar-asphalt.

For non-homogeneous pavements with many different layers and thicknesses involving different suppliers, more analyses are needed than the minimum number indicated in the table under Protocol 2. In this case, the areas are subdivided again to assess the tar content.

The laboratory investigation is completed with a report of the results, including where tar asphalt is located in the pavement. The report includes a schematic or graphical representation with the analysis results indicated for the core locations.

The Analysing Cores and Research Results procedure diagram is reproduced in Figure 4.5.

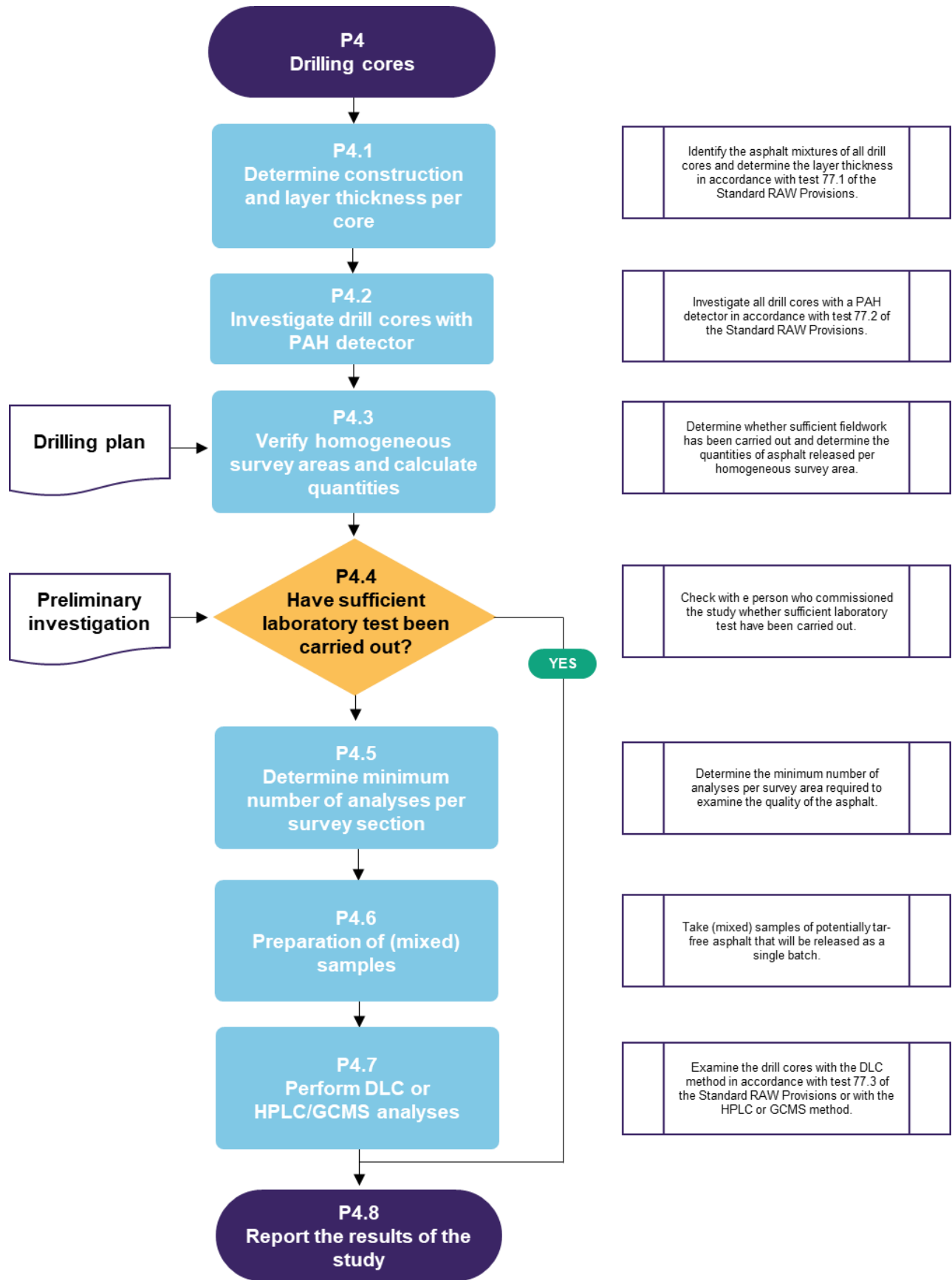


Figure 4.5 CROW 210 Protocol 4: Analysing cores and research results

### **Protocol 5: Developing a Milling Plan**

In this step, the results of the research and analysis are translated into a plan indicating how tar-containing and tar-free asphalt is to be removed separately. An advisor to the road authority, a contractor or a consultant of the contractor can execute this step. The milling plan must also include agreements in case the preliminary investigation deviates from the actual situation. The road authority, being the owner of the asphalt, can check the milling plan.

When milling tar-free and tar-containing asphalt separately, an additional milling margin (safety margin) of 20 mm at the top and bottom of the tar-containing layer is removed with the tar-containing layer classed as tar-containing.

The milling plan should include a drawing or diagram showing how the different sections of asphalt should be removed, what they contain and clear measurements for all sections. The plan should also indicate what should be done in unexpected situations in the event of unexpectedly milling asphalt containing tar.

The Developing a Milling Plan procedure diagram is reproduced in Figure 4.6.

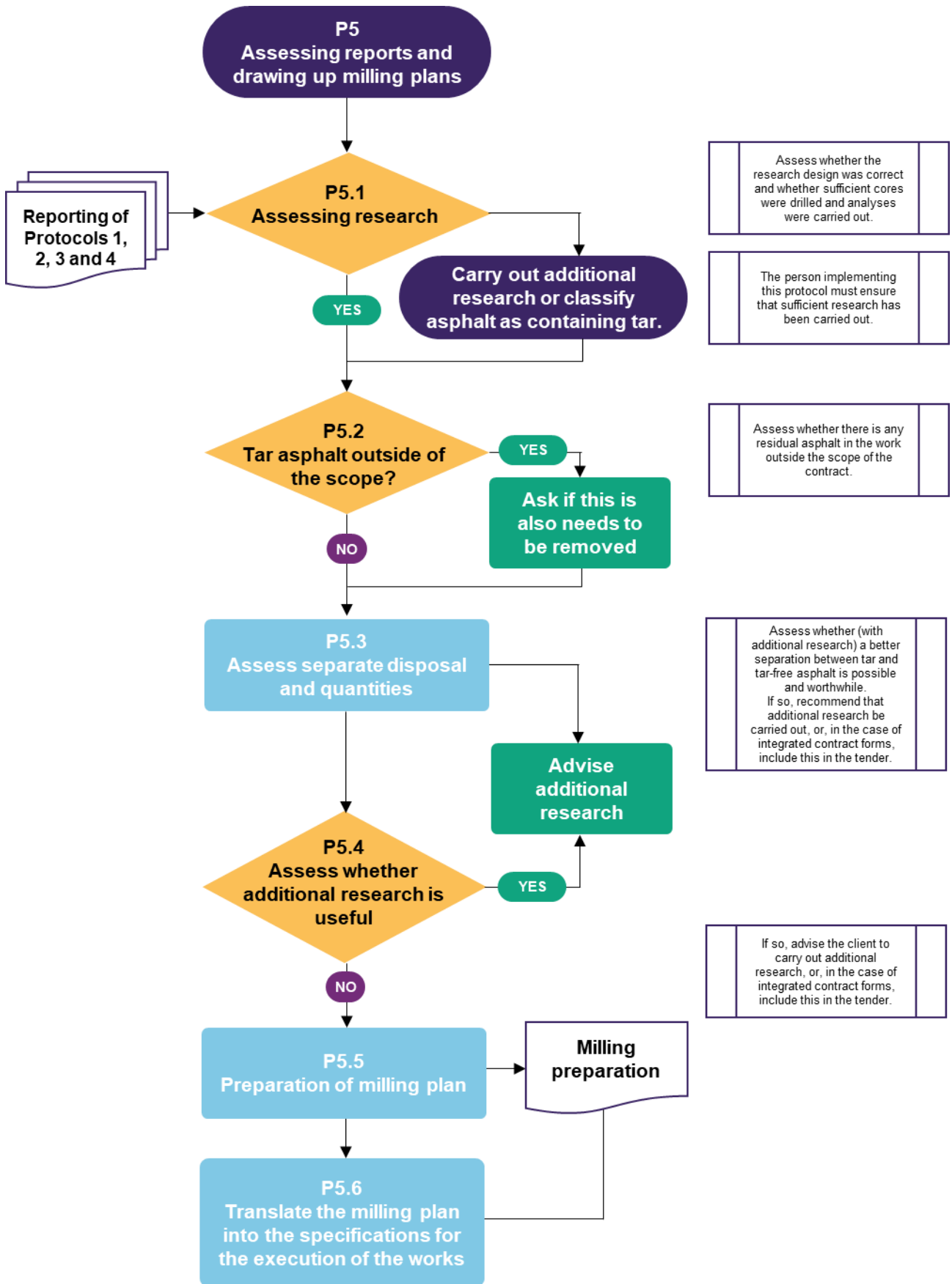


Figure 4.6 CROW 210 Protocol 5: Developing a milling plan

## **Protocol 6: Removing the Asphalt**

During the preparation for the removal phase, a Health & Safety plan is drawn up including who will be undertaking the works and when they will occur. Agreements are made with the processors of the asphalt and this must include confirmation that the recipient has the required environmental permit to receive the material.

The separate sections to be milled must be clearly marked up on site indicating which sections contain tar. As each layer is removed, the substrate is marked up again. After removing a tar containing layer, the sweepings that are removed are also classed as tar asphalt.

Tar asphalt must be kept separate from tar-free asphalt and transported directly to a thermal processor or handed over to a collector. In situations where, for example, by organoleptic observation, it appears that asphalt unexpectedly does contain tar, this asphalt must be treated as such. Tar-containing asphalt often has a black, shiny appearance, has a specific odour and is easily recognised by experienced operating personnel.

Checks are carried out to assess whether the quantities of tar-containing and tar-free asphalt align with the original plan. For deviations of more than ten percent from the expected quantities, the new quantities are reported to the processors.

The Removing the Asphalt procedure diagram is reproduced in Figure 4.6.

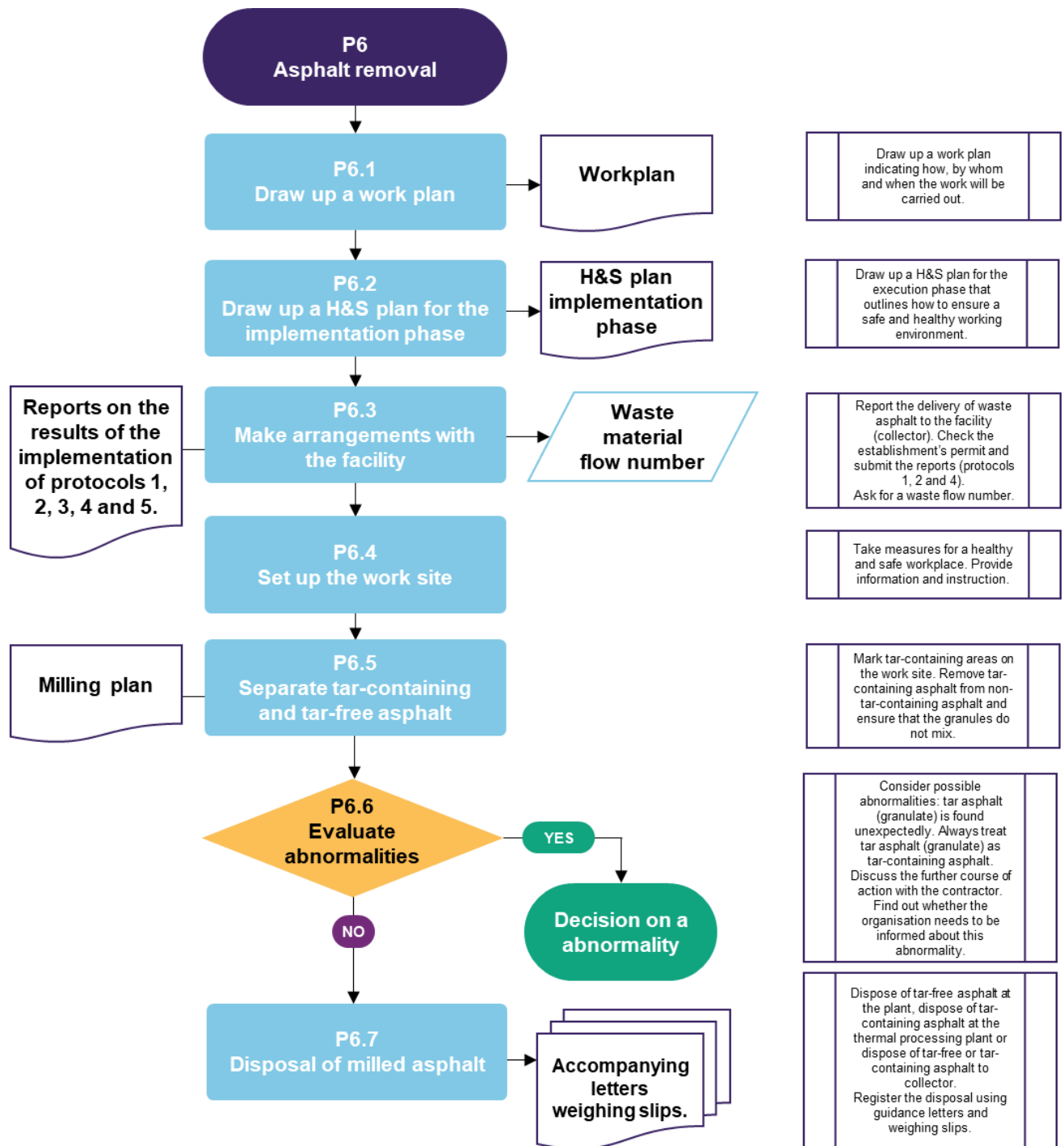


Figure 4.7 CROW 210 Protocol 6: Removing the asphalt

### Protocol 7: Transport and Disposal

The road authority must determine that the destination of the asphalt has contractually been agreed. In addition, transfer forms are completed and must always accompany tar containing or tar-free asphalt during transportation (according to the Decree on reporting industrial waste substances and hazardous waste). In this step it is indicated which (processing) codes should be used to ensure that the asphalt is processed in the desired way.

The responsibility of the client of the work, as disposer, ends as soon as tar-containing asphalt has been accepted by a thermal processor, tar-free asphalt has been issued to an authorized collector, or tar-free asphalt has immediately been incorporated into cold or hot in situ recycling process.

When removing tar-containing asphalt, the client as disposer, has a duty of care (Article 15 of the Framework Directive waste 98/2008 and article 1.1a of the Environmental Management Act) to check that the Tar asphalt has actually been delivered to a thermal processor.

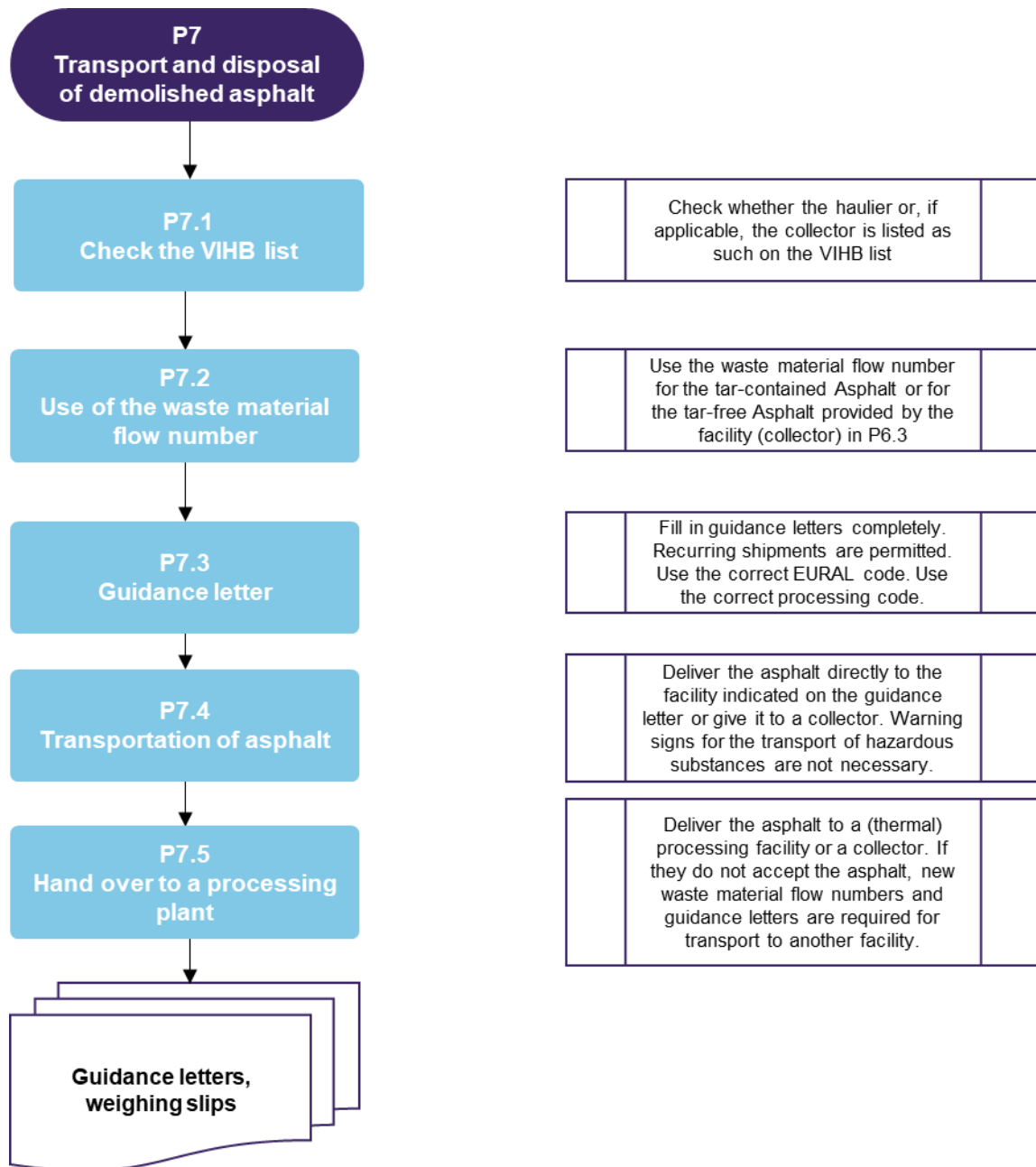
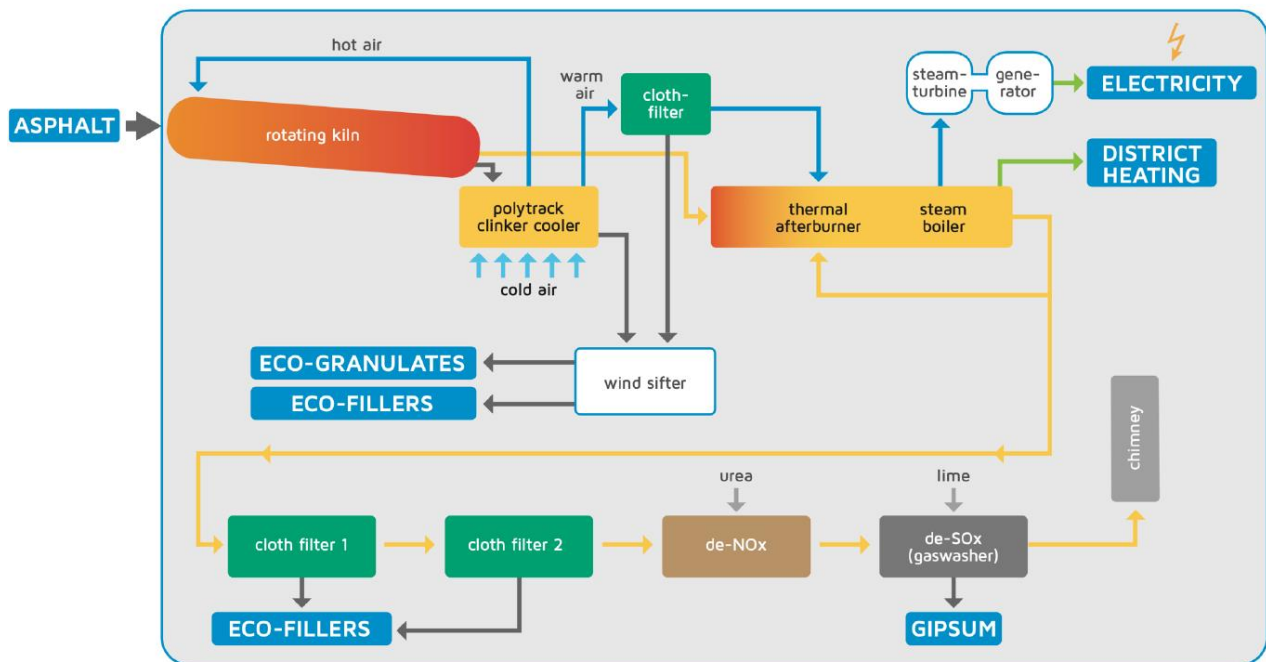


Figure 4.8 CROW 210 Protocol 7: Transport and disposal

### Thermal Processing

The cleaning process of tar-containing asphalt is carried out by the private sector in the Netherlands. Four companies operate these facilities and have processed twenty million tons to date. The following process diagram and notes are reproduced from the website of one of the companies that undertakes thermal processing, Recycling Combinatie REKO B.V. [6]

## The cleaning process of tar-containing asphalt



**Figure 4.9 Thermal processing of tar-containing asphalt [6]**

1. **Pre-treatment of the asphalt**  
The tar-containing asphalt released during reconstruction of roads is delivered to REKO by ship or by truck. The tar-containing asphalt is crushed to form Tar Asphalt Granulate.
2. **Incineration**  
The tar-containing asphalt is fed into a rotating incineration drum. At the front of the drum is a burner that heats the material to a temperature of 850 to 1000 °C. At this temperature, all pollution present is completely removed.
3. **Cooling process**  
After the incineration drum, the cleaned material is cooled by cold air. The air heated up in this process is returned to the front of the incineration drum as combustion air. This way the heated air is put to good use, reducing overall gas consumption in the system.
4. **Cleaning the released flue gases**  
The flue gases released during the combustion process are cleaned of fine dusts, nitrogen oxide and sulphur oxide. The scrubbing of flue gases released during the thermal cleaning of tar-containing asphalt is a technologically advanced process.
5. **Afterburner and energy recovery**  
The afterburner reheats all released flue gases. The hot gases are then passed through a boiler where they transfer their heat and produce steam.  
  
The steam is passed through a steam turbine, which in turn drives a generator that converts the energy into electricity. The electricity generated by both thermal treatment plants is more than sufficient to supply a city of approx. 100,000 inhabitants with electricity. The plants also have the ability to supply heat for district heating.

6. Dust collectors  
After cooling, the gases are cleaned of dust in dust collectors. The dust released by these collectors is sold as certified filler under the name ECO filler and is used in the concrete and asphalt industry.
7. DeNOx (catalyst)  
After dust collection, the gases pass through a DeNOx plant. In this unit, nitrogen oxide in the flue gases is converted into harmless atmospheric nitrogen (N<sub>2</sub>) and oxygen.
8. Gas scrubber  
Coal tar has a high sulphur content. Burning it produces sulphur oxide. As a final step in the process, the flue gases are treated in a gas scrubber. By scrubbing the gases with water in which lime has been dissolved, the sulphur oxide present is converted via a chemical reaction into gypsum. The moisture is removed from the gypsum in a press, after which it is suitable for high-quality application in various building products.
9. Controls  
Each stage of the cleaning process is monitored and controlled in a central control room. Any deviation is detected in real time and corrected if necessary. This guarantees a high-quality end product and ensures there are no excess emissions.
10. Circular economy  
After the thermal cleaning process, all materials are used again as high-quality raw materials. No residues remain. Our goal is to produce high-quality raw materials from tar-containing Asphalt and which can be used over and over again in the asphalt and concrete industry. This means that the loop is completely closed, there are no residuals.

## 4.2.2 Netherlands Bibliography

- [1] <https://lap3.nl/service/english/>
- [2] [https://lap3.nl/vaste-onderdelen/zoeken/?zoeken\\_term=Teerhoudend+asfalt](https://lap3.nl/vaste-onderdelen/zoeken/?zoeken_term=Teerhoudend+asfalt)
- [3] Richtlijn omgaan met vrijgekomen asphalt Selectief verwijderen van teervrij en teerhoudend asphalt, (Publicatie 210), 2014
- [4] Bouwprocesbepalingen van het Arbobesluit: Hoofdstuk 2, afdeling 5, artikelen 2.23 tot en met 2.35.
- [5] RAW Proeven vermeld in CROW-publicatie 210 'Richtlijn omgaan met vrijgekomen asphalt'
- [6] <https://www.rekobv.eu/en/>

## 4.3 England

### 4.3.1 Guidance on the Classification and Assessment of Waste (1st Edition v1.1.GB) Technical Guidance WM3

The Environment Agency (EA), Scottish Environment Protection Agency (SEPA) and Natural Resources Wales published joint Guidance on the classification and assessment of waste, Technical Guidance WM3, in 2015, with the latest version published in January 2021 [1] There is a requirement to identify if waste is hazardous before it can be classified.

The guidance document explains how to undertake the assessment and classification. Waste duty of care legally requires businesses to classify waste produced:

- before it is collected, disposed of or recovered
- to identify the controls that apply to the movement of the waste
- to complete waste documents and records
- to identify suitably authorised waste management options
- to prevent harm to people and the environment.

A specific section of the document deals with what is termed as 'Asphalt waste containing coal tar' (AWCCT).

Coal tar is a complex mix of hydrocarbon compounds which must be added together to determine the concentration. Assessments based on PAH's alone are not consistent with the legislation and cannot be used to classify a waste as non-hazardous.

However, if the concentration of coal tar is known, the Mandatory Classification List (MCL) under the GB Classification, Labelling and Packaging of Substances Regulation (CLP) uses benzo[a]pyrene (BaP) as a marker compound for carcinogenicity for certain coal tar entries. Where the concentration of BaP is less than 0.005% of the concentration of the coal tar (rather than in the waste as a whole), the coal tar is not carcinogenic and does not need to be considered for Hazardous Property HP7, carcinogenic.

The following applies only to Asphalt material classified in the List of Wastes as

- 17 03 01\* bituminous mixtures containing coal tar
- 17 03 02 bituminous mixtures other than those mentioned in 17 03 01

Where the concentration of benzo[a]pyrene is at or above 50 ppm (mg/kg) in the asphalt alone then the amount of coal tar should be sufficient (0.1% or more) for the material to be hazardous and thus coded 17 03 01\*. Any sampling of asphalt must ensure that layers with different concentrations of benzo[a]pyrene are identified and sampled.

Appendix D of Technical Guidance WM3 details the requirements to plan and conduct a proper sampling programme to ensure accurate and representative results. The plan must be undertaken before the first sample is taken. This will help to ensure the compiler has considered relevant factors and taken sufficient representative samples. Then all parties will have confidence in the reliability of the results and their interpretation.

The figure below is reproduced from Appendix D of Technical Guidance WM3.

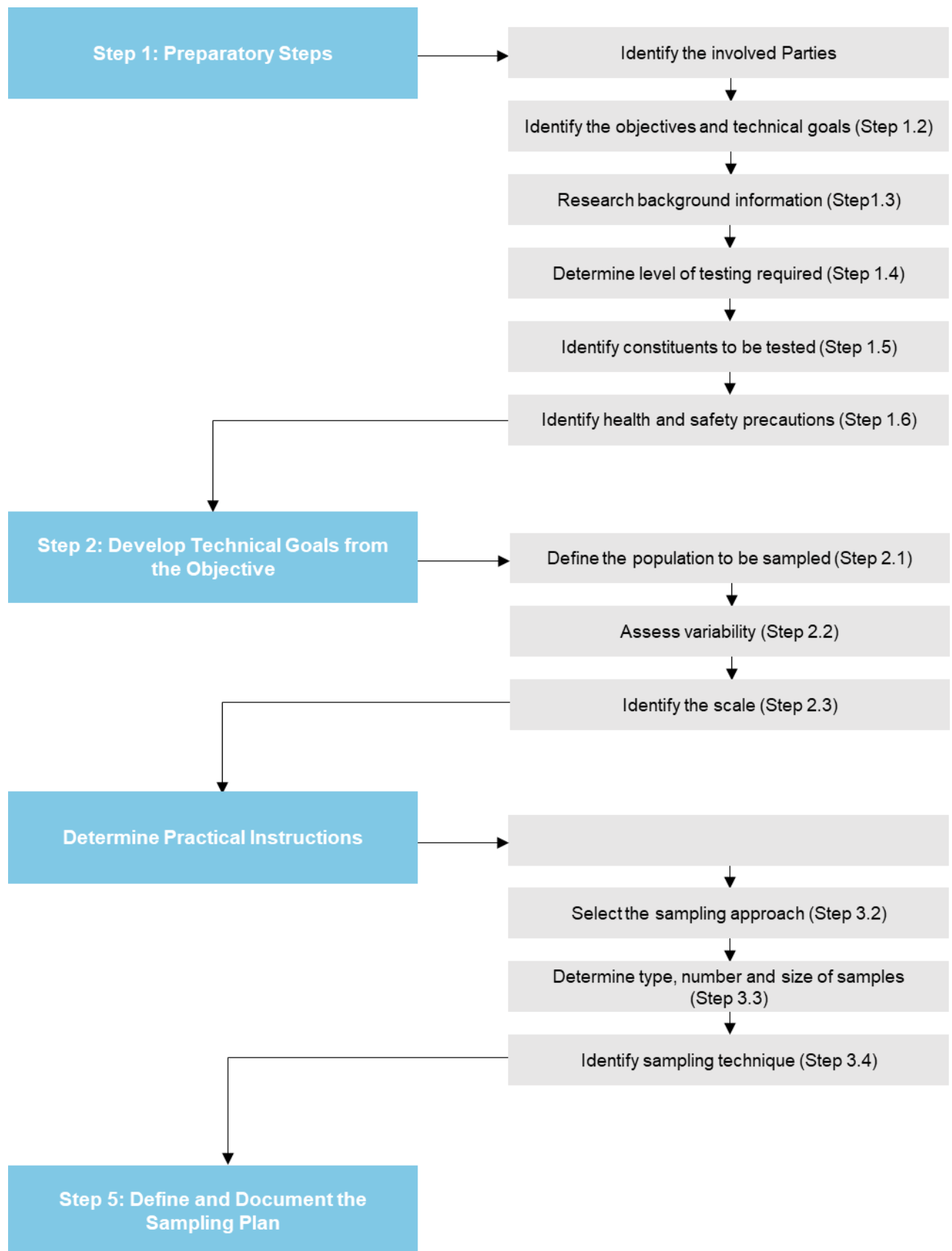


Figure 4.10 Technical Guidance WM3 Appendix D: Defining the sampling plan

Regulatory Position Statement 075 issued by the EA [2] addresses the movement and use of AWCCT. If the requirements are complied with, the EA allow the final use of AWCCT in certain construction operations without an environmental permit. The EA also relax the hazardous waste reporting requirements for the place of end-use of treated AWCCT.

AWCCT is commonly treated by crushing, grinding and screening, following which it is then used again in the construction of roads or pathways. The use of AWCCT in these construction applications is a waste recovery operation that requires a permit under the Environmental Permitting (England and Wales) Regulations 2010. However, it is considered disproportionate to require a permit. The environmental risk of the activity is low and capable of being adequately controlled by means of suitable general rules. The EA will not pursue an application for an environmental permit where:

- i. The treated AWCCT meets the requirements of clause 948, ex-situ cold recycled bound material, within the Specification for Highways Works Series 900, or clauses 810 to 880 for cement and other hydraulically bound mixtures within the Specification for Highway Works Series 800.
- ii. The material is used only in bound sub-surface layers e.g. sub-base, base and binder layers. Use in surface applications is not allowed.
- iii. The user meets the relevant objectives of the Waste Framework Directive. The Waste Framework Directive lays down some basic waste management principles. It requires that waste be managed:
  - a) without endangering human health and harming the environment
  - b) without risk to water, air, soil, plants or animals
  - c) without causing a nuisance through noise or odours
  - d) and without adversely affecting the countryside or places of special interest

The EA also allow a simplified quarterly return where consignments of AWCCT received at a single place of end use in a three month period can be summarised into a single, one-line consignee return, using the postcode nearest to the place of end use.

#### **4.3.2 Managing Reclaimed Asphalt – Highways & Pavements ADEPT & CDWF Guidance**

The Association of Directors of Environment, Economy, Planning and Transport (ADEPT) in conjunction with the Construction Demolition Waste Forum, produced a guidance document for Managing Reclaimed Asphalt [3] with the latest version issued in August 2019.

The guidance document is intended as an aid to classifying and reusing arisings from bituminous bound road materials. The main aim is to reduce the amount of hazardous, or non-hazardous, waste being sent to landfill, or even for incineration, and allow industry to reuse as much of this valuable material as possible.

The document considers the regulatory position, sample preparation and testing for coal tar, site investigation, treatment options, production monitoring plus health, safety and environmental considerations. The document refers to the EPA PAH 16 compounds, used as markers for both coal tar and road tar. In their pure state these PAH have high boiling points, over 200°C. At room temperature all are solids in their pure form. PAH are generally only slightly soluble in water. Most solubilities are less than 1 mg/litre and all those in the PAH 16 group are less than 4 mg/litre.

## Regulatory Position

The document submits that the Environmental regulators generally take the view that all arisings from construction processes should be classed as waste. As such anyone carrying these materials, recycling them, or reprocessing them, must possess all appropriate permits and licences.

The document refers to the EA regulatory position statement (covered above) and SEPA guidance on the Production of fully Recovered Asphalt Road Planings, (covered separately under Scotland in the section below) Sample preparation and testing for coal tar It is vital that any samples presented for analysis are representative and homogenous. The chemical tests used for PAH analysis only require very small amounts of material, typically 5g.

A suitable method for sample preparation is given in Appendix C of the guidance. Great care is therefore needed to prepare these small samples from core samples or other large bulk samples.

To detect tar products two tests are usually used:

- Speciated PAH 16 analysis
- Phenols and cresols either by speciated analysis, or by phenol index

The description of these tests is given in Appendix C of the guidance. Road tars do not generally contain a lot of phenol so the phenol index test may be used to judge the likely quantities. If the result from the phenol index test is >1000 mg/kg then the speciated Phenol analysis should be performed.

To establish whether a waste is hazardous it is only necessary to test the material in the solid form. To obtain an accurate picture of the composition of the material it is vital that suitably representative samples are submitted for analysis and reference is made to Appendix D of the Technical Guidance WM3v1.1 (*referred to above*). A suggested protocol for sample preparation and testing is given in Appendix C of the ADEPT guidance. The number and type of samples will depend on the type of investigation and is discussed below.

The method for screening for PAH with aerosol PAK marker spray is detailed under Appendix D of the ADEPT guidance. PAK spray triggers at a minimum of 125mg/kg of total PAH 16 with a greater level of certainty above 150mg/kg. PAK spray can give false positive results. One instance of a false negative has been reported, the use of odour as an additional screening method is recommended although close personal contact should be avoided.

Leaving tar bound material undisturbed is acceptable without testing for leachate potential – it therefore never becomes waste and is the highest level in the waste hierarchy and the preferred methodology (economically and environmentally). Leachate testing is required if the material is to be disposed of in landfill. The leaching properties, as required by the appropriate WAC test, then need to be established.

If an investigation has not been carried out and the asphalt planings are not characterised prior to milling then the milled material must be tested instead. This will require significantly more testing than is described under production monitoring below.

## Site Investigation

If records exist, or the provenance is known, showing the materials used do not contain tar, then no investigation is necessary. Cores are recommended for investigating the bound construction and allow individual layers to be easily distinguished. The guidance suggests 150mm diameter cores are appropriate for this type of investigation and will be needed to provide sufficient material for testing and analysis.

If the road construction is known, and the binders used can definitely be established, then the extent of the investigation and the frequency of sampling can be reduced or eliminated.

The starting point assumes that the existing road construction is unknown and variable. In this case cores should be taken between 25 and 50 m centres to ensure that any changes in construction are accurately located and any variation on a load by load basis can be identified. A minimum of 3 cores should be taken unless the site is less than 30 m<sup>2</sup> when 1 core is adequate.

The number of tests required for proper assessment of the PAH content will depend on the variability of the source material. It is necessary to determine the average and assess the variability of the PAH content so that the potential hazard from the excavated material can be properly determined.

During the design phase it is necessary to identify exactly the location and nature of any tar bound layers. This will allow the designer to formulate a suitable economic maintenance treatment. The investigation project manager should have sufficient experience of highway investigation and be familiar with the legislation and guidance referred to in this document.

### **Treatment Options**

Any treatment chosen must meet the engineering demands of the specific road.

#### **In-Situ Stabilisation**

In-situ stabilisation can be used to repair roads containing tar. As the material is not removed from the road but is mixed in situ, the material under treatment does not become waste. All roads can be stabilised using this treatment, regardless of their contamination status.

It is sometimes necessary to remove some material from the road to make space for the new surface course, the contamination state of this material must be considered, as this material does become waste upon removal from the road.

#### **Ex-Situ Treatment**

Ex-situ treatment involves the removal and treatment of the asphalt by crushing, grinding and screening. This is permitted under EA Regulatory Position Statement 075 mentioned earlier.

#### **Leave in Place**

If possible, the tar can be left in place by designing an overlay or limited inlay to not disturb the tar contaminated layers. This may only be a short term solution as road tar has not been used for many years and is susceptible to oxidation and weathering. The extent to which this has occurred will depend on many factors. If the road tar remains competent then it should not be disturbed.

Currently planings containing tar can only be re-used in cold mix processes. The preparation should follow a similar path to that described in EN 13108-8.

Some form of binder must be added to planings containing road tar to ensure they are made into a dense, non-permeable, material that has suitable properties for the purpose intended. The processing can take place in a mobile plant local or remote to the source, or at a permanent installation. Any mobile plant used must hold a mobile plant permit, and the associated deployment form must be registered with the Regulator before processing commences.

#### **Disposal**

This should be the option of last resort. Incineration or landfill may be available but material destined for landfill should be assessed for leaching potential in accordance with the appropriate WAC, prior to excavation. This leachate assessment can be made using the same samples used to assess the PAH content.

## **Production Monitoring**

Regardless of the use, hazard classification, or destination of the planings some monitoring must be done to ensure the findings of the investigation were correct and to confirm compliance with the appropriate quality plan. Monitoring for road tar content should be done at a rate of 1 per 100 tonne, with a minimum of one per site.

## **Health, Safety and Environmental Considerations**

A full assessment of the hazards associated with handling asphalt arisings should be carried out including a full COSHH assessment.

PAH can become absorbed through ingestion, skin contact, inhalation of dust and fume inhalation if the tar is heated enough. It is possible to measure airborne PAH concentrations using personal sampling. HSE and NIOSH guidance [4] and [5] exists for performing these measurements.

There is a Biological Monitoring Guidance Value (BMGV) for PAH quoted in HSE publication EH40, Workplace Exposure Limits. The BMGV listed in Table 2 of EH40/2005 for PAH as 4  $\mu\text{mol}$  1-hydroxypyrene per mol creatinine in urine. The appropriate sampling time is stated as post shift. This guidance value can be used to assess ongoing exposure in order to gauge whether the exposure is of significance, and whether control measures in place are working.

PAH can affect other organisms with transmission by air, surface or groundwater or direct contact. Asphalt plants, and other processing areas can be monitored for PAH emissions, either as dust or vapour.

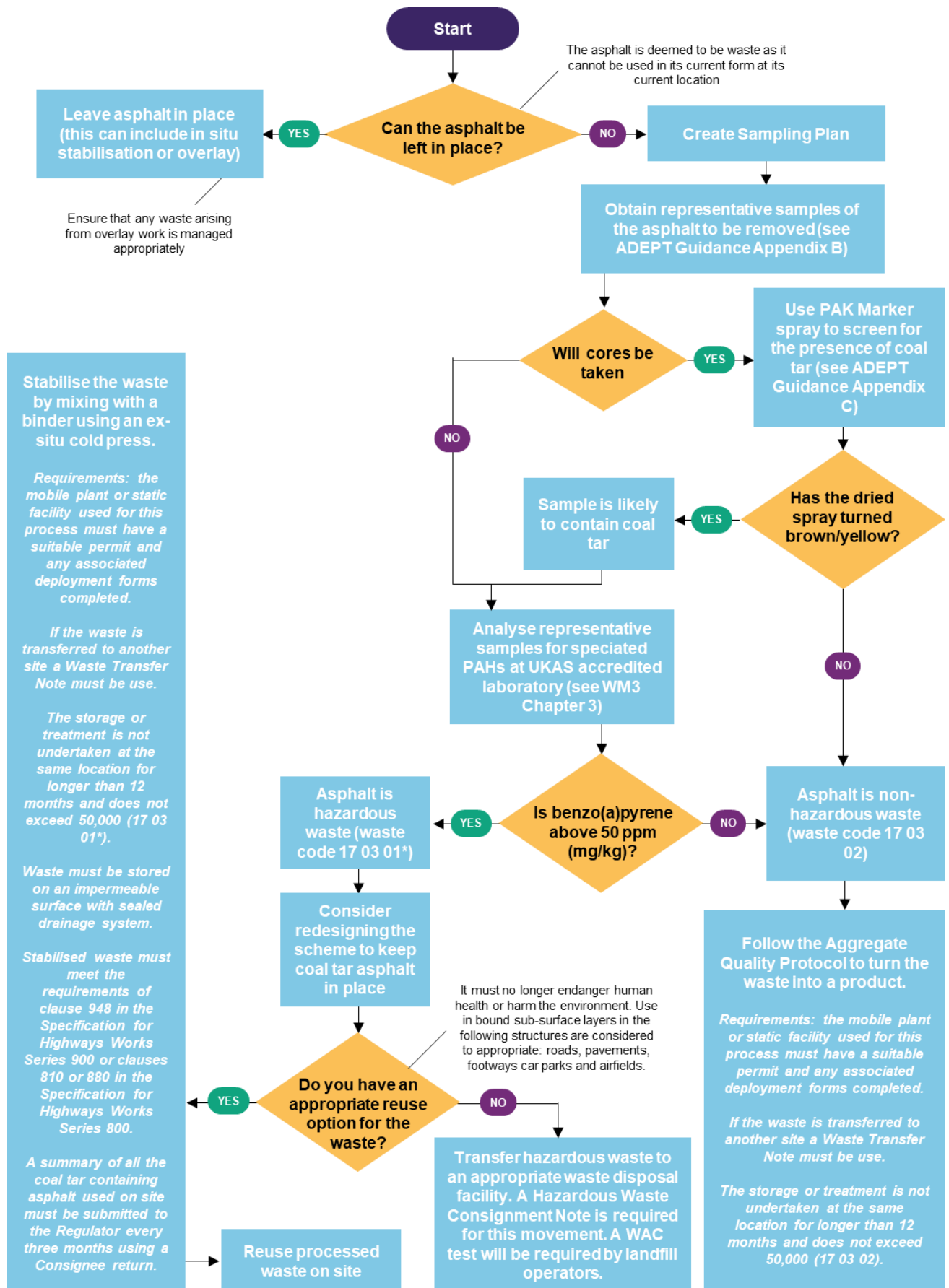


Figure 4.11 ADEPT guidelines: Main stages and control mechanisms for the reuse of asphalt waste

## ADEPT Guideline Appendix C - Sample Preparation and Testing

### Competence

Ideally laboratories should be UKAS accredited for the methods given. As a minimum a laboratory performing sampling and sample preparation to C2 to C5 should hold UKAS accreditation for BS EN 932-1, BS EN 932-2, BS EN 12697-28 and BS EN 12697-6. Laboratories performing chemical analysis should hold UKAS accreditation for that analysis.

### Test Frequency

From a core survey it is necessary to know the mean Benzo[a]pyrene (BaP) content with sufficient accuracy by testing an appropriate number of cores. Criteria that should be considered are:

- Level of the tar bound layer(s) within the core
- Thickness of the tar bound layer(s)
- Type of tar bound material (i.e. surface dressing, surface course, base material)
- Frequency of occurrence of road tar at any level

**Table 4.5 Required test frequency based on site variability**

Site Variability	Test Frequency	Minimum Test Frequency
High, with all the criteria above changing	All cores	3 tests
Medium, where 3 criteria vary	Two thirds of the cores	3 tests
Slight, where only level or thickness vary	One third of the cores	3 tests
Consistent	One fifth of the cores	3 tests

A minimum of 3 tests is recommended because it is difficult to have confidence about the assessment of even a small amount of planings with fewer results. For large projects it would be appropriate to use the statistical analysis described in C8.2 to assess the accuracy of the result.

### From Planings Derived from any Source

Samples should be taken as described in BS EN 932-1.

PAH screening can be used to identify potentially hazardous material, and that this screening must be done on samples, random screening of the planings heap is not recommended. Samples that show a positive screening result must be sent for analysis and the load quarantined until the result is obtained. Routine, random, testing of negative screening samples must also be undertaken at a rate of 1 in 20. The number of samples necessary must be adequate to assess the composition of the whole, taking into account any information already available.

- Where there is no knowledge of the source, samples must be taken per load.
- For stockpiles or deliveries of unknown variability but from a single source, samples should be taken at a rate of 1 per 100 tonnes with a minimum of 3 samples per stockpile.
- For stockpiles or deliveries from a known source that has already been characterised for road tar content as described in this document, a sample rate of 1 per 1000 tonnes, with a minimum of one per site.

### *PAH Analysis for Benzo[a]pyrene Content (BaP)*

The most common method for PAH analysis is GC-MS, gas chromatography and mass spectrometry. Other methods can be used provided they can accurately distinguish the required PAH types and have a detection limit of 1 mg/kg or less. There is no standard method for this test, laboratories that are UKAS accredited for PAH analysis must be used.

The US EPA set of 16 PAH types is sufficient for normal analysis, in fact based on research (see Appendix D) only benzo[a]pyrene (BaP), CAS number 50-32-8, is needed. If also testing for waste characterisation coronene must be added to the PAH16 suite to meet the inert WAC criterion for total PAH.

### *Assessment of Hazard*

This is potentially a complex assessment requiring consideration of a number of factors. The following should ensure compliance with Appendix D of WM3v1.1. The following assumes that the sampling or coring rates discussed above are applied. It also assumes that the distribution of test results will approximate to a normal distribution. This is a reasonable assumption given the nature of the source material. On larger projects it would be advisable to confirm this using an appropriate statistical test.

It is not possible to divorce the assessment from the use of some simple statistics without loss of discrimination. A simplified scheme is presented but a grey area remains where full analysis will be needed.

Different heaps of planings should be judged as separate batches. The test results from each batch should be analysed as described in C8.1 and C8.2.

For cores, it may be necessary to divide the area of the road that is to be planed into zones with similar concentrations of BaP. Areas that can clearly be defined in this way must be treated separately. The results from each zone should be analysed separately as described in C8.1 and C8.2 to decide the classification of the planings, when produced. All results and calculations must be recorded and traceable to the sample plan.

### *C8.1 Simple Assessment*

Case 1 - If all the following apply:

- a) The guidance on sample numbers has been observed
- b) All the BaP concentrations are below 25 mg/kg
- c) There are 3 or more results

The planings can be classed as inert for the purposes of the Quality Protocol for Aggregates from Inert Waste.

Case 2 - If all the BaP concentrations are above the hazardous threshold, 50 mg/kg, then the planings are classed as hazardous and must be treated accordingly. Note: If all the results are close to the threshold, and there are only a few results, there may be some doubt. In this case testing further samples and applying the full statistical assessment may be appropriate.

Case 3 - Material with some, or all, results above 25 mg/kg and below 50 mg/kg. This is anything that does not meet Case 1 or Case 2.

These materials cannot be classed as non-hazardous without performing the analysis in C8.2. If the expertise to perform the assessment in C8.2 is not available then the material can be classed as hazardous but this will cause some non-hazardous material to be incorrectly assigned.

### C8.2 Full statistical Assessment

Only those with expertise in simple statistical analysis should carry out this assessment. If this expertise is not available then refer to Case 3 in C8.1. The following analysis is identical in result to the one described in Step 3 of Appendix D to WM3v1.1.

Calculate the mean and sample standard deviation of the BaP results.

Calculate the 90<sup>th</sup> percentile confidence interval for the mean result as follows:

$$n = \text{number of BaP results}$$

$$\text{Standard Error (SE)} = (\text{Standard Deviation of BaP})/\sqrt{n}$$

$$\text{Margin of Error (ME)} = SE \times \text{Critical value of } t - \text{distribution}$$

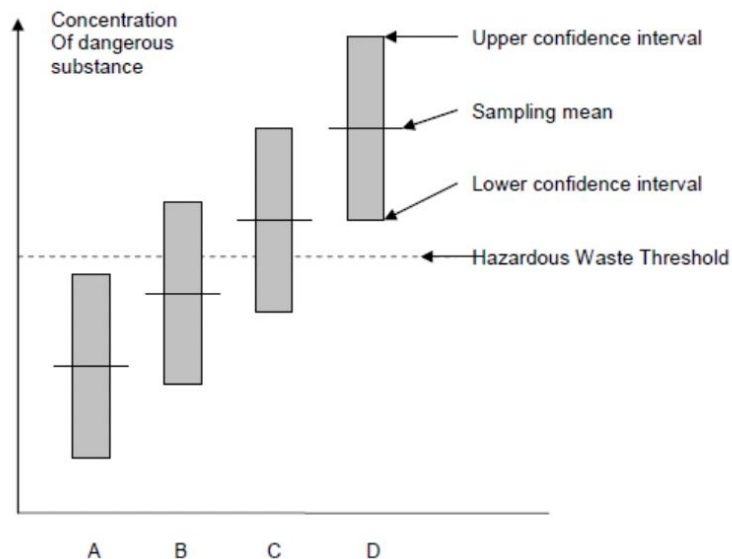
$$\text{Confidence Interval} = \text{Mean BaP} \pm ME$$

**Figure 4.12 Calculating the 90th percentile confidence interval**

The critical values of the t-distribution are determined for (n-1) degrees of freedom and a two tailed probability of 0.10.

The figure below shows 4 different scenarios:

- A: The material is non-hazardous and can be treated as inert for the purposes of the Quality Protocol for Aggregates from Inert Waste.
- B and C: The status is uncertain. Either further samples should be tested and their results included in the analysis to reduce the uncertainty, or the planings should be classed as hazardous.
- D: the planings should be classed as hazardous.



**Figure 4.13 Concentration of dangerous substance distribution scenarios**

Results of chemical analysis are never reported as zero; if the value is reported as less than the detection limit, <0.1 for example, then the detection limit should be used in calculations.

## ADEPT Guideline Appendix D - PAH Screening Methods

PAK Marker is sprayed on the suspect contaminated material and left to dry. If the white spray discolours to a light brown/yellow this is an indication that PAH may be present.

Accuracy is improved using a UV lamp. Under UV light material the discoloured PAK spray lightens and becomes yellow/ green. In cases of doubt UV should be used.

### Other Screening Methods

- White acrylic spray paint (goes brown in the presence of tar, little affected by bitumen)
- Adding a drop of Methylene Chloride to a fragment of material on a filter paper. Tar gives a yellow-brown stain; bitumen gives a dark brown stain)
- Most people can detect tar by its odour and this can be used as a coarse screening method.

These methods should be checked for accuracy before use.

### Relationship between Benzo[a]pyrene and Total PAH

The graph shows BaP plotted against total PAH for 197 data points. This data was collected from several different areas of England and demonstrates that road tar is generally a quite consistent product, in terms of its PAH content. The linear correlation indicates quite a strong relationship and shows that 50 mg/kg of BaP is equivalent to 865 mg/kg total PAH. Since road tar contains other constituents besides PAH this strongly supports that the assertion that 50 mg/kg BaP is a good indicator of the presence of 1000 mg/kg road tar.

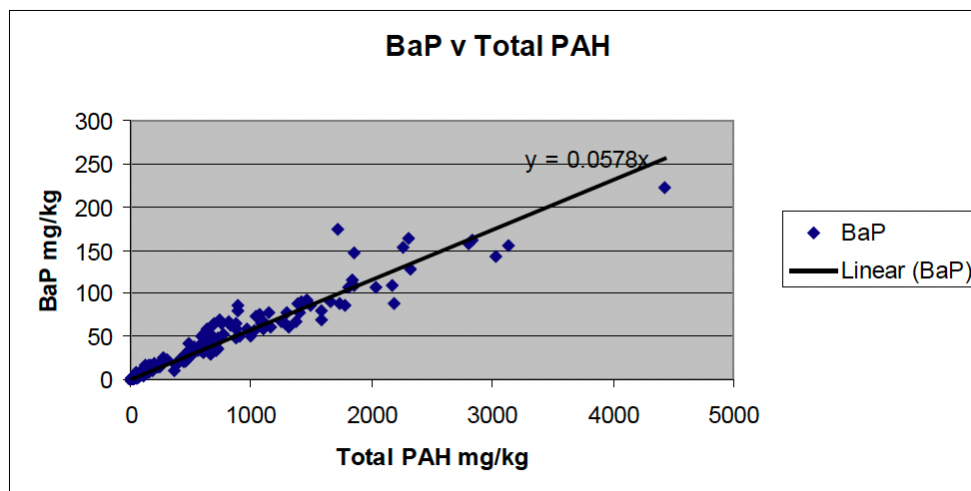


Figure 4.14 ADEPT guidelines Appendix D: Graph of BaP plotted against total PAH for 197 data points

### 4.3.3 English Bibliography

- [1] Guidance on the classification and assessment of waste (1st Edition v1.1.GB) Technical Guidance WM3, 1st edition May 2015, Version 1.1 GB January 2021. *Northern Ireland uses version 1.1.NI*
- [2] Regulatory position statement 075, Environment Agency, MWRP RPS 075 Version: 4 Issued: September 2014. Doc ref: LIT 10118
- [3] Managing Reclaimed Asphalt – Highways & Pavements ADEPT & CDWF Guidance, Version 2019 Revision 1 August 2019
- [4] NIOSH Manual of Analytical Methods 5515 Polynuclear Aromatic Hydrocarbons by GC
- [5] MDHS 72 Volatile Organic Compounds in Air - Laboratory method using pumped solid sorbent tubes, thermal desorption and gas chromatography; HSE, and MDHS 96 Volatile organic compounds in air - Laboratory method using pumped solid sorbent tubes, solvent desorption and gas chromatography. Health and Safety Executive

## 4.4 Scotland

The Scottish Environment Protection Agency (SEPA), need to ensure that waste management is carried out without endangering human health or the environment. Currently in Scotland regulatory approval to recycle an existing road contaminated with road tar is given on a site by-site basis, i.e. approval is scheme specific.

### 4.4.1 An Approach to Cold Recycling of Bitumen and Tar Bound Roads, Transport Scotland

On behalf of Transport Scotland, WSP developed a guideline document in 2021 [1] with the intention to provide a protocol or approach to cold recycling of bitumen and tar bound roads. It contains procedures and rules that provide a framework for warranting technical approval from Transport Scotland and will assist SEPA to review individual scheme proposals.

The guide provides an approach to treat tar bound road arisings to ensure that:

- A site is suitable for recycling
- hazardous contaminants are encapsulated, making them harmless to the environment and human health; • recycled base materials comply with the Specification for Highways Works (SHW) Clause 947, Clause 948 [2] and TRL 611 [3];
- the end-performance properties demonstrated at the design stage are achieved in the permanent works. The guide does not provide information on sampling or testing strategies to identify the presence of road tar, but advice on this aspect can be found in the ADEPT guidance note

Managing Reclaimed Asphalt (discussed under England above).

The guide gives summary descriptions of:

- in situ recycling;
- ex situ recycling;
- evaluating site suitability;
- SEPA compliance requirements;

- quality plan and mix design; and
- demonstrating compliance.

### **In Situ Recycling**

A description of the process is given along with some limitations of use as follows:

its use in urban areas where the risk to damage shallow underground services or structures is assessed to be a problem. Previous research also suggested that the process should be limited for traffic levels up to 20 msa to ensure a satisfactory recycled pavement. It is also contended that there is a practical thickness limit of around 300mm, above which, adequate compaction of a single, thick lift of recycled material would be too difficult to achieve. Recycling using a two-layer process is feasible, but the need to temporarily stockpile the top layer whilst recycling the bottom layer, would reduce the energy saving and advantage gained by the in-situ recycling process.

### **Ex Situ Recycling**

A description of the process is given along with some points in relation to use as follows:

The plant needs to be located close enough to the site to enable placing and compaction of the material within the appropriate setting time, which is dependent on the binding agents used. It is important to identify a suitable compound for the plant that comprises a hardstanding area and that permits safe access for heavy vehicle movements. The ex situ technique allows for better control of the materials going back into the pavement. The risk that design stiffnesses will not be achieved is reduced and generally the recycled material is laid in thinner layers compared to the in situ method. However, ex situ does require the need for temporary sites, for both storing and processing the arisings, which can be difficult.

### **Evaluating Site Suitability**

A flowchart is provided with the intention to assist the process of determining whether a site is suitable for cold recycling and deciding the most appropriate option.

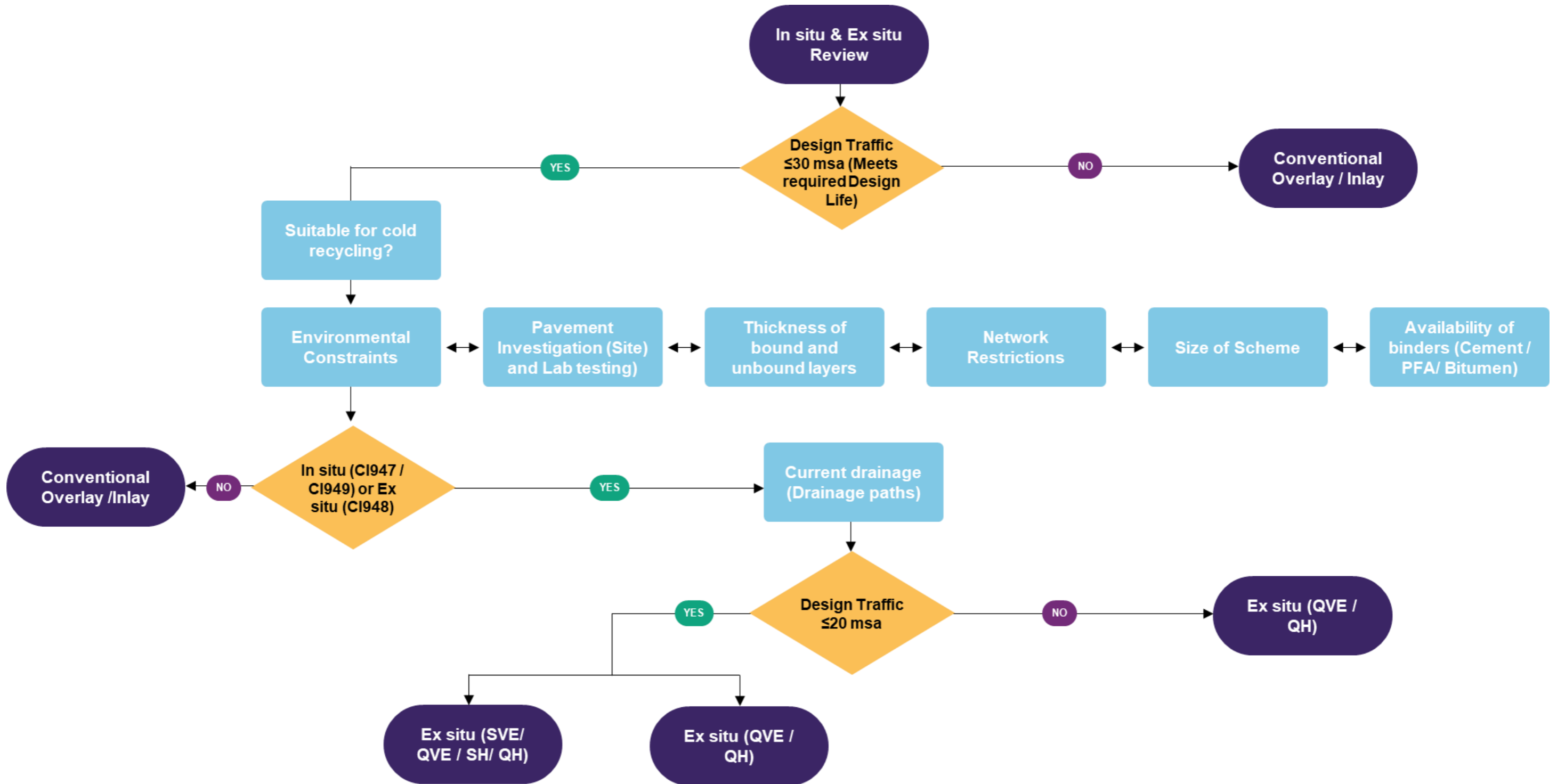


Figure 4.15 Transport Scotland guideline: Determining site suitability for cold recycling

## Considerations

### *Design Traffic*

The DMRB (CD 226) [4] restricts pavement designs containing cold recycled base material up to a design traffic of 30 msa. Transport Scotland review each scheme proposal independently. It should be noted that cold recycled materials can often rely upon their internal mechanical stability to resist damage in their early life. It is therefore essential that the materials have gained sufficient strength, prior to opening to traffic.

### *Environmental Constraints*

The environment in which the cold recycling technique will take place needs to be considered where the use of large plant, presence of shallow underground services and the generation of dust is less conducive in an urban setting compared to a rural setting. Seasonal conditions such as winter, particularly sites located at high altitude, will influence the curing rate of binding agents.

### *Thickness of Layers*

The selection of a site will normally depend on whether there is sufficient thickness of existing pavement to accommodate the design thickness. It is preferable if the in situ pulverisation depth is with the bound layers, although some of the foundation platform can be pulverised if deemed to be of suitable quality. An allowance for bulking should be made due to the pulverisation being accompanied by an increase in material volume. Consideration needs to be given to this excess material, such as movement, storage on site, or removal from site, particularly if the material to be removed is hazardous.

### *Size of Scheme*

Ideally the scheme should be greater than 3000 m<sup>2</sup>. However, the presence of road tar could lead to excessive disposal costs. Where schemes can be grouped, smaller scale cold recycling projects may still offer an environmental and cost effective solution.

### *Availability of Binders*

The local availability of specific binders needs to be considered; for instance, pulverised fuel ash (PFA), a by-product from burning of fuels in power stations, may need to be transported over long distances.

### *Pavement Investigation*

The location, condition and construction of the existing pavement will have a significant bearing on the pavement design process and it is essential that adequate samples of the existing road are obtained throughout the site.

### *SEPA Compliance Requirements*

If it can be demonstrated that a material has been fully recovered, i.e. ceases to become a waste, SEPA may permit an exemption (Paragraph 13 exemption) that is specific to that individual project or scheme. SEPA provides guidance on the production of fully recovered asphalt road planings however this guidance is not applicable to tar bound aggregates. Waste with hazardous properties is called "special waste" in Scotland.

Ideally tar bound material should be left in place if it is assessed to be sound and located at a pavement depth that does not require to be renewed.

However, a pavement investigation may also conclude that owing to a weak foundation the pavement requires strengthening to a depth that contains tar bound material.

If the tar bound material needs to be disturbed, then it can be reused as a Cold Recycled Bound Material (CRBM) using the in situ or ex situ method. The in situ method has been recognised as a technique that can be used to repair roads containing tar bound material as the contaminated material is treated in place. For the ex situ method, the tar bound material is removed from the road and is treated through a process of crushing, screening and mixing to meet the requirements of Clause 948.

#### Obtaining SEPA Approval

The Environmental Protection (Duty of Care) (Scotland) Regulations 2014 (SSI No. 4, 2014) [5] places a legal duty of care on all to keep waste safe. This requirement is also echoed under the Construction (Design and Management) Regulations 2015 (SI No. 51, 2015) [6], where those involved in the design of a scheme have a duty to highlight and minimize construction hazards. SEPA ensures that any proposal to reuse tar bound material in an individual road scheme is properly assessed prior to approval. Information needs to be provided to demonstrate that a scheme has been carefully designed and that the treatment of any tar bound material does not lead to pollution or environmental damage. The information can be submitted using a pro forma.

The pro forma is prepared at least 28 days prior to the commencement of a proposed scheme start date. The document should provide enough information to enable both SEPA and Transport Scotland to assess the proposed treatment. An example of a pro forma, which includes sites details and controls, is provided in Appendix A of the guidance – *reproduced below*.

Individual proposals will be different but the pro forma should include specific information concerning the project, specification, risk assessment focussing on the identification of any environmental risks and how they will be managed, specific measures to avoid cross contamination with other materials, e.g. how material prepared using the ex situ method will be crushed, screened and stored and a statement to the effect that the treatment or reuse of the tar bound material meets the relevant objectives of the Waste Framework Directive.

**Table 4.6 Pro Forma for Cold Recycling of Tar Bound Material, Transport Scotland**

<b>Pro Forma for Cold Recycling of Tar Bound Material (including site details and controls)</b>	
<b>Contact Details</b>	
Name of Business:	
Address of Business	
Primary Contact Name:	
Email Address:	
Phone Number:	
<b>Scheme Information</b>	
Scheme Location:	
Scheme NGR:	
Recycling Process to be Utilised:	
Recycling Plant Location:	
Recycling Plant Location NGR:	
Recycling Plant PPC(s)	
Production Site Licence/Exemption	
Evidence of Landowner Consent:	
Scheme Dimensions:	

<b>Pro Forma for Cold Recycling of Tar Bound Material (including site details and controls)</b>	
Estimated Volume of Tar Bound Planings:	
Provide details of how the treated material will only be used in bound sub-surface layers e.g. at the sub-base, base or binder course:	
Provide reference to relevant specifications and design guides, for example: <ul style="list-style-type: none"> <li>• Clause 948, Ex Situ Cold Recycled Bound Material (MCHW);</li> <li>• Clause 947, In Situ Cold Recycled Bitumen Bound Material (MCHW); and</li> <li>• TRL Report TRL 611 (Guidance and specification for in situ method using hydraulically bound cold recycled material).</li> </ul>	
<b>Stockpiling and Subsequent Reuse of Excess Tar Bound Material</b>	
Excess Material Stockpile Location:	
Excess Material Stockpile NGR:	
Proposed Stockpile Volume:	
Proposed Duration for Storage:	
Stockpile Environmental Control Measures:	
Evidence of SEPA approval for stockpile location:	
Details of Sites where Stockpiled Material will be Reused:	
<b>Site Environmental Management Plan</b>	
Provide details of how the work will be carried out safely, focussing on the identification of any environmental risks and how they will be managed and minimised:	
Provide details of specific mitigation measures to be put in place:	
<b>Declaration:</b>	
I ( <i>insert name</i> ) confirm that no treated material will be used in surface applications.	
I ( <i>insert name</i> ) confirm that the treatment and reuse of the tar bound material meets the relevant objectives of the Waste Framework Directive	
Signed:	Date:
Completed pro forma to be issued to Transport Scotland and SEPA at least 28 days prior to any scheme start date.	

## **Transport Scotland Guideline: Appendix A**

### *Quality Plan and Mix Design*

The quality plan is an important document for any cold recycling scheme as it sets out the stages involved in both designing and producing an in situ or ex situ CRBM. The flowchart shown in Figure 2-10 of the document reproduced below describes the typical stages that should be covered in a quality plan. In addition, the quality plan should refer to any standards, specifications, and quality objectives.

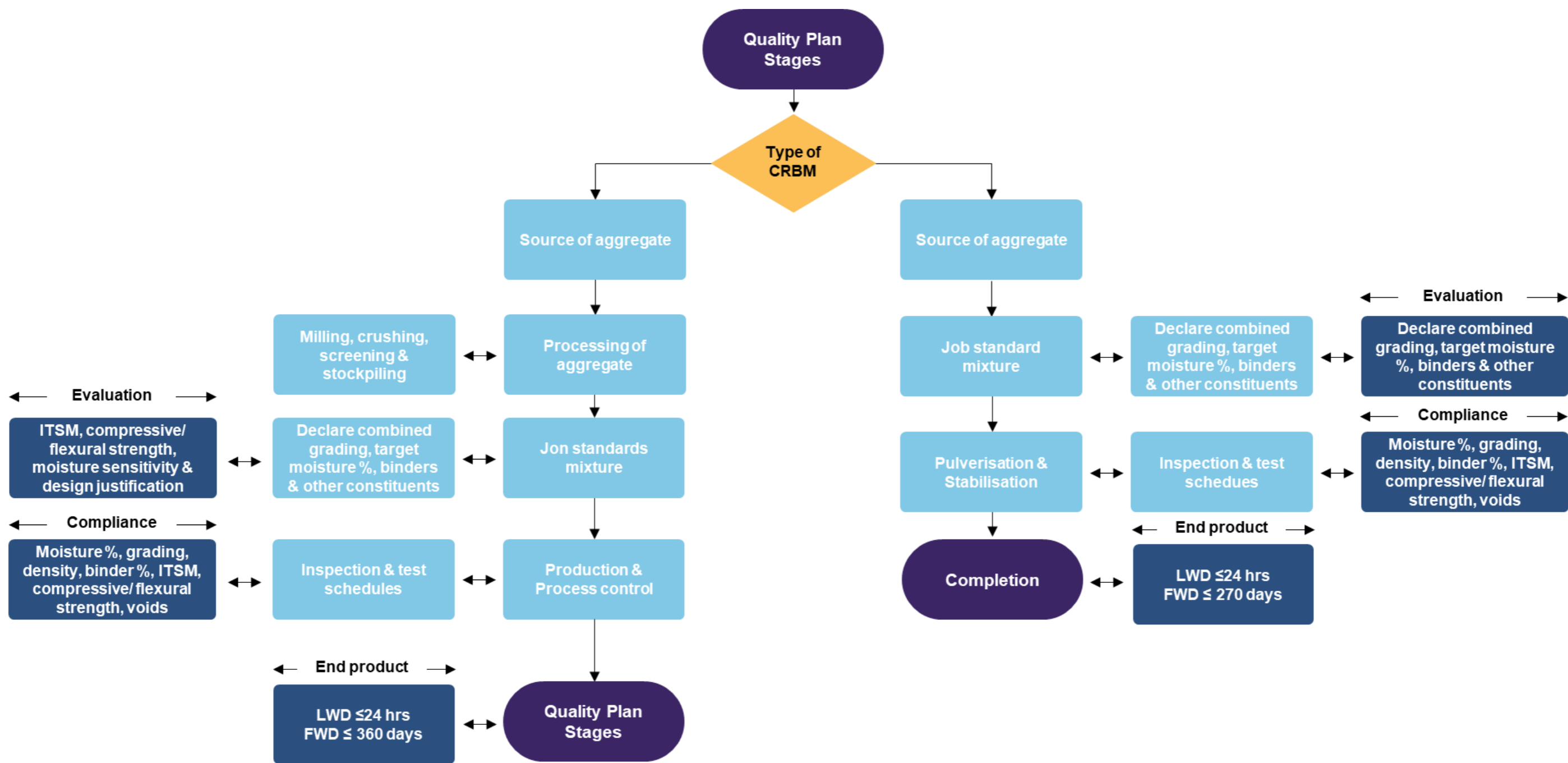


Figure 4.16 Transport Scotland guideline: Quality plan stages

The document provides additional details regarding the specific items contained in the quality plan.

### *Demonstrating Compliance*

Compliance testing targeted at assessing the quality and condition of the material during manufacture and placement is considered process control testing. The information gathered permits adjustments to be made to the production process.

End product performance testing relates more to the desired performance of the recycled pavement. End product performance tests can be both non-destructive and destructive, although the latter tend to be used following concerns regarding the performance of the pavement.

### *Early Life Material Properties*

The recently installed performance of the CRBM should be assessed using a Light Weight Deflectometer (LWD). It is important that the LWD can demonstrate a satisfactory correlation 50

with an agreed reference test method, i.e. the Falling Weight Deflectometer (FWD). Two options are permitted for LWD correlation (BS 1924-2, 2018) [7]: a site-specific correlation trial, or an annual correlation certificate. The performance of the final stabilised layer should be evaluated using a calibrated LWD within 24 hours of final compaction. Dependant on weather conditions testing could commence immediately, but in some instances a small rest period may be required. The final stabilised layer should meet the following criteria:

- The minimum surface modulus measurement should be  $\geq 50$  MPa within 2 hours of installation; or  $\geq 100$ MPa within 24 hours of completion of installation.
- Where this criteria is not met, consideration should be made to delaying final surfacing to allow further curing and stiffening of the layer to occur. Alternatively, a repeat of all or part of the recycling process should be undertaken until a compliant surface modulus is achieved.

### *In-Service Material Properties*

After 270 days of completion of an in situ scheme, or after one year for an ex situ scheme, FWD surveys should be carried out in accordance with CS 229 (DMRB) [8] and meet the following criteria:

- The FWD surveys should be carried out when the pavement temperature, at a depth of 100 mm, is within the range 15 to 25°C.
- The FWD results should be analysed with the pavement modelled as a two-layer system: Layer 1 should represent the combined design thickness of the bound materials and Layer 2 the unbound foundation layer of infinite depth.
- Compliance is achieved when the calculated stiffness of Layer 1, uncorrected for temperature, using the rolling mean of 10 results is:

Recycled layer containing Quick Visco Elastic (QVE) & Slow Visco Elastic (SVE) binders – Not less than 2500 MPa and no individual result is less 2100 MPa.

Recycled layer containing Quick Hydraulic (QH) & Slow Hydraulic (SH) binders – Not less than 5000 MPa and no individual result is less than 4200 MPa.

In the event that these performance standards are not achieved using the FWD then core testing should be considered as a final course of action when the pavement is one year old. However, consideration should be given to repeating the FWD survey, assuming no surface defects are visible, towards the end of the contract maintenance period. This would maximise the success rate for the extraction of cores and offer the best opportunity for obtaining suitable test specimens and achieving the required ITSM values given in Table 9/27 and 9/24 of Series 900 or requirements given in Figure A4.1, TRL 611.

#### 4.4.2 Dealing with Coal Tar Bound Arisings, Scottish Road Research Board

The Scottish Road Research Board (SRRB) is a partnership between Transport Scotland, the Society of Chief Officers of Transportation in Scotland (SCOTS) and the Scottish Road Works Commissioner (SRWC). The SRRB commission research and development work and in 2018 published a guideline document developed by CH2M titled Dealing with coal tar bound arisings [9].

The purpose of the document is to provide practical guidance on the planning and preparation for investigation; sampling and testing protocols; the interpretation of laboratory test results and the safe handling, transportation, storage, reuse and disposal of coal tar bound road arisings.

The following is a summary of the key points of the document; however, the status of the document in terms of implementation is currently being sought. The document refers extensively to an earlier version of the ADEPT guidelines covered under the England section of this report.

The guideline covers preliminary investigation through to disposal with under the following headings:

- Sampling protocol
- Logging the core
- Sampling
- Testing protocols
- Safe working practices
- Record keeping
- Classification of waste
- Producing hazardous/special waste
- Safe handling and storage of coal tar bound arisings

The content of the sections is expanded on below.

##### Sampling Protocol

The first step is identifying the date of construction. As-built records, where available, will provide information on the original construction design and may be available from the relevant authority's Pavement Management Systems.

It is recommended that cores of the road be taken ahead of any works as this will aid in determining whether coal tar containing materials can be left undisturbed and allows the removal process to be designed. Where the thickness of the pavement has been identified to be or is suspected to be variable, a Ground Penetrating Radar (GPR) survey may be undertaken to identify where changes in thickness occur.

The document refers to a sampling plan in accordance with WM3 as covered under the England section earlier. The document also refers to comprehensive flowcharts with flowchart A, relating to the positioning of cores, reproduced below.

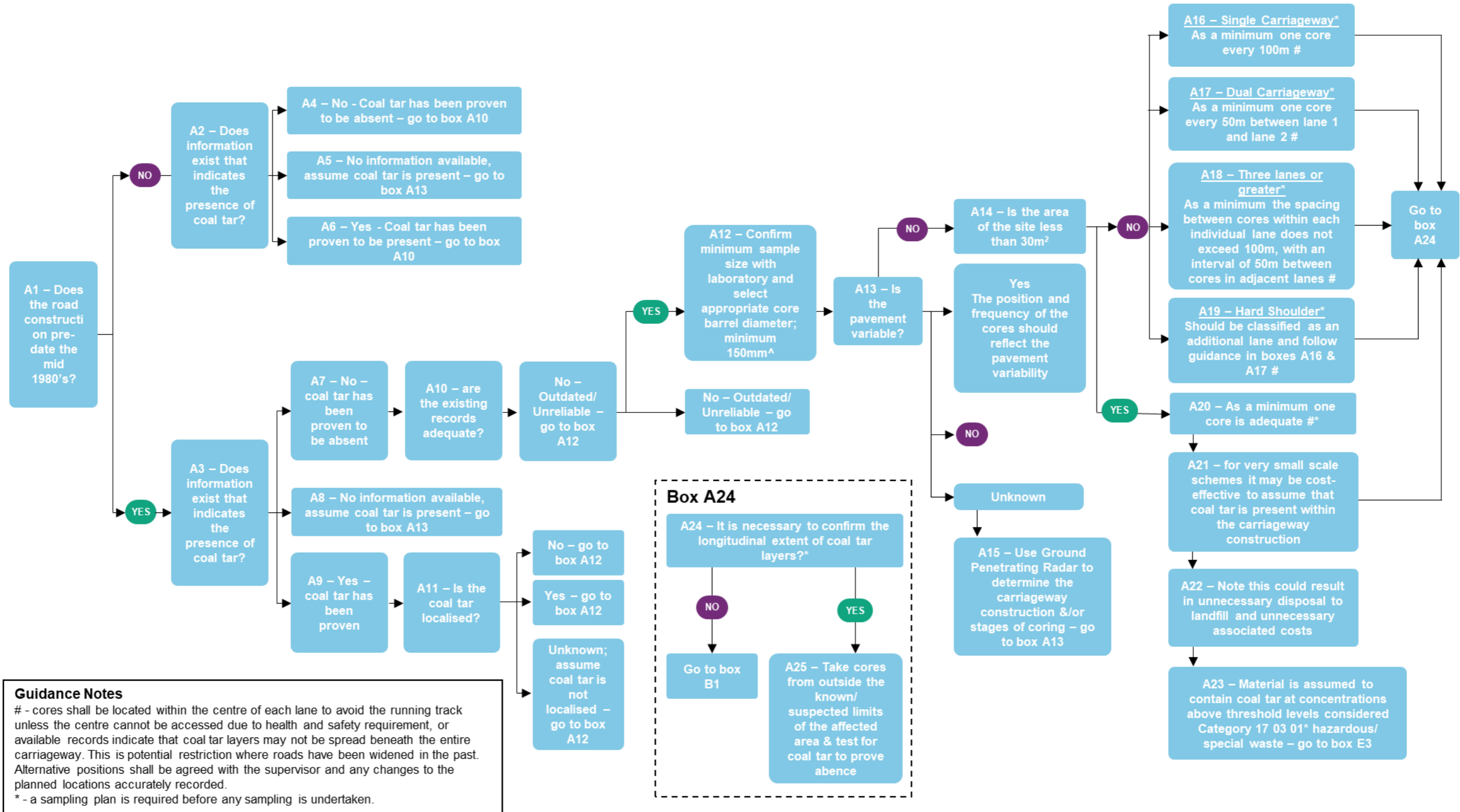


Figure 4.17 SRRB document: Appendix B Flowchart A: Positioning of cores

## **Logging the Core**

The sample sizes required by laboratories ranges from 50g to 100g, although some may require samples of up to 250g. Hence a larger diameter increases the amount of material recovered for test. The document refers to flowchart B, relating to the logging and sub sampling of cores, reproduced below.

Until proven otherwise it should be assumed that all cores contain coal tar layers and as such the core should be handled using disposable or PVC gloves to avoid dermal contact. To avoid the generation of dust and thus avoid the inhalation of potentially coal tar contaminated material the Contractor shall employ an appropriate dust suppression system when coring through the carriageway. Potentially contaminated surface water run-off should not be allow to enter the drainage system or the environment.

The core should be wrapped in multiple layers of cling film and sealed. The core should be clearly labelled (including top and bottom), and securely stored to prevent damage. Where the core is fragmented, care should be taken to prevent cross-contamination of the layers.

Each disintegrated layer should be placed within its own glass jar with the headspace kept to a minimum to limit the loss of volatile contaminants.

On completion of the works, the location of each core hole must be referenced against network sections to an accuracy of +/- 1m longitudinally and +/- 0.1m transversely from the nearside lane.

## **Sampling**

Once layers for testing have been identified, the core should be cut and sampled for testing, dividing the core into sections for each construction layer. This should be as early as possible, ideally the same day.

The document also refers to flowchart B, relating to the logging and sub sampling of cores, reproduced below.

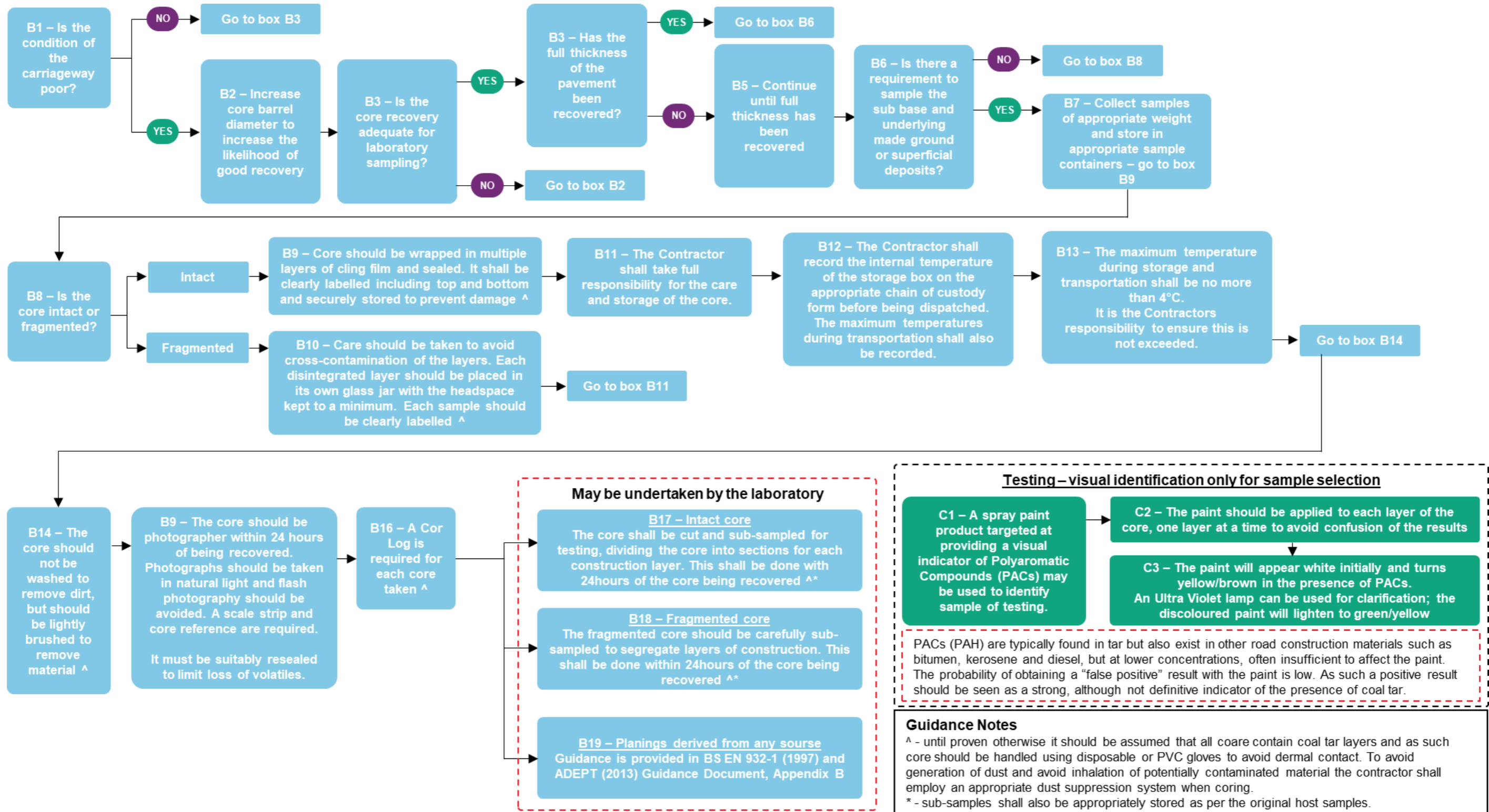


Figure 4.18 SRRB document: Appendix B Flowchart B: Logging and sub sampling of cores

## Testing Protocols

Testing must be undertaken within a maximum of 10 days of sampling to prevent inaccurate results due to sample degradation. The sample preparation and testing laboratory must be UKAS accredited. Tests based on detecting the presence of PAH 16 alone are unable to state whether concentrations of Benzo[a]pyrene are caused by other contaminants such as diesel. The presence of coal tar is therefore ascertained by also testing for phenol; and is based on the premise that coal tar does not contain very much phenol. This is based on ADEPT (2016).

Testing to determine the total % coal tar by means of gravimetric determination of toluene extractable matter are also unable to differentiate between coal tar and other hydrocarbon sources such as diesel, creosote, lube oil etc. This test is simply a means of determining if the gross level exceeds the threshold of 0.1%, at which concentration coal tar is classified to be Hazardous Waste/Special Waste. If the sample contain less than 0.1%, whether it contains coal tar or not becomes irrelevant with regards to waste disposal. However, should the sample contain greater than 0.1% further testing is required to determine if a concentration greater than 0.1% can be attributed to coal tar.

Testing by solvent extraction and analysis by Gas Chromatography-Mass Spectrometry (GCMS) is also unable to definitively identify coal tar from other sources of contamination such as diesel.

Test methods based on extraction of contaminants at different pH levels to determine potential concentrations of both the acid and basic components of coal tar are also unable to definitively determine coal tar as the source of the contaminant. Instead, the presence and absence of certain compounds can assist in the apportioning of coal tar as the contributing source.

There is a possibility that, where other coal tar derived products may also be present, that the results could be masked, or false positives may occur (e.g. high levels of phenol could mask the fact that coal tar bound arisings are present, similarly the presence of coal tar creosote, could indicate coal tar is present when it is not). As such, the results should not be reviewed in isolation and the likelihood of these other products being present should be assessed to determine the accuracy of the results.

The tests methods given outline the different analyses currently available to assist in identify the presence of coal tar bound materials. These range from visual identification only, through to identification and quantification in order to assist in apportioning coal tar as the contributing source.

The document also refers to flowchart C, providing a step by step guide for testing, reproduced below.

Chart C – Step by step guide to testing for coal tar (Part 2 of 2)

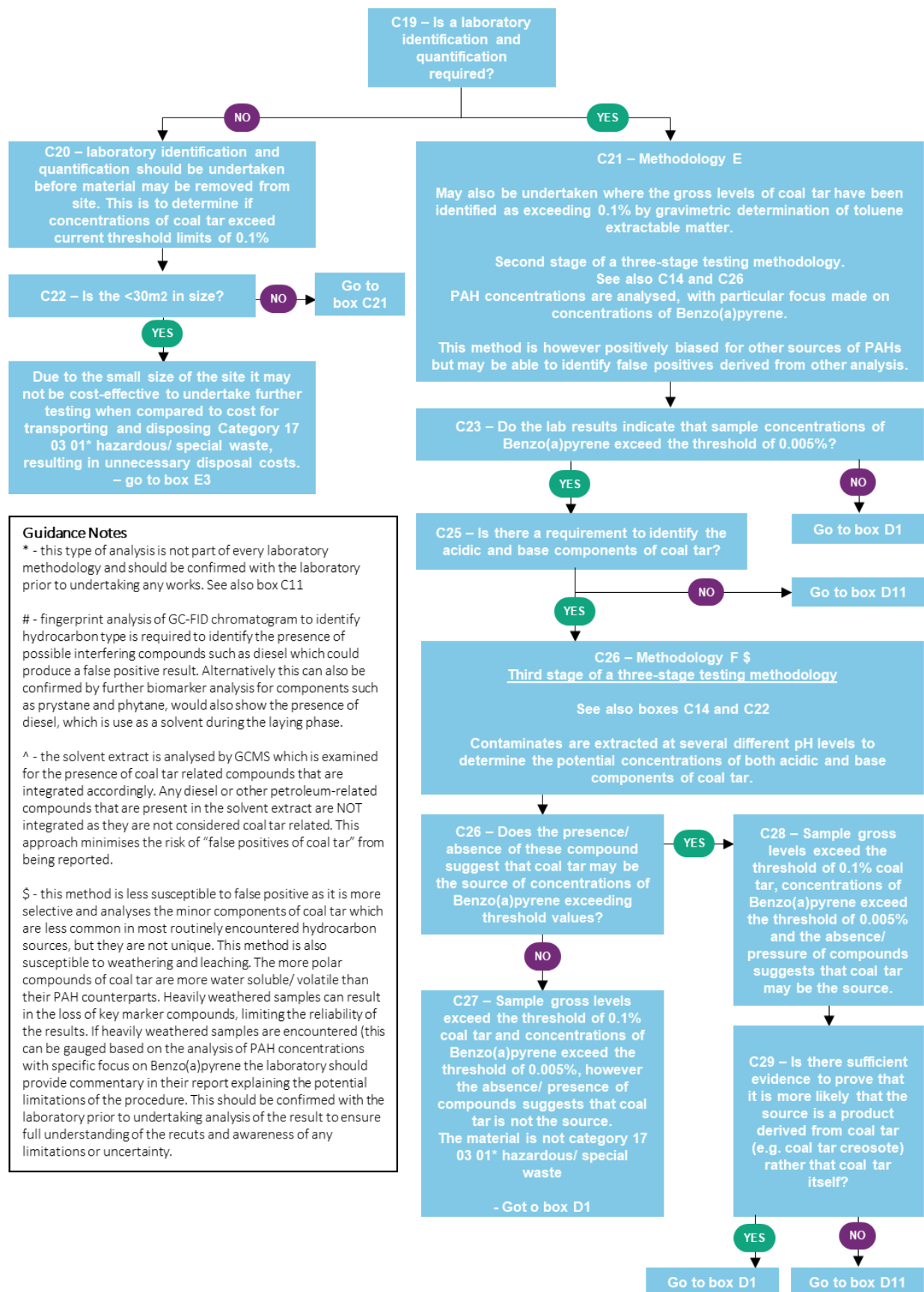


Figure 4.19 SRRB document: Appendix B Flowchart C: Testing (part 1)

Chart C – Step by step guide to testing for coal tar (Part 2 of 2)

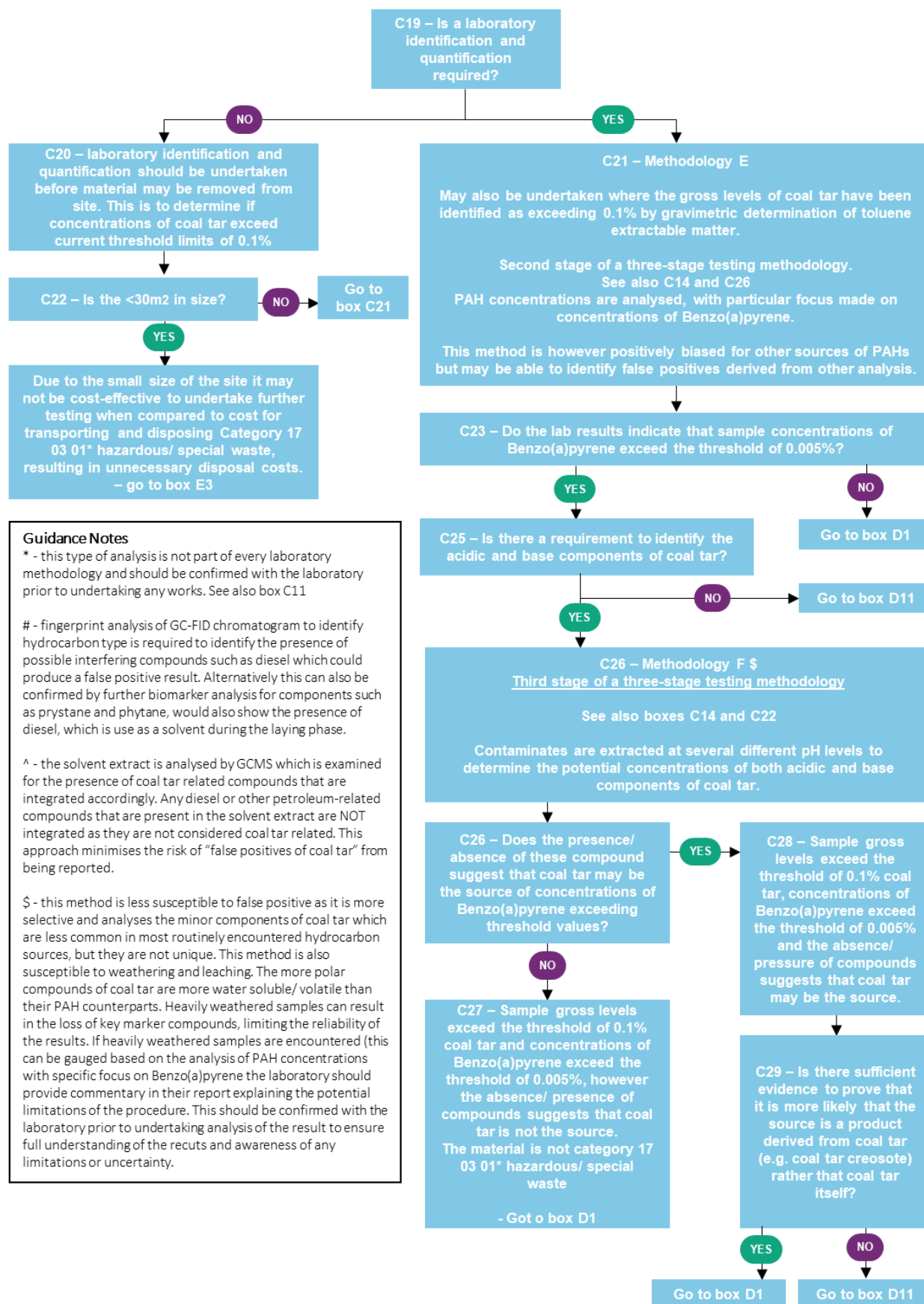


Figure 4.20 SRRB document: Appendix B Flowchart C: Testing (part 2)

## **Safe Working Practices**

Coal tar bound arisings are likely to be found within both the urban environment and rural countryside, with each setting potentially having different pathways and receptors. The document contains an outline risk register, which should be considered for each site.

As the hazardous contaminants contained within coal tar have been identified as potentially carcinogenic, and are toxic to the environment the effect they pose to human health and the environment is therefore considered to be very high.

Health Risks to site operatives are considered to be through dermal contact, and the inhalation of contaminated dust and vapours. The likelihood of dermal contact by site operatives is considered comparable with inhalation due to the nature of the work. This is a

worst case and is based on the assumption that task specific PPE will not be worn. The risk of ingesting contaminated dust by site operatives is considered to be lower than inhalation, but would be increase by poor hygiene standards. Risks to site operatives can be considerably reduced with the use of task specific PPE.

It is unlikely that the arisings will be heated sufficiently during the planing process to result in the release of fumes. However suitable respiratory protection is recommended in poorly ventilated or enclosed areas.

Health risks to members of the public/ passers-by from inhalation of contaminated dust is considered to be lower than the risk posed to those living directly adjacent to sites. The risk from fumes/vapours to people passing by the site is considered to be low because of the short exposure times. Animals and birds may utilise contaminated surface waters for drinking, particularly if run-off from the works is not controlled. In the urban environment, the likelihood of aquatic life (particularly fish), being directly impacted by short-term run-off is relatively low.

## **Record Keeping**

Whenever coal tar is identified in investigative works, the extent of it must be entered into the national highway database, including the depth (or depths) of the affected layers. This data must be made available to all operatives working on affected sections of carriageway, in particular utility companies. Populating the national highway database will in the long term reduce the need to undertake chemical testing prior to works and may enable resurfacing works to be planned to avoid disturbing the affected horizon(s). Where coal tar bound layers are removed from the carriageway, this must also be recorded in the national highway database such that it is clear if the risk remains.

## **Classification of Waste**

Classification is referred out to the ADEPT guidelines but the document also includes a flowchart D, concerning the test results, reproduced below.

Chart D – Step by step guide to the results

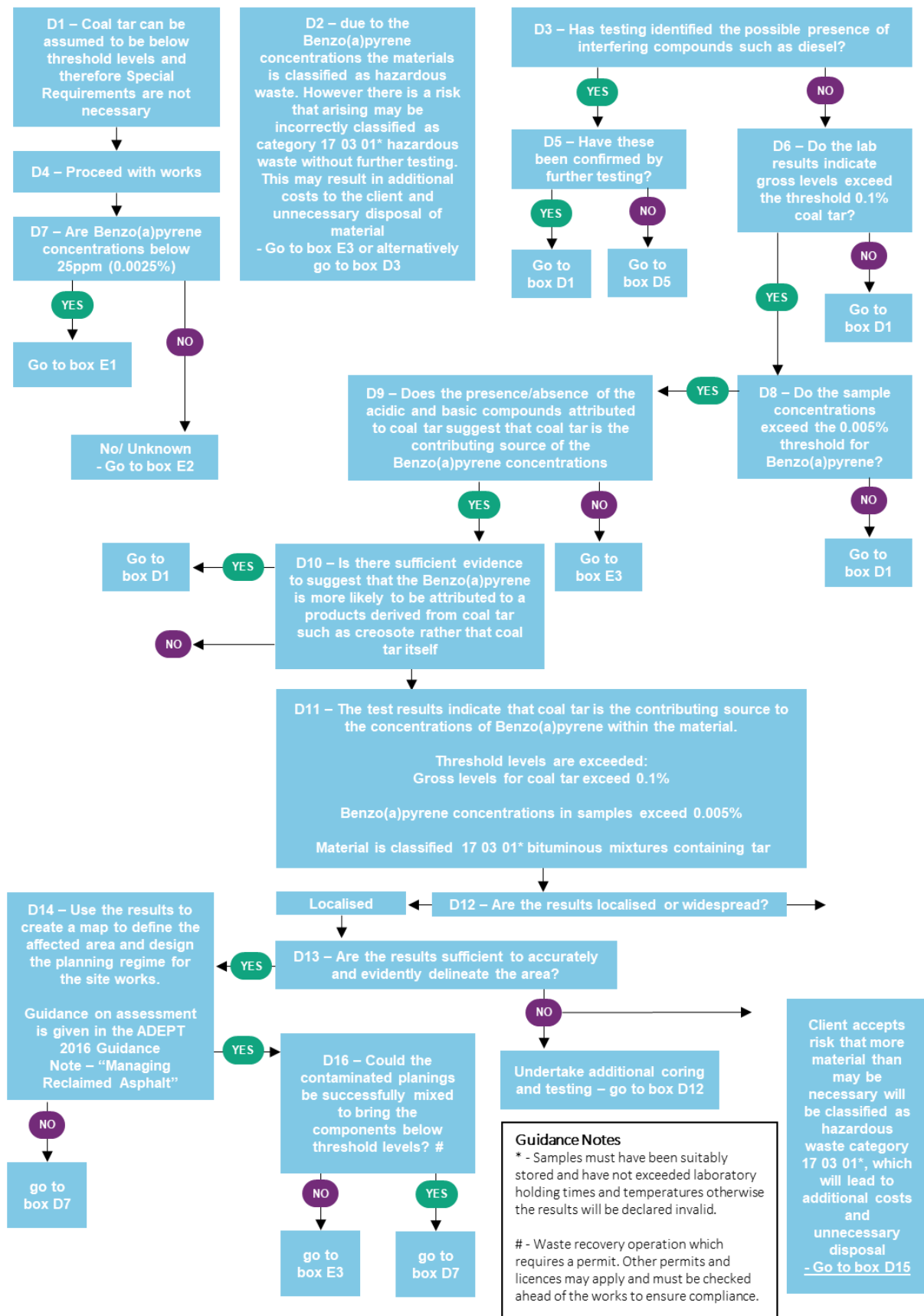


Figure 4.21 SRRB document: Appendix B Flowchart D: Results

## **Safe Handling and Storage of Coal Tar Bound Arisings**

Hazardous Waste/Special Waste must be transported by a registered waste carrier under the Control of Pollution Act 1989, [10] and the Controlled Waste Regulation 1991; [11] and be accompanied by a consignment note, The Environmental Protection (Duty of Care) (Scotland) Regulations 2014) [12]. It must also be sent to a facility that holds suitable pollution prevention and control permits and waste management licences.

It is currently a requirement in Scotland that SEPA be notified prior to Special Waste (Hazardous Waste) leaving site, if it is a single movement or the first in a series of movements, at least 72 hours and not one month before the material is moved, must be consigned using a SEPA-issued consignment note or code, regardless of its final destination within the UK.

Waste must be transported in a safe and secure manner to prevent the release of contaminated material en-route. This should include using enclosed or covered vehicles to prevent the spread of dust, and generation of leachate from precipitation.

There are no specific guidelines for the safe temporary storage of coal tar bound arisings within the UK, nor specific to Scotland.

An environmental permit may be required for the storage of coal tar bound arisings and must be applied for in advance of any works to ensure that permission has been obtained.

### **Re-Use**

In Scotland, there is currently no regulatory position for the re-use of planings containing tar, with all wastes containing above threshold concentrations classified as Special Waste (Hazardous Waste) (codes 17 03 01\* and 17 03 03\*) requiring disposal.

Further information is given in Flow Chart E, located within Appendix B of the document, reproduced below.

Diluting Special Waste (Hazardous Waste) by mixing it with Non-Hazardous materials does not qualify as treatment. Therefore, if Special Waste (Hazardous Waste) is mixed with a consignment of Non-Hazardous waste, this will result in the whole consignment being classified as Special Waste (Hazardous Waste).

Chart E – What to do next – options (based on current practices within England)

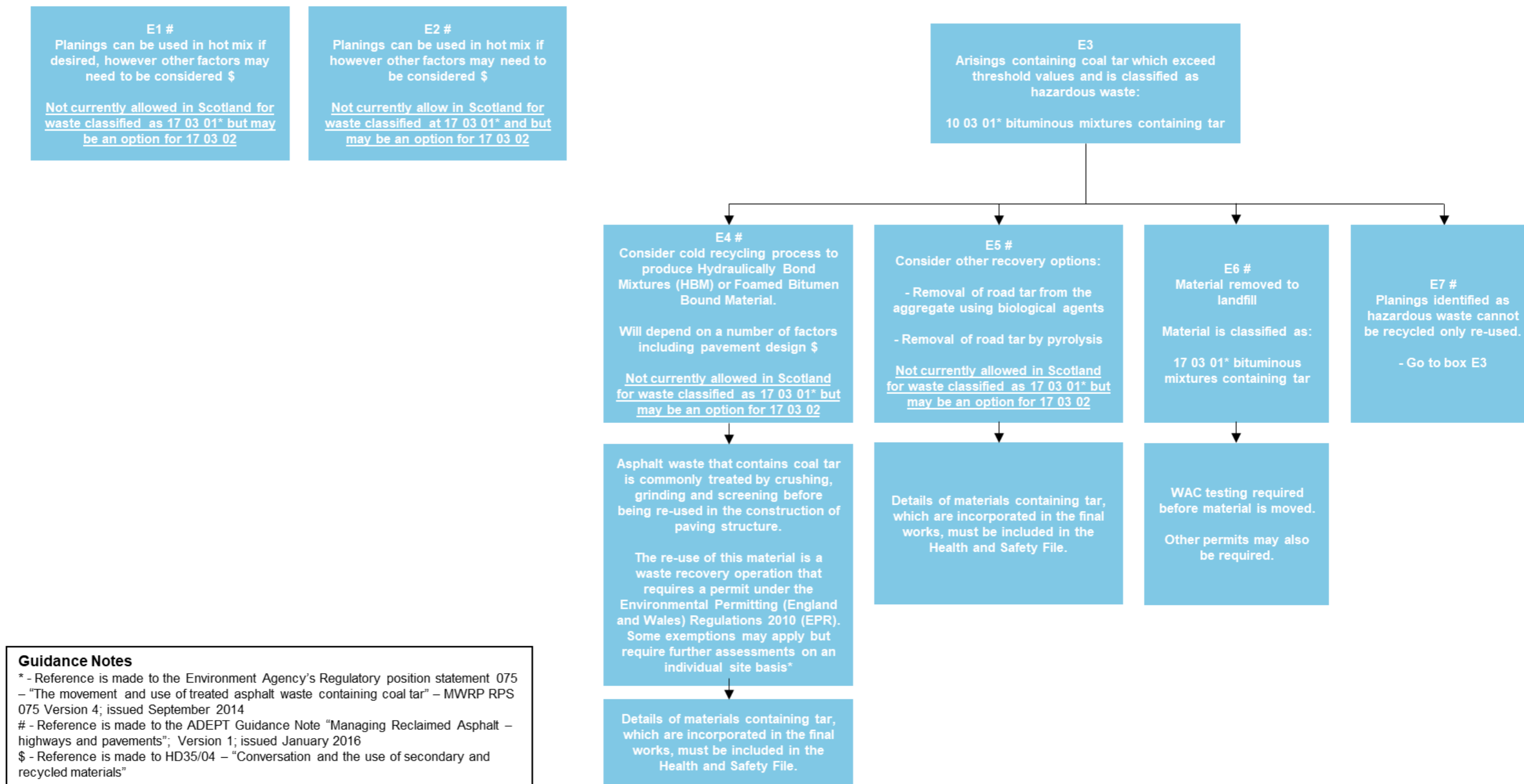


Figure 4.22 SRRB document: Appendix B Flowchart E: What to do next - options

Chart S – Summary of Charts A-E; Step by step guide to testing for coal tar boundarising

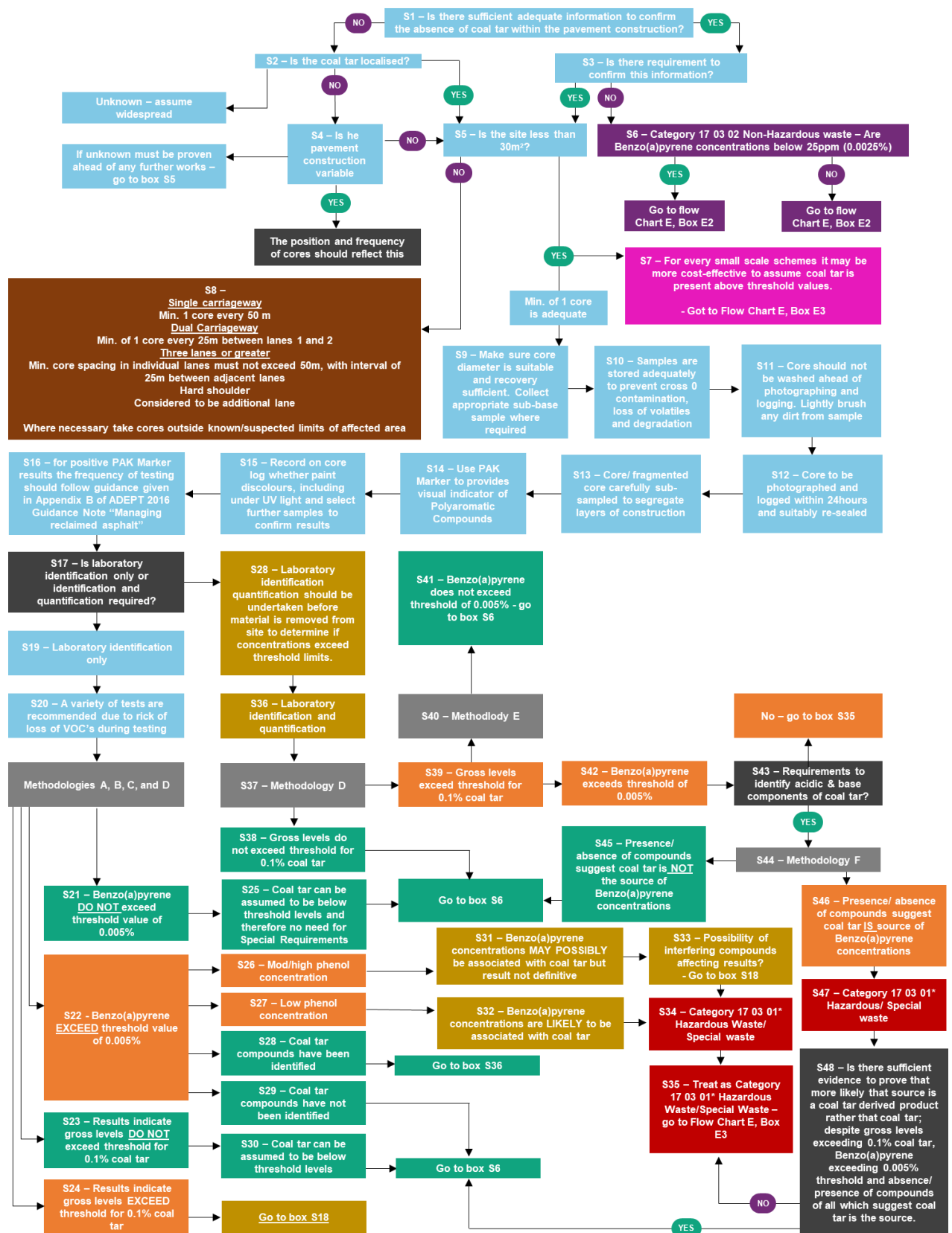


Figure 4.23 SRRB document: Appendix B Flowchart F: Summary of Charts A to E

#### 4.4.3 Scottish Bibliography

- [1] An approach to cold recycling of bitumen and tar bound roads, Transport Scotland, WSP Project No.: TS/TRBO/SER/2017/04/07 February 2021 [2] Manual of Contract Documents for Highway Works (MCHW), Volume 1 Specification for Highway Works (SHW) Series 900, Road Pavements – Bituminous bound materials Clause 947 In Situ Cold Recycled Bound Material & Clause 948 Ex Situ Cold Recycled Bound Material
- [3] Merrill D, Nunn M E and Carswell I (2004) A guide to the use and specification of cold recycled materials for the maintenance of road pavements. TRL Report TRL 611. TRL Limited.
- [4] Design Manual for Roads and Bridges (DMRB) CD 226, Design for new pavement construction
- [5] Scottish Statutory Instruments 2014 No. 4 (2014) The Environmental Protection (Duty of Care) (Scotland) Regulations 2014
- [6] Statutory Instruments 2015 No. 51 (2015) The Construction (Design and Management) Regulations 2015
- [7] BS 1924-2:2018, Hydraulically-bound and stabilised materials for civil engineering purposes Part 2: Sample preparation and testing of materials during and after treatment
- [8] Design Manual for Roads and Bridges (DMRB) CS 229, Data for pavement assessment. [9] Dealing with coal tar bound arisings, Scottish Road Research Board, CH2M, 2018
- [10] Control of Pollution (Amendment) Act 1989
- [11] Controlled Waste (Registration of Carriers and Seizure of Vehicles) Regulations 1991
- [12] Environmental Protection (Duty of Care) (Scotland) Regulations 2014

## 5. Protocols & Procedures - Proposals

Based on the information gathered and presented in Sections 2, 3 and 4 the following initial proposals are made with respect to the development of protocols for the screening, testing and treatment of road tar bearing materials.

### 5.1 Detection

The methods of detection are consistent across other jurisdictions, the use of a historical data review followed by a methodical coring approach would be practical for Ireland. The focus in all jurisdictions is to establish a sampling plan. Whilst all suggest coring as the best method for detection, some divergence occurs with the diameter of the cores, with the Netherlands suggesting 100mm diameter is sufficient whereas in England and Scotland, 150mm diameter cores are required to provide sufficient material for testing and analysis.

As other testing can be carried out on larger diameter cores, it is considered more beneficial to extract the 150mm diameter cores. The frequency of core extraction differs between jurisdictions, the most stringent requirement in the Netherlands is two cores for an area below 500m<sup>2</sup> and one core above 500m<sup>2</sup> whereas in England the recommendation is one core per 25 to 50m distance, so assuming a lane width of 4m, this equates to one core per 100 to 200m<sup>2</sup>.

For Ireland, the subnetwork data and risk profiles established in Section 3 should be the starting point for the investigation. For Engineered pavements in Subnetwork 1 the frequency could be low at one core per 1 000m<sup>2</sup> but where the likely presence of tar increases on Subnetworks 2, 3 and 4, the frequency could be more stringent at one core per 200m<sup>2</sup>. The logic for this is that cores are required to be extracted currently every 50m when structural analysis using FWD is undertaken. These cores could be used for the initial detection methods.

### 5.2 Screening

The use of fast detection PAH (PAK) marker sprays is consistent across the jurisdictions for a qualitative indication of the presence coal tar. All jurisdictions suggest the accuracy is improved when the material is assessed in UV light with yellow filter. However, the procedure for use differs with the Netherlands having a detailed assessment process on cut cores and does not recommend the test is used on loose materials. Whereas in Germany and England the test may be used on milled material.

The recommendation would be to develop a protocol for Ireland that contains a specific methodology along the lines of the Netherlands to ensure a consistent approach is taken.

### 5.3 Testing

The test methods for quantitative assessment are similar across all jurisdictions with GCMS, gas chromatography and mass spectrometry, common to all four jurisdictions for PAH content. The phenol index is determined using the HPLC, High Performance Liquid Gas Chromatography in the Netherlands and Germany.

Divergence does occur with the compounds assessed. In Germany and England, the US EPA PAH 16 types are considered, with England and Scotland generally only concerned with the threshold for benzo[a]pyrene (BaP). In Germany it is the Total PAH in solids and the Phenol index that have thresholds. In the Netherlands they use a PAH 10 threshold.

This aspect of the testing will require some specialist advice to determine what is most suitable for Ireland with regards to the Environmental legislation in place. Further consultation with the Environmental Protection Agency (EPA) will be required to make this determination.

## **5.4 Classification**

As mentioned above, different jurisdictions apply different thresholds for what is deemed hazardous according to local Environmental legislation. Further consultation with the EPA and consideration of Irish environmental legislation will provide guidance in the determination of suitable classifications levels.

## **5.5 Reuse Options**

Germany and England permit the use of coal tar asphalt to be used in in situ and ex situ cold mix applications. Scotland permits similar but only on a case by case basis once it is agreed with SEPA, the Scottish environment agency. The Netherlands has a zero tolerance policy and all coal tar asphalt must undergo thermal processing to remove all PAHs and return the residual aggregates and fillers to use in the asphalt industry.

The case by case re-use approach, with EPA consultation, taken in Scotland is recommended for implementation in Ireland.

## **Appendix A:** Specification Extracts



Bonneagar Iompair Éireann  
Transport Infrastructure Ireland

# TII Publications



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## Road Pavements - Bituminous Materials

**CC-SPW-00900**  
September 2017

## **8. MISCELLANEOUS PRODUCTS AND PROCESSES**

### **8.1 Low Energy Bound Mixtures**

Low Energy Bound Mixtures (LEBM) shall comply with this Specification.

Low Energy Bound Mixtures (LEBM) shall be produced ex situ, in either fixed or mobile mixing plants, or in situ by machinery capable of pulverising the existing road pavement and uniformly mixing controlled amounts of water and binder agents to the full depth in one pass.

The requirements under this Clause relate to constituents and composition. Separate and additional requirements for installation in the Works are contained in Clause 10.3.1 of this Series.

#### **8.1.1 Constituent Materials**

The constituent materials of the LEBM shall be CE marked, where appropriate.

##### **8.1.1.1 Binder**

Binder shall conform to the following standards unless otherwise specified in Appendix 7/12:

- (i) Bitumen used for foaming shall be Grade 70/100 or 160/220 and comply with IS EN 12591 and the requirements of Table 14. The foam shall have a minimum expansion ratio of 10% and a half-life of 8 seconds. A minimum of 1% Portland cement shall also be incorporated in such mixes as an adhesion agent / filler aggregate.
- (ii) Bitumen emulsion shall be cationic bituminous emulsion in accordance with the requirements of Table 24b. Fluxed and cutback bitumen binders shall not be permitted. A minimum of 1% Portland cement shall also be incorporated in such mixes as an adhesion agent / filler aggregate.
- (iii) Cement shall be CEM I conforming to IS EN 197-1.

##### **8.1.1.2 Aggregates**

Aggregate shall comprise of reclaimed asphalt and/or virgin aggregate.

Aggregate shall include:

- (i) Asphalt, concrete or granular material planed or excavated from roads or other paved areas outside of the Works and stockpiled.
- (ii) Primary or secondary aggregate from other sources.
- (iii) Asphalt, concrete or granular material planed or excavated from the road or other paved areas inside of the Works being resurfaced/reconstructed.

Virgin aggregates shall be in accordance with the requirements of Table 24a.

The processed aggregate, including added filler, shall not contain deleterious material that adversely affects the performance of the mixture.

Materials used within 450mm of the designed final surface of a road shall not be frost susceptible. Materials shall be classified as non-frost susceptible if the mean heave is 15mm or less when tested in accordance to BS 812-124.

### **8.1.1.3 Filler**

Filler shall come from primary or secondary sources. Virgin filler shall comply with the requirements of Table 24a.

### **8.1.1.4 Reclaimed Asphalt**

Reuse of asphalt reclaimed directly from the site is permitted provided the material is demonstrated to be homogeneous and allows the mix design to meet the requirements of this Series.

### **8.1.1.5 Water**

Water for moisture content control of the granular material shall normally be obtained from a water company supply and used without testing. Water from an alternative source shall comply with IS EN 1008.

Water shall not contain material that adversely affects the performance of the mixture.

### **8.1.1.6 Additives**

Other constituents, including setting, hardening and adhesion agents, shall only be used to enhance the performance of the mixture provided it is demonstrated that they are not harmful to the stability of the mix over its design life and are suitable for the intended use on site.

## **8.1.2 Product Composition**

The grading of the mixture (the aggregate together with the other constituents including binders) shall comply with one of the zones in Table 24d. Use of Zone B, C, or D shall only be permitted when the results of a full mix design showing compliance with the required performance properties.

The minimum binder content shall comply with Table 24c.

LEBM shall be subject to a Type Test in accordance to DN-PAV-03075 to demonstrate the product composition and constituent materials comply with the requirements of this Specification.

### **8.1.2.1 Mixture Production**

The plant used for production shall be capable of uniformly mixing controlled amounts of water and binder agent(s) into the full depth of LEBM.

The Producer shall provide a written statement and material quality plan detailing the following:

- (i) A description of mixture management including aggregate traceability, aggregate stockpiles, aggregate treatment (crushing and screening) and aggregate availability.
- (ii) A description of the plant (mixing plant location, aggregate and binder feeders and spreaders, mixing equipment, storage bins, water tank, binder tank, recycler rollers, grader (as applicable) and the production process, preferably including a flow diagram, detailing how material is to be produced in accordance with this Specification.
- (iii) Evidence confirming the capabilities of the plant and the calibration of flow meters. Calibration schedules for all parts of the plant involved in determining mixture consistency shall be provided. These shall be accompanied by calibration records and production capacity (tons/hour and tons/day).

- (iv) Details of transportation which shall include the expected time between mixing and laying the LEBM.

Ex situ LEBM shall be produced in proprietary mixing plants, which allow sufficient time in the mixer to produce a homogenous mixture. The mixing plant shall have an automated surveillance and data collection system.

For production of in situ LEBM, the following requirements shall be complied with:

The plant used for stabilisation shall be equipped with a spraybar system within the mixing chamber capable of producing and uniformly distributing foamed bitumen binder or bitumen emulsion at a monitored and controlled rate. An accessible sampling jet shall also be fitted that produces foamed bitumen or bitumen emulsion having the same characteristics as that produced by the main spraybar. Flow rate meters for measuring the supply rate of hot bitumen or bitumen emulsion and other liquid additives to the mixture shall be capable of recording the correct rate of flow during all states of pipeline flow (i.e., fully or partially charged).

The plant used shall be capable of processing, diluting, dispersing and encapsulating hazardous tar contaminants into the recycled road structure thereby rendering them safe.

If any corrective virgin aggregate or hydraulic binders (e.g. cement) are needed, they shall be spread uniformly over the full-width of the surface before any pulverisation takes place. The rate of spread of these materials shall be calculated to achieve the target mixture composition.

Pulverisation of the existing road structure shall be carried out in a systematic pattern and to the required depth for all parts of the existing road specified in Appendix 7/12. An overlap of at least 150mm shall be made between adjacent passes. Any material missed along hard edges or around obstructions shall be excavated and placed in the path of subsequent passes of the machine until a uniform fully pulverized aggregate is obtained. The pulverised material shall not be contaminated by material drawn in from the verges.

Moisture content of the pulverised aggregate immediately prior to stabilisation shall be measured in accordance with IS EN 1097-5 using the high temperature method and comply with Table 24g.

If the moisture content of the unstabilised pulverised aggregate fails to meet the specified moisture content range, corrective action shall be taken either by aeration to reduce the moisture content or by controlled addition of water to increase the moisture content as described in DN-PAV-03074.

Prior to stabilisation, pulverised materials within 100mm of restricted hard edges such as kerbs and channels, or around obstructions such as gullies, shall be removed and spread uniformly over the remaining full width of the pulverised material.

Immediately prior to stabilisation, any filler and/or additives shall be spread uniformly over the full width of the layer using a mechanical spreader capable of distributing the material(s) in a uniform controlled manner.

The stabilisation shall be carried out to the required depth in a systematic pattern similar to that used for the pulverisation process, with an overlap of at least 150mm between adjacent passes of the machine.

The binder shall be supplied to the spraybar of the stabilising machine by pumped pipeline from on-board tanks or from a tanker moving in tandem with the stabilising machine.

## **9. RECLAIMED ASPHALT**

Reclaimed Asphalt shall comply with this Specification, which is derived from IS EN 13108-8.

Reclaimed Asphalt shall only be added where it is demonstrated that the asphalt plant has the capability to add the Reclaimed Asphalt accurately and procedures are in place to record the quantity being added. The mixing time needs to be sufficient to achieve homogeneous blending of the active binder and the added bitumen.

### **9.1 Source**

The source asphalt shall only contain mineral aggregate, filler and paving grade bitumen. Source asphalt containing tar shall not be permitted. Other contaminants should be considered on an individual basis in terms of their potential effect on the durability of the resulting asphalt and the environment.

### **9.2 Classification and Description**

Reclaimed Asphalt shall be tested in accordance with the requirements of Table 13a to ensure that the material is suitable for use. Any unsuitable material shall be discarded and the remainder shall be classified as the feedstock of Reclaimed Asphalt.

The mix group(s) and/or course(s) of the reclaimed asphalt from which the feedstock has been derived shall be declared. The presence and content of any foreign matter shall be classified as Group 1 and Group 2 and shall be declared.

The grading shall be carried out after removing the binder by solvent (or ignition) method. This grading shall be used for the mixture design. At the same time, a grading shall be carried out on the processed feedstock material to determine the maximum size of Reclaimed Asphalt particles.

The binder coating the aggregate particles shall be tested for binder content and recovered penetration and softening point. If the penetration of the recovered binder is less than 15 the recovered binder shall be considered inert for the purposes of consideration of the mixture binder content.

### **9.3 Storage**

Feedstock that has been classified as acceptable shall be stored in labelled stockpiles, protected from rain, snow and direct sunshine. Feedstock from different stockpiles shall be treated separately without cross-contamination from other feedstock stockpiles unless it can be shown that the properties of the feedstock are similar. If the feedstock production process separates the material into more than one size, then they shall be stored in separate stockpiles. The feedstock shall be stored under cover.

Since the requirements for bituminous mixtures are the same for mixtures with and without reclaimed asphalt, the level of homogeneity of the bituminous mixture in practice determines the maximum amount of reclaimed asphalt that can be used.

### **9.4 Mixture Design**

The composition and properties of the bituminous mixture contained in Table 2 are suitable for mixtures with up to 10% Reclaimed Asphalt as a constituent. Where more than 10% Reclaimed Asphalt is used, additional properties shall be established in accordance with Table 13b.

# ROAD PAVEMENTS – BITUMINOUS BOUND MATERIALS

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### General

- 24 The Engineer may direct the application of a bituminous tack coat spray, complying with Clause 920, to the surface on which laying is to take place.
- 25 Bituminous material shall be kept clean and uncontaminated. The only traffic permitted to run on bituminous material to be overlaid shall be that engaged in laying and compacting the next course or, where a basecourse is to be blinded or surface dressed, that engaged on such surface treatment. Should any bituminous material become contaminated the Contractor shall make it good by cleaning it and, if this proves impracticable, by rectification in compliance with the 700 Series.
- 26 Basecourse material shall not remain uncovered by either the wearing course or surface treatment, whichever is specified in the Contract, for more than three consecutive days after being laid. The Engineer may extend this period by the minimum amount of time necessary because of weather conditions or for any other reason; in this case the Contractor shall apply a bituminous tack coat spray complying with Clause 920 to the surface immediately prior to laying the next layer.

### Regulating Course

- 27 Regulating course material shall be made and laid in accordance with the requirements of Clause 907.

### 902 Not Used

### 903 Dense Bitumen Macadam Roadbase

- 1 Dense bitumen macadam roadbase shall be 28mm nominal size aggregate dense roadbase complying with BS 4987 : Part 1, and with sub-Clauses 2, 3 and 4 of this Clause and the requirements of Appendix 7/1. The nominal layer thickness shall be within the range of 70mm to 100mm.

### Aggregate

- 2 The coarse aggregate shall consist of crushed rock or crushed gravel complying with the requirements of BS 4987: Part 1. The fine

aggregate may be crushed rock or sand or mixtures thereof, but the type shall be subject to the approval of the Engineer. The quality of the fine aggregate shall comply with the requirements of BS 4987: Part 1. The aggregate shall be in a surface dry condition prior to mixing unless the macadam is manufactured in a drum mixing plant in compliance with Clause 923.

### Filler

- 3 When the coarse aggregate is crushed gravel, 2% by mass of total aggregate of Portland cement or hydrated lime shall be added. The percentage of fine aggregate shall be reduced accordingly. Cement or hydrated lime is not required when the crushed gravel is limestone.

### Binder

- 4 The binder shall be petroleum bitumen of 100 pen grade complying with the specification issued by the National Roads Authority/ Department of Environment as appropriate.

### 904 Not Used

### 905 Rolled Asphalt Basecourse

- 1 Rolled asphalt basecourse shall comply with BS 594 : Part 1 for basecourse mixtures, and with sub-Clauses 2 and 3 of this Clause, and the requirements of Appendix 7/1. Unless otherwise specified in Appendix 7/1, it shall contain 60 per cent of crushed rock or crushed gravel coarse aggregate of 28 mm nominal size.

### Filler

- 2 When the coarse aggregate is crushed gravel, 2% by mass of total aggregate of Portland cement or hydrated lime shall be added. The percentage of fine aggregate shall be reduced accordingly. Cement or hydrated lime is not required when the crushed gravel is limestone.

### Binder

- 3 The binder shall be petroleum bitumen of 50 pen grade complying with the specification issued by the National Roads Authority/ Department of Environment as appropriate.

## 906 Dense Bitumen Macadam Basecourse

- 1 Dense bitumen macadam basecourse shall comply with BS 4987 : Part 1 for dense basecourse, and with sub-Clauses 2, 3 and 4 of this Clause, and the requirements of Appendix 7/1. Unless otherwise specified in Appendix 7/1, it shall be of 28 mm or 20 mm size. The nominal layer thickness of material containing aggregate of 28mm size shall be within the range of 60 to 100mm. The nominal layer thickness of material containing aggregate of 20mm size shall be within the range of 50 to 80mm.

### Aggregate

- 2 The coarse aggregate shall consist of crushed rock or crushed gravel complying with the requirements of BS 4987: Part 1. The fine aggregate may be crushed rock or sand or mixtures thereof, but the type shall be subject to the approval of the Engineer. The quality of the fine aggregate shall comply with the requirements of BS 4987: Part 1. The aggregate shall be in a surface dry condition prior to mixing unless the macadam is manufactured in a drum mixing plant in compliance with Clause 923.

### Filler

- 3 When the coarse aggregate is crushed gravel, 2% by mass of total aggregate of Portland cement or hydrated lime shall be added. The percentage of fine aggregate shall be reduced accordingly. Cement or hydrated lime is not required when the crushed gravel is limestone.

### Binder

- 4 The binder shall be petroleum bitumen of 100 pen grade complying with the specification issued by the National Roads Authority/ Department of Environment as appropriate.

## 907 Regulating Course

- 1 Regulating courses shall be in accordance with sub-Clauses 2, 3 and 4 of this Clause. Bituminous materials for regulating courses shall meet the requirements for the appropriate material, as specified in BS 594 or BS 4987 as relevant.

- 2 Regulating courses, which may consist of one or more layers of a bituminous material, shall have their finished surfaces laid to achieve the appropriate tolerances for horizontal alignments, surface levels and surface regularity, for pavement layers, in accordance with Clause 702.
- 3 Rolled asphalt shall be used for regulating courses where rolled asphalt is specified for the next pavement layer.
- 4 Where the total depth of a regulating course exceeds 100 mm then the course shall be laid so that each regulating layer has a compacted thickness of between 50 mm and 100 mm.

## 908 Not Used

## 909 Not Used

## 910 Rolled Asphalt Wearing Course (Recipe Mix)

- 1 Rolled asphalt wearing course shall comply with BS 594 : Part 1 for wearing course recipe mixtures, and with sub-Clauses 2, 3, 4 and 5 of this Clause, and the requirements of Appendix 7/1. It shall have a nominal coarse aggregate content of 30% by mass of the total mix and the nominal size of the coarse aggregate shall be 14 mm. It shall comply with the requirements for the recipe mixture approved by the Engineer.

### Binder

- 2 The binder shall be petroleum bitumen of 50 pen grade complying with the specification issued by the National Roads Authority/ Department of Environment as appropriate. The binder content, expressed as percentage by mass of the total mix, shall be  $7.8 \pm 0.6\%$  where the coarse aggregate is crushed rock, and  $7.5 \pm 0.6\%$  where the coarse aggregate is crushed gravel.

### Coarse Aggregate

- 3 The coarse aggregate shall consist of crushed rock or crushed gravel complying with the quality and grading requirements of BS 594, and shall have a polished stone value, when determined in accordance with BS 812: Part 114, not less than 45.



**SPECIFICATION  
FOR  
ROAD WORKS**

**An Roinn Comhshaoil  
Department of the Environment**

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**Table 8/8 Wet Mix Macadam**

Range of Grading	
BS sieve size	percentage by mass passing
50 mm	100
37.5 mm	95-100
20 mm	60-80
10 mm	40-60
5 mm	25-40
2.36 mm	15-30
600 $\mu$ m	8-22
75 $\mu$ m	0-8

The particle size shall be determined by Test 7A of BS 1377.

#### **Moisture Content**

3 The moisture content of the wet-mix macadam shall be the optimum  $\pm$  0.5 percent as determined in accordance with the Vibrating Hammer Method Test 13 of BS 1377.

#### **Laying and Compaction**

4 The material shall be laid and compacted in layers of not more than 200 mm thickness in accordance with Clause 802. Any areas of compacted material having a loose surface deficient in fines shall be removed and replaced with properly graded material.

#### **811 Dry-Bound Macadam**

1 Dry-bound macadam shall be made and constructed in the following manner using coarse and fine aggregate consisting of crushed rock in accordance with Clause 1702, except that the coarse aggregate shall comply with either the 50 mm or the 40 mm nominal sizes of BS 63 as described in the Contract and the fine aggregate shall all pass the 5 mm BS sieve size. The fine aggregate shall be dry on arrival at the Site and if stockpiled it shall be kept dry by being sheeted until required for use.

2 The coarse aggregate shall be laid by mechanical plant to a thickness within the range 75-100 mm and given two passes by a smooth-wheeled roller having a mass per metre

#### **Sub-bases and Roadbases**

width of roll of at least 2500 kg on at least one roll. The fine aggregate shall then be spread on it to a thickness of approximately 25 mm by a suitable spreading machine and vibrated into the voids of the coarse aggregate by a vibrating-plate compactor having a mass per  $m^2$  of the base-plate of at least 1400  $kg/m^2$  or a vibrating roller having a mass per metre width of vibrating roll of at least 1800 kg.

3 The operations of spreading and vibrating the fine aggregate shall be repeated as necessary until no more will penetrate into the layer of coarse aggregate and no hungry patches are visible on the surface, when it shall be brushed to remove the excess fines and leave the coarse aggregate standing 3-6 mm proud. The layer shall then be rolled with a smooth-wheeled roller having a mass per metre width of at least 5000 kg on at least one roll.

4 The whole operation shall be repeated as necessary to provide the full specified thickness of roadbase.

#### **812 Dense Bitumen Macadam Roadbase**

1 This material, to the nominal size of aggregate described in the Contract, shall be made in accordance with the requirements of BS 4987: 1973. It shall be laid and compacted to Clauses 704 and 705.

#### **Aggregate**

2 The coarse aggregate shall consist of crushed rock or gravel complying with the quality requirements of BS 4987: 1973. The fine aggregate may be crushed rock or sand or mixtures thereof, but the type shall be subject to the approval of the Engineer. The quality of the fine aggregate shall comply with the requirements of BS 4987:1973.

#### **Filler**

3 If filler is required it shall consist of crushed rock, Portland cement or other material approved by the Engineer. The quality of the filler shall comply with the requirements of BS 4987 1973.

#### **Binder**

4 The binder shall be petroleum bitumen of 100 pen grade complying with the specification issued by the Department of the Environment.

<b>Table 8/9      Dense Bitumen Macadam Roadbase</b>			
<i>Nominal Size (mm)</i>		40 mm	28 mm
<i>Range of thickness of compacted course (mm)</i>		60–105	50–60
<i>Binder Grade</i>		100 pen.	100 pen
<i>Binder Content: (percentage by mass of total mixture)</i>			
Crushed Rock Aggregate		3.5 ± 0.6	4.0 ± 0.6
Gravel Aggregate		4.5 ± 0.6	4.5 ± 0.6
<i>Aggregate Grading: (percentage by mass passing)</i>			
BS Sieve Size	50 mm	100	
	37.5 mm	95–100	100
	28 mm	70–94	90–100
	20 mm		71–95
	14 mm	56–76	58–82
	10 mm		
	6.3 mm	44–60	44–60
	3.35 mm	32–46	32–46
	300 μm	7–21	7–21
	75 μm	2–8*	2–8*
<i>Range of temperatures:</i>			
Mixing temperatures of Aggregate °C		120–140	120–140
Mixing temperatures of Binder °C		130–165	130–165
Delivery temperatures of Macadam °C		105–130	105–130
Minimum Rolling temperature °C		80	80
*When gravel other than limestone gravel is the aggregate, the material passing the 75 μm BS test sieve shall include Portland cement or hydrated lime to the amount of 2 percent by mass of the total aggregate.			

**Composition of Mixed Material**

5 On analysis of the freshly mixed material, its composition shall comply with that specified in Table 8/9, as described in the Contract.

**Temperature of Material**

6 Before coating the aggregate shall be surface-dry. The macadam shall be mixed and delivered to the laying site within the range of temperatures given in Table 8/9 and at the time of rolling shall not be less than the temperature given in Table 8/9.

**Mixing**

7 The materials including any added filler shall be accurately weighed and measured into a mechanical mixer of approved type and thoroughly mixed in such a manner that all particles of the aggregate are completely and uniformly coated. The weighing or measuring mechanisms shall at all times be maintained within the accuracies recommended by the manufacturer.

**813 Maintenance of Surface of Roadbase**

1 On completion of the roadbase and until any surfacing is laid on it, the finished surface shall be maintained free from potholes, ruts and undulations, irregularities, depressions, loose material or other defects.

**814 Paved Hardshoulders and Hardstrips**

1 Paved hardshoulders and hardstrips shall be constructed of the materials and to the dimensions described in the Contract. Where hardshoulder construction is shown to differ from that of the carriageway, the Contractor may, with the agreement of the Engineer, construct them to the same depth and materials as the carriageway.

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Flexible Surfacing

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**901 Regulating Course**

1 Regulating course material shall be made and laid in accordance with the requirements for one or other of the wearing course, basecourse or roadbase materials in this Specification as described in the Contract. It shall include the appropriate nominal sized aggregate to ensure compliance with the requirements of Clause 704.

**902 Dense Bitumen Macadam Basecourse**

1 This material, to the nominal size aggregate described in the Contract shall be made in accordance with the requirements of BS 4987:1973. It shall be laid and compacted to Clause 705.

**Aggregate**

2 The coarse aggregate shall consist of crushed rock or gravel complying with the equality requirements of BS 4987: 1973. The fine aggregate may be crushed rock or sand or mixtures thereof, but the type shall be subject to the approval of the Engineer. The quality of the fine aggregate shall comply with the requirements of BS 4987: 1973.

**Filler**

3 If filler is required it shall consist of crushed rock, Portland cement or other material approved by the Engineer. The quality of the filler shall comply with the requirements of BS 4987: 1973.

**Binder**

4 The binder shall be petroleum bitumen of 100 pen grade complying with the specification issued by the Department of the Environment.

**Composition of Mixed Material**

5 On analysis of the freshly mixed material, its composition shall comply with that specified in Table 9/1, as described in the Contract.

**Temperature of Material**

6 Before coating the aggregate shall be surface-dry. The macadam shall be mixed and delivered to the laying site within the range of temperatures given in table 9/1 and at the time of rolling shall not be less than the temperature specified in Table 9/1.

**Mixing**

7 The materials including any added filler shall be accurately weighed and measured into a mechanical mixer of approved type and thoroughly mixed in such a manner that all particles of the aggregate are completely and uniformly coated. The weighing or measuring mechanisms shall at all times be maintained within the accuracies recommended by the manufacturer.

**903 Open and Medium-Textured Wearing Course Macadam**

1 This material to the nominal size of aggregate described in the Contract shall be made in accordance with the requirements of BS 4987: 1973. It shall be laid and compacted to Clause 705.

**Aggregate**

2 The coarse aggregate shall consist of crushed rock complying with the quality requirements of BS 4987: 1973, and shall have a polished stone value not less than that described in the Contract. The fine aggregate may be crushed rock or sand or mixtures thereof but the type shall be subject to the approval of the Engineer. The quality of the fine aggregate shall comply with the requirements of BS 4987: 1973.

**Binder**

3 The binder shall be petroleum bitumen of 100 sec. or 200 pen grade as described in the Contract complying with the specification issued by the Department of the Environment.

**Composition of the Mixed Material**

4 On analysis of the freshly mixed material, its composition shall comply with that specified in Table 9/2 as described in the Contract.

**Temperature of Material**

5 Before coating the aggregate shall be surface dry. The macadam shall be mixed and delivered to the laying site within the range of temperatures given in Table 9/2, and, at the time of rolling shall not be less than the temperature specified in Table 9/2.

<b>Table 9/1 Dense Basecourse Macadam</b>			
<i>Nominal Size (mm)</i>	40 mm	28 mm	20 mm
<i>Range of thickness of compacted course (mm)</i>	60-80	50-60	35-50
<i>Binder Grade</i>	100 pen.	100 pen.	100 pen.
<i>Binder Content: (percentage by mass of total mixture).</i>			
Crushed Rock Aggregate	4.5 ± 0.6	4.7 ± 0.6	4.7 ± 0.6
Gravel Aggregate:	4.8 ± 0.6	5.0 ± 0.6	5.0 ± 0.6
<i>Aggregate Grading (percentage by mass passing)</i>			
BS Sieve Size	50 mm	100	
	37.5 mm	95-100	100
	28 mm	70-94	90-100
	20 mm		71-95
	14 mm	56-76	58-82
	10 mm		65-85
	6.3 mm	44-60	44-60
	3.35 mm	32-46	32-46
	300 μm	7-21	7-21
	75 μm	2-8*	2-8*
<i>Range of temperatures</i>			
Mixing temperatures of Aggregate °C	120-140	120-140	120-140
Mixing temperatures of Binder °C	130-165	130-165	130-165
Delivery temperatures of Macadam °C	105-130	105-130	105-130
Minimum Rolling temperatures °C	80	80	80
*When gravel other than limestone gravel is the aggregate, the material passing the 75 μm. BS test sieve shall include Portland cement or hydrated lime to the amount of 2 percent by mass of the total aggregate.			

<b>Table 9/2 Open and Medium-Textured Wearing Course Macadam</b>			
<i>Nominal Size (mm)</i>	14 mm	10 mm	6 mm
<i>Range of thickness of compacted course (mm)</i>	25-40	20-25	15-20
<i>Binder Grade</i>	100 sec or 200 pen.	100 sec or 200 pen.	100 sec or 200 pen.
<i>Binder Content: (percentage by mass of total mixture)</i>			
Crushed Rock Aggregate other than limestone	4.8 ± 0.5	5.3 ± 0.5	5.4 ± 0.5
Crushed Rock Aggregate limestone	4.6 ± 0.5	5.1 ± 0.5	5.4 ± 0.5
<i>Aggregate Grading (percentage by mass passing)</i>			
BS Sieve Size	20 mm	100	
	14 mm	90-100	100
	10 mm	55-75	85-100
	6.3 mm	25-45	30-60
	3.35 mm	15-25	15-25
	1.18 mm		90-100
	75 μ m	2-6	2-6
			*45-65
			10-30
			2-8
<i>Range of Temperatures:</i>			
Binder Grade	100 sec.	200 pen.	
Mixing temperature of Aggregate °C	40-70	100-120	
Mixing temperature of Binder °C	65-130	110-150	
Delivery temperature of Macadam °C	—	80-105	
Minimum Rolling temperature °C	—	55	
*If the Engineer allows this material to be laid cold, the lower limit of the quantity of aggregate passing the 3.35 mm sieve shall be 25 percent.			

**Mixing**

6 The materials shall be accurately weighed and measured into a mechanical mixer of approved type and thoroughly mixed in such a manner that all particles of the aggregate are completely and uniformly coated. The weighing or measuring mechanisms shall at all times be maintained within the accuracies recommended by the manufacturer.

**904 Dense Bitumen Macadam Wearing Course**

1 This material to the nominal size of aggregate described in the Contract shall be made in accordance with the requirements of BS 4987: 1973. It shall be laid and compacted to Clause 705.

**Aggregate**

2 The coarse aggregate shall consist of crushed rock complying with the quality requirements of BS 4987:1973 and shall have a polished stone value not less than that described in the Contract. The fine aggregate may be crushed rock or sand or mixtures thereof, but the type shall be subject to the approval of the Engineer. The quality of the fine aggregate shall comply with the requirements of BS 4987: 1973.

**Binder**

3 The binder shall be petroleum bitumen of 100 pen or 200 pen, as described in the Contract, complying with the specification issued by the Department of the Environment.

**Composition of the Mixed Material**

4 On analysis of the freshly mixed material, its composition shall comply with that specified in Table 9/3, as described in the Contract.

**Temperature of Material**

5 Before coating the aggregate shall be surface dry. The macadam shall be mixed and delivered to the laying site within the range of temperatures given in Table 9/3, and at the time of rolling shall not be less than the temperatures specified in Table 9/3.

**Mixing**

6 The materials shall be accurately weighed and measured into a mechanical mixer of approved type and thoroughly mixed in such a manner that all particles of the aggregate are completely and uniformly coated. The weighing or measuring mechanisms shall at all times be maintained within the accuracies recommended by the manufacturer.

**905 Rolled Asphalt Wearing Course**

1 This material to the nominal size of aggregate, and course aggregate content described in the Contract shall be made in accordance with the requirements of BS 594: 1973 for recipe mixtures. In certain cases where it is shown that unsatisfactory asphalt is produced by the use of fine aggregate which fully complies with the requirements of BS 594:1973 the supplier shall with the agreement of the Engineer, determine the optimum binder content for that fine aggregate by the design method given in section 3 of BS 594: 1973. Where the design method is used the suppliers shall give the Engineer full details of the mix design for his approval, and shall verify either by the laying of a trial strip, or other means acceptable to the Engineer, that the mix proposed is satisfactory when manufactured, laid and compacted in the manner proposed for the Contract, before full scale works commence.

2 This material shall be laid and compacted to Clause 705.

**Aggregate**

3 The course aggregate shall consist of crushed rock or gravel complying with the quality and grading requirements of BS 594: 1973, and shall have a polished stone value not less than that described in the Contract. The fine aggregate may be crushed rock or sand or mixtures thereof, but the type shall be subject to the approval of the Engineer. The quality and grading of the fine aggregate shall comply with the requirements of BS 594: 1973.

**Binder**

4 The binder shall be petroleum bitumen of 50 pen grade complying with the requirements issued by the Department of the Environment.

<b>Table 9/3 Dense Wearing Course Macadam</b>		
<i>Nominal Size (mm)</i>	14 mm	10 mm
<i>Range of thickness of compacted course (mm)</i>	25-40	20-25
<i>Binder Grade</i>	200 pen or 100 pen	200 pen or 100 pen
<i>Binder Content: (percentage by mass of total mixture)</i>		
Crushed Rock Aggregate other than limestone	4.9 ± 0.5	5.1 ± 0.5
Crushed Rock Aggregate limestone	4.6 ± 0.5	5.0 ± 0.5
<i>Aggregate Grading: (percentage by mass passing)</i>		
BS Sieve Size 20 mm	100	
14 mm	95-100	100
10 mm	70-90	95-100
6.3 mm	45-65	55-75
3.35 mm	30-45	30-45
1.18 mm	15-30	15-30
75 µm	3-7	3-7
<i>Range of Temperatures</i>		
Binder Grade	200 pen	100 pen
Mixing temperature of Aggregate °C	100-120	120-140
Mixing temperature of Binder °C	110-150	130-165
Delivery temperature of Macadam °C	80-105	105-130
Minimum Rolling temperature °C	55	70

<b>Table 9/4 Rolled Asphalt Wearing Course (recipe method)</b>		
<i>Nominal Size (mm)</i>	20 mm	20 mm
<i>Range of thickness of compacted course (mm)</i>	35–50	35–50
<i>Coarse Aggregate Content (percentage by mass of total mixture)</i> Retained on a 2.36 mm BS Sieve	30 ± 5	*55 ± 5
<i>Content of Aggregate passing 75 μm BS Sieve (percentage by mass of total mixture)</i>		
Crushed Rock Aggregate	8.9 ± 1.5	5.4 ± 1.5
Gravel Aggregate	8.7 ± 1.5	—
<i>Binder Grade</i>	50 pen	50 pen
<i>Binder Content: (percentage by mass of total mixture)</i>		
Crushed Rock Aggregate	7.9 ± 0.6	5.9 ± 0.6
Gravel Aggregate	7.6 ± 0.6	—
<i>Range of temperatures</i>		
Mixing temperature of Aggregate °C	150–205	150–205
Mixing temperature of Binder °C	140–175	140–175
Delivery temperature of Asphalt °C	125–190	125–190
Minimum Rolling temperature °C	100	100
*Where a coarse aggregate content of 55 percent is specified only crushed rock coarse aggregate shall be used.		

<b>Table 9/5 Rolled Asphalt Wearing Course (design method)</b>		
Nominal Size (mm)	20 mm	20 mm
<i>Range of thickness of compacted course (mm)</i>	35-50	35-50
<i>Coarse Aggregate Content (percentage by mass of total mixture) Retained on a 2.36 mm BS sieve</i>	30 ± 5	*55 ± 5
<i>Content of Aggregate Passing 75 µm BS Sieve (percentage by mass of total mixture)</i>		
Crushed Rock Aggregate	9.0 ± 1.5	5.5 ± 1.5
Gravel Aggregate	9.0 ± 1.5	—
<i>Binder Grade</i>	50 pen	50 pen
<i>Binder Content (percentage by mass of total mixture)</i>	On analysis of the freshly mixed materials its nominal Binder Content shall be in accordance with the relevant course aggregate content and Optimum (soluble) binder content of fine aggregate/filler/binder mixture as set out in Table 13 for rock aggregate, and Table 14 for Gravel aggregate of BS 594: 1973, and within the tolerance of ± 0.6 percent.	
<i>Range of temperatures</i>		
Mixing temperature of Aggregate °C	150-205	150-205
Mixing temperature of Binder °C	140-175	140-175
Delivery temperature of Asphalt °C	125-190	125-190
Minimum Rolling temperature °C	100	100
*Where a coarse aggregate content of 55 percent is specified, only crushed rock coarse aggregate shall be used.		

**Filler**

5 Filler shall consist of crushed limestone or Portland cement or other material approved by the Engineer. The filler shall contain not less than 85 percent by mass of particles passing a 75  $\mu\text{m}$  BS test sieve when determined in accordance with BS 812. The bulk density in Toluene shall not be less than 0.5 g/ml and not more than 0.9 g/ml, when measured in accordance with BS 812.

**Composition of the Mixed Material**

6 On analysis of the freshly mixed material its composition shall comply with Table 9/4 for recipe method and Table 9/5 for design method as described in the Contract.

**Temperature of Material**

7 The coarse and fine aggregate shall be thoroughly dried, the asphalt shall be mixed and delivered to the laying site within the range of temperatures given in Table 9/4 or Table 9/5, and at the time of rolling shall not be less than the temperature specified in Table 9/4 or Table 9/5.

**Mixing**

8 The materials shall be accurately weighed or measured into a mechanical mixer of approved type and thoroughly mixed in such a manner that all particles of the aggregate are completely and uniformly coated. The weighing or measuring mechanisms shall at all times be maintained within the accuracies recommended by the manufacturer.

**Coated Chippings**

9 Coated chippings for rolling into the surface of rolled asphalt shall comply with Clause 907

**906 Asphaltic Concrete (Marshall Design Method)**

1 Asphaltic concrete shall be designed and manufactured in accordance with the recommendations of the Asphalt Institute, Asphalt Institute Building, College Park, Maryland 20740, U.S.A. It shall be laid and compacted to Clause 705.

**Aggregates**

2 The coarse aggregate shall consist of crushed rock or gravel complying with the quality requirements of BS 4987: 1973 and shall have the polished stone value and aggregate abrasion value described in the Contract. The fine aggregate may be crushed rock or sand or mixtures thereof, but the type shall be subject to the approval of the Engineer. The quality of the fine aggregate shall comply with the requirements of BS 4987: 1973.

**Fillers**

3 If filler is required it shall consist of crushed rock, Portland cement or other material approved by the Engineer. The quality of the filler shall comply with the requirements of BS 4987:1973.

**Binder**

4 The binder shall be petroleum bitumen of 100 pen grade complying with the specification issued by the Department of the Environment.

**Temperature of Material**

5 Before coating the aggregate shall be surface dry. The material shall be mixed and delivered to the laying site within the range of temperatures given in Table 9/6 and at the time of rolling shall be not less than the temperature specified in Table 9/6.

**Mixing**

6 The materials including any added filler shall be accurately weighed or measured into a mechanical mixer of approved type and thoroughly mixed in such a manner that all particles of the aggregate are completely and uniformly coated. The weighing or measuring mechanism shall at all times be maintained within the accuracies recommended by the manufacturer.

**Composition of Mixed Material**

7 The material, to the nominal size of aggregate described in the Contract, shall consist of an intimate mixture of coarse aggregate, fine aggregate, filler if necessary, and binder, combined in proportions by mass to lie within the limits set out in Table 9/6.

<b>Table 9/6 Asphaltic Concrete (Marshall Design Method)</b>				
<i>Nominal Size (mm)</i>	20 mm	14 mm	10 mm	6 mm
<i>Range of thickness of compacted course (mm)</i>	35-50	25-40	20-25	15-20
<i>Binder Grade</i>	100 pen	100 pen	100 pen	100 pen
<i>Binder Content (percentage by mass of total mixture)</i>	4-6	4-6.5	4.5-7	5-7.5
<i>Percentage of Voids in Mineral Aggregate (minimum)</i>	14	15	16	18
<i>Aggregate Grading: (*percentage by mass Passing)</i>				
BS Sieve Size	28* mm	100	—	—
	20 mm	80-100	100	100
	10 mm	50-80	70-90	80-100
	5 mm	40-65	50-75	55-80
	2.36 mm	30-46	35-55	40-60
	1.18 mm	20-35	25-40	30-45
	600 μm	15-30	15-30	20-35
	300 μm	10-20	10-20	15-25
	150 μm	5-15	5-15	5-15
	75 μm	3-8	4-9	4-9
<i>Range of temperatures</i>	<i>100 pen grade</i>			
Mixing temperature of Aggregate °C	120-140			
Mixing temperature of Binder °C	130-165			
Delivery temperature of Asphalt °C	105-130			
Minimum Rolling temperature °C	80			
*In addition to complying with the above grading envelopes at least 4 percent by mass shall be retained between any consecutive sieves.				

The mixture shall satisfy the following criteria when compacted and tested using the Marshall Method as specifically by the Asphalt Institute:

Number of compaction blows on each side of each specimen	50
Stability (minimum)	450 kgf
Flow	2-4 mm
Per cent air voids in mix	3-5 mm
Per cent voids in mineral aggregate	See Table 9/6

At least two weeks before laying is to commence, the Contractor shall submit details of the mixture he intends to use to the Engineer for approval. These details shall include the following information:

- (i) Grading curve (per cent by mass passing)
- (ii) Bitumen content (per cent of total mass)
- (iii) Composition of mixture (percentages of constituents)
- (iv) Mix design data curves showing Marshall stability, flow, unit weight, voids in mineral aggregate and voids in the mix for a range of different binder contents. The test data curves should show a well-defined optimum value, through tests made on triplicate specimens.
- (v) Temperatures of mixing and compaction of test specimens and temperature-viscosity relationship of the bitumen.

#### Acceptance of Plant Mixes

**8** Before full scale laying commences the Contractor shall prove to the Engineer by the laying of a preliminary trial length at a location approved by the Engineer that the asphaltic concrete he intends to supply complies with the specified requirements. For the trial the Contractor shall use the materials, mix proportions, mixing, laying, compaction plant and construction procedure that he proposes for the main work. The asphaltic concrete and its job-mix formula will be agreed after verification of the specified requirements, texture and appearance of coating at this trial.

#### Tolerance Limits

**9** Agreement will be reached between the contractor and the Engineer on the job-mix formula. On analysis of the freshly mixed material, its composition shall comply with the job tolerances specified in Table 9/7

**Table 9/7. Tolerances for Asphaltic Concrete Job-mix Formula**

BS Sieve Size	Job tolerance percent by mass
20 mm	± 6
10 mm	± 6
5 mm	± 6
2.36 mm	± 6
1.18 mm	± 6
600 μm	± 4
300 μm	± 4
150 μm	± 3
75 μm	± 1.5
Binder Content	± 0.5

#### Acceptance of Compaction

**10** Two samples of uncompacted asphaltic concrete shall be taken, either on Site or at the plant as directed by the Engineer, for each 200 tons of asphaltic concrete or part thereof laid each day and shall be compacted using the Marshall Method in a laboratory nominated by the Engineer.

In addition two cores shall be taken from the same batch of asphaltic concrete from which the uncompacted samples were taken. The cores shall be taken by the Contractor after the asphaltic concrete has been laid and fully compacted, using a suitable core-cutting machine. The Contractor shall make good the core-holes by cleaning them, painting the sides with bitumen and filling with compacted asphaltic concrete. The density of each core taken must not be less than 97 per cent of the density of the corresponding specimen compacted in the laboratory.

#### 907 Coated Chippings for Application to Pre-Mixed Surfacing

**1** The chippings shall comply with the requirements of Table 9/8. The grading of the chippings, as found on analysis, shall comply with the requirements of Table 9/9 for the nominal size described in the Contract.

**Table 9/8 Coated Chippings for Application to Pre-Mixed Surfacing—  
Aggregate requirements**

Values when tested in accordance with BS 812			
Category of Site	Aggregate Abrasion Value	Polished Stone Value	Flakiness Index
A. Difficult sites and roads carrying high-speed traffic	12 max	62 min	20 max
B. Other roads	12 max	59 min	25 max

**Table 9/9 Coated Chippings for Application to Pre-Mixed Surfacing—  
Grading Requirements**

BS Sieve	Nominal Size of Chippings	
	20 mm	14 mm
Percent by mass passing a BS 28 mm Sieve	100	100
Percent by mass passing a BS 28 mm Sieve retained on a BS 20 mm Sieve.	0-10	0
Percent by mass passing a BS 20 mm Sieve retained on a BS 14 mm Sieve.	80-100	0-10
Percent by mass passing a BS 14 mm Sieve retained on a BS 10 mm Sieve.	0-20	80-100
Percent by mass passing a 10 mm Sieve retained on a BS 6.3 mm Sieve	0-4	0-20
Percent by mass passing a 6.3 mm Sieve retained on a BS 5 mm Sieve.		0-4
Percent by mass passing a BS 2.36 mm Sieve	0-2	0-2
Percent by mass passing a BS 75 $\mu$ m Sieve	0-1.5	0-1.5

2 The binder shall be bitumen of 50 pen. grade complying with the specification issued by the Department of the Environment.

3 The chippings shall be completely coated with the specified binder at a rate found on analysis of  $1.5 \pm 0.3$  percent by weight. The analysis shall be carried out on chippings taken from the stockpile when their temperature is below 130°C.

4 The chippings shall be dried and fed into the mixer at a temperature of 130°C to 185°C. The binder shall be added at a temperature not exceeding 175°C and the temperature of the coated chippings on discharge from the mixer shall be in the range 130°C to 185°C. On discharge from the mixer the chippings shall be cooled quickly to ambient temperature by the application of clean water or by spreading out in a layer not exceeding 1 metre in thickness.

5 Coated chippings shall be tested as described in Clause 1807 and shall comply with one of the following requirements:

- (i) Not more than 7.5 percent of chippings shall fail the Solvent Test.
- (ii) The mass of sand retained in the Hot Sand Test shall be not less than 40 g/kg for 20 mm chippings or 50 g/kg for 14 mm chippings and not more than 7.5 percent of chippings shall fail the visual assessment of sand cover.

The test to be used shall be that required by the Engineer.

6 The coated chippings, before deposition into the spreading machine, shall be rendered free-flowing by watering or other means of loosening them.

#### Application of Chippings

7 Chippings of the nominal size described in the Contract shall be applied to rolled asphalt wearing course mixtures containing 30 percent of coarse aggregate. The rate of spread of the chippings shall comply with the requirements of Table 9/10 for the category of road described in the Contract.

#### 908 Surface Dressing

1 Surface dressing as described in the Contract, shall be carried out in accordance with the specification issued by the Department of the Environment.

#### 909 Bituminous Sprays

1 When it is necessary to prepare a surface for the application of a bituminous spray and to undertake the spraying and any specified blinding, this shall be done in accordance with the specification for surface dressing issued by the Department of the Environment in so far as it applies to the work to be undertaken in accordance with the undermentioned general requirements and any specified requirements as described in the Contract.

**Table 9/10 Rate of Spread of Coated Chippings in Rolled Asphalt Wearing Course Mixtures**

Category of Site	Rate of Spread (kg/m <sup>2</sup> )					
	20 mm nominal size chippings			14 mm nominal size chippings		
	Relative Density			Relative Density		
	2.6	2.7	2.8	2.6	2.7	2.8
A. Difficult sites and roads carrying high-speed traffic	11.0	11.5	12.0	8.5	9.0	9.5
B. Other roads	9.5	10.0	10.5	7.5	8.0	8.5

\*The tolerance on all these rates of spread is  $\pm 1$  kg/m<sup>2</sup>.



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the emulsion. The addition of a wetting agent to a cutback bitumen, or the use of an X-grade cutback bitumen, is unnecessary when coated chippings are used.

### 5.4 Sampling of aggregates

Recommendations on sampling of aggregates for determination of size and shape of chippings, and for determination of polished stone value, aggregate abrasion value and aggregate crushing value, are given in Appendix C.

## 6. Binders for Surface Dressing

The two types of binder used for surface dressings in Ireland at present are cutback bitumen and bitumen emulsion. Both may be regarded as modified penetration-grade bitumens. The factors determining the type of binder used and the choice of nominal viscosity grade are the traffic and weather conditions. It is important to note that binder viscosity increases in service due to a combination of evaporation and oxidation processes and chemical and physical reactions between bitumen constituents.

### 6.1 Cutback bitumen

A cutback bitumen is a penetration-grade bitumen diluted with an appropriate amount of a volatile solvent, usually kerosene. The addition of kerosene lowers the viscosity of the binder and thus facilitates wetting of the chippings. After application the kerosene solvent evaporates over a period of time with a resultant increase in viscosity of the binder.

Three viscosity grades of cutback bitumen are available: 50, 100 and 200 seconds. These binders must comply with the current specification issued by the Department of the Environment, which is given in Appendix D.

### 6.2 Bitumen emulsion

A bitumen emulsion is a stable suspension of minute bitumen droplets in water. It is manufactured by passing appropriate proportions of an emulsifying agent/water mixture and hot penetration-grade bitumen, cutback with a volatile solvent (5

per cent maximum), simultaneously through a colloid mill where the bitumen is drawn in thin films between a stator and high-speed rotor so that it forms small droplets in the continuous water medium. The purpose of the emulsifying agent is to prevent the bitumen droplets from coalescing prior to the application of the emulsion. The emulsifying agent is comprised of charged ions, and "like" electrical charges are imparted to the bitumen droplets, which afford a resistance to their coalescence. Emulsions may be either cationic or anionic; in cationic emulsions, which are used exclusively for surface dressing in Ireland, the bitumen droplets are positively charged. On spraying the emulsion, the interaction of the charged bitumen droplets with negative surface charges on the road surface and chippings, as well as the loss of water by evaporation, cause the emulsion to break.

Only cationic bitumen emulsions with a nominal bitumen content of seventy per cent are used for surface dressing in Ireland. They must comply with the current specification issued by the Department of the Environment, which is given in Appendix E.

### 6.3 Choice of binder type — cutback bitumen or bitumen emulsion

The relative merits of cutback bitumen and bitumen emulsion can be summarised as follows:

- (1) *Cutback bitumen* — The use of cutback bitumen and coated chippings enables rapid adhesion of chippings to binder to be achieved. High viscosity cutback bitumens (100 or 200 sec), in combination with pre-coated chippings, are most suitable for heavily trafficked roads and difficult sites, where a strong binder and immediate achievement of good adhesion are particularly necessary to ensure good resistance to displacement of chippings by traffic.
- (2) *Bitumen emulsion* — Surface dressings with cationic bitumen

emulsion are less susceptible to damage by rain during the period immediately after surface dressing. Development of adhesion between binder and chippings is less affected by damp chippings. The use of cationic bitumen emulsion can prolong the season within which satisfactory surface dressing can be carried out.

Bitumen emulsions are stored and sprayed at lower temperatures than cutback bitumen; this reduces energy requirements and the risk of fire in the handling and application of binders.

Bitumen emulsions contain considerably less volatile solvent than cutback bitumens, and thus result in a saving in the use of a scarce and expensive commodity.

When using emulsion it is necessary to ensure that it has completely broken before allowing traffic on the surface dressing. This can be a serious disadvantage on heavily trafficked roads.

### 6.3.1 Choice of viscosity grade of cutback bitumen

Upon application the viscosity of the binder, at the prevailing road temperature, must be such that adequate initial wetting of the chippings is achieved while affording sufficient resistance to chipping dislodgement under traffic. It has been suggested that the appropriate viscosity range is  $10^4$  to  $5 \times 10^5 \text{ mm}^2/\text{s}$  (centistokes)<sup>(5)</sup>.

Based on this assumption road surface

### Binders for Surface Dressing

temperature ranges are suggested in Table 7 for the various cutback bitumen grades.

As a general rule the highest viscosity grade possible should be used and it is advocated that in June, July and August the 100 second grade be used provided that the minimum air temperature (sunrise) expected on the day subsequent to surface dressing is not less than  $10^\circ\text{C}$ . It is particularly advisable to observe this requirement from mid-August onwards.

Other considerations may decide the choice of viscosity grade; for example, high viscosity binders are preferable for surface dressing on concrete or on areas of high surface stresses at roundabouts, steep hills and traffic intersections, etc. In these cases the work should be done only when road temperatures comply with the recommendations in Table 7. In addition it is suggested that the work should not be carried out if the minimum air temperatures expected in the period subsequent to construction are less than the following:

	Uncoated	Coated
50 Second grade	$6^\circ\text{C}$	$2^\circ\text{C}$
100 Second grade	$10^\circ\text{C}$	$6^\circ\text{C}$
200 Second grade	$14^\circ\text{C}$	$10^\circ\text{C}$

It is recommended that forecasts of minimum air temperatures for the period be obtained from the nearest meteorological station.

### 6.4 Use of adhesion agents

The importance of achieving adequate initial adhesion of chippings to the binder should never be underestimated. The use

**Table 7 Recommended ranges of road surface temperatures ( $^\circ\text{C}$ ) for cutback bitumen**

Viscosity Grade STV Seconds @ $40^\circ\text{C}$	Traffic: less than 200 c.v./lane/day			Traffic: more than 200 c.v./lane/day		
	Lower Temperature Limit		Upper Temperature Limit	Lower Temperature Limit		Upper Temperature Limit
	Uncoated Chippings	Coated Chippings		Uncoated Chippings	Coated Chippings	
50	18	8	47	24	14	42
100	22	12	52	29	19	46
200	31	21	59	37	27	55

# Appendix D

Department of the Environment Specification for Cutback Bitumen							
Grade of Cut-Back Bitumen Nominal Viscosity (S.T.V.) at 40°C		50 sec		100 sec		200 sec	
Property	Test Method	Specification					
		Min	Max	Min	Max	Min	Max
Viscosity (S.T.V.) at 40°C	I.P.72	40	60	80	120	160	240
Flash Point (Closed cup) °C	I.P.113	65	—	65	—	65	—
Distillation (% by volume) Distillate to 360°C	I.P.27	8	14	6	12	4	10
Tests on Residue from Distillation Penetration at 24°C (100 g 5 sec)	I.P.49	100	250	100	250	100	250
Solubility in trichloroethylene (% by mass)	I.P.47	99.5	—	99.5	—	99.5	—
Ash content (% by mass)	I.P.4	—	0.5	—	0.5	—	0.5

GENERAL. Cutback bitumen shall be composed of an intimate homogeneous mixture of bitumen and a suitable distillate. The bitumen used shall comply with the requirements for Penetration Grade Petroleum Bitumen and be within the grade range of 100 pen to 200 pen. The distillate shall be a volatile petroleum distillate or creosote. Cutback bitumen may also contain additives; such additives shall not exert any deleterious effect on the bitumen deposited. Cutback bitumen shall be substantially free from water, shall not separate when allowed to stand, and shall not foam when heated to permissible temperatures.

Where the supplier increases the adhesive properties of any grade of cutback bitumen by the addition of an optimum amount of adhesion agent, then that grade shall be suffixed by the letter 'X'. Cutback bitumen with an additive added shall be subject to the same requirements as specified for the normal grades.

Test methods shall be in accordance with "I.P. standards for petroleum and its products" current edition, published by the

Institute of Petroleum, or, where stated, in accordance with the 'Annual Book of A.S.T.M. STANDARDS' current edition, published by the American Society for Testing and Materials.

**Notes on the Purpose of the Specification Tests for Cutback Bitumen Viscosity (STV Seconds) at 40°C** Cutback bitumens are graded in terms of the efflux time from the standard tar viscometer (STV) at 40 seconds.

**Flash Point** Bitumens containing light cutting-back oils are extremely flammable at the high temperatures used to handle these liquids and there is a risk of ignition if care is not exercised. The flash point may be regarded as the minimum temperature at which the binder can be made to ignite under standardised conditions.

**Distillation** The rate of curing of cutback when sprayed on the road is dictated by temperature and weather conditions. These aside, the rate is primarily dictated by the amount and type of cutting-back oils used and to a much lesser extent, the grade of bitumen used. This part of the

Specification places limits on the amount of oil used and to some degree on the type of oil used.

***Tests on the Residue from the Distillation***

***Penetration*** This sets limits on the penetration of the bitumen and indicates the hardness of the bitumen remaining after the evaporation of the cutting-back oil.

***Solubility in Trichloroethylene*** This is used to ensure that excessive amounts of

## Appendices

carbon are not present. The presence of carbon would be indicative of excessive heating during the manufacture of the base bitumen which would in turn imply a reactive bitumen giving poor durability. The test will also indicate any foreign matter present.

***Ash Content*** This is used to determine the amount of any mineral matter present in the bitumen.

## Appendix E

Department of the Environment Specification for Cationic Bitumen Emulsion (70 per cent Bitumen Content)			
Grade of Cationic Road Emulsion (Binder content — nominal per cent by mass)		70%	
Property	Test Method	Specification Min.	Max.
Particle Charge Test	ASTM D 244 Sections 19-20	Positive	
Viscosity °Engler 20°C	I.P. 212	—	—
Viscosity Redwood No. II (seconds at 85°C or at spraying temperature)	BS 434: Part 1 Appendix F	25	35**
Storage Stability test — 1 day (per cent by mass)	ASTM D 244 Sections 56-62	—	1
Demulsibility 35 ml 0.8% sodium dioctyl sulphosuccinate % by mass	ASTM D 244* Sections 25-28	40	—
Sieve Test % by mass 85 micron sieve	ASTM D 244 Sections 38-41	—	0.10
Distillation	ASTM D 244		
Oil distillate by volume of emulsion %	Sections 8-10	—	3***
Residue % by mass	Sections 8-10	67	—
Test on Residue from Distillation Test			
Penetration at 25°C (100 g 5 sec)	I.P. 49	100	250***
Solubility in trichloroethylene % by mass	I.P. 47	99	—

\* Use 35 ml of 0.8% solution of sodium dioctyl sulphosuccinate in place of 35 ml of calcium chloride solution (0.02N) as described in the method.

\*\* Viscosity greater than 35 seconds can be used provided that the emulsion can meet the transverse distribution requirements of BS 1707 when spraying in hot binder distributors conforming to BS 1707.

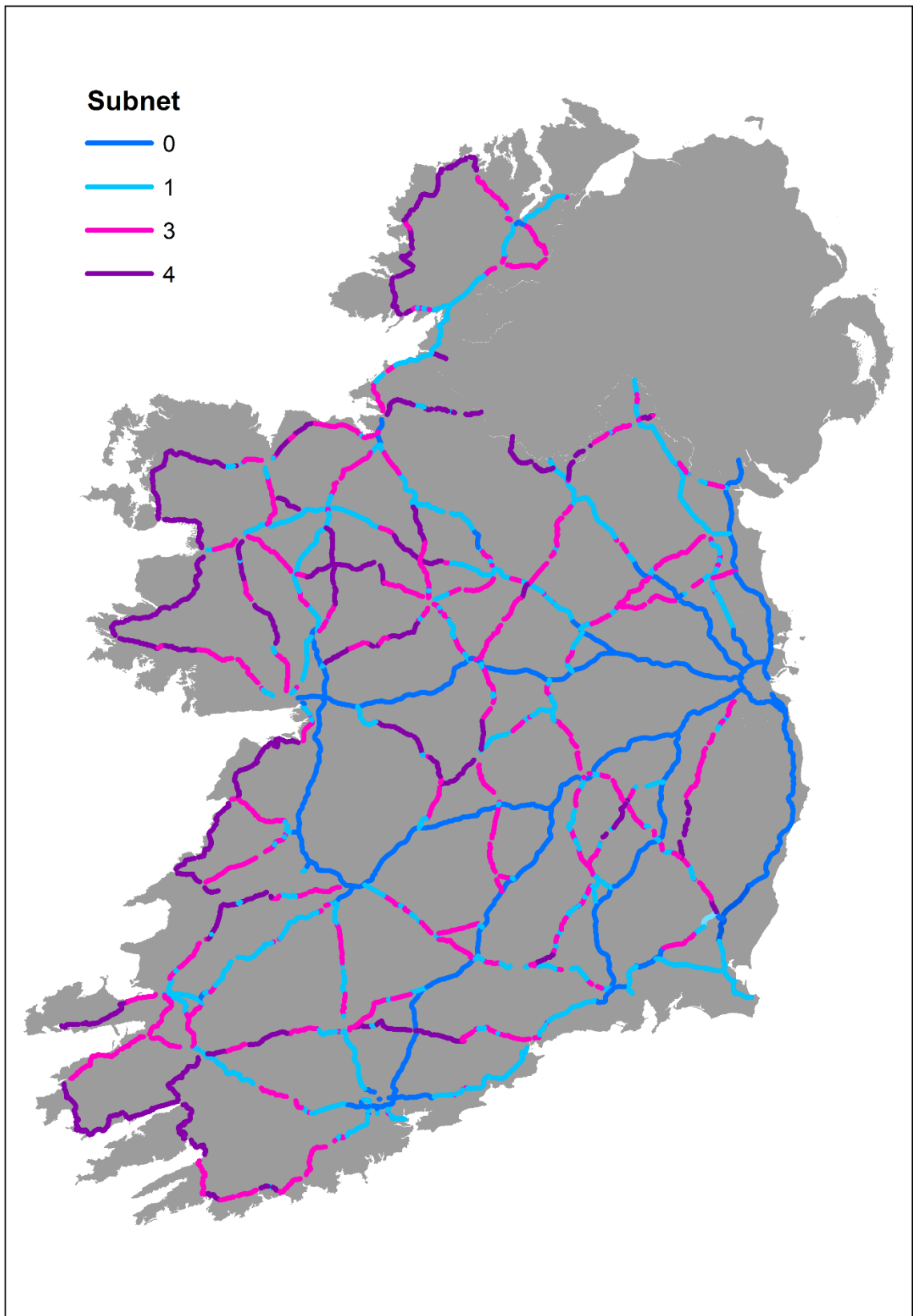
\*\*\* The oil distillate by volume of emulsion % may be increased to 5, and the penetration at 25°C (100 g 5 sec) of the residue from distillation increased to 300, when spraying is carried out between 1st October and 30th April.

GENERAL Cationic Bitumen Road Emulsions should be homogeneous at spraying temperatures. After static storage, when reheated to spraying temperatures and stirred the emulsion should be homogeneous and free from coagulation. The emulsifying agent should not exert any deleterious effect on the bitumen deposited and should be such that any drainage, washings or the like passing from the work into streams, ponds, rivers, etc. should not after dilution in water have any toxic effect upon plant, animals or fish life. The bitumen

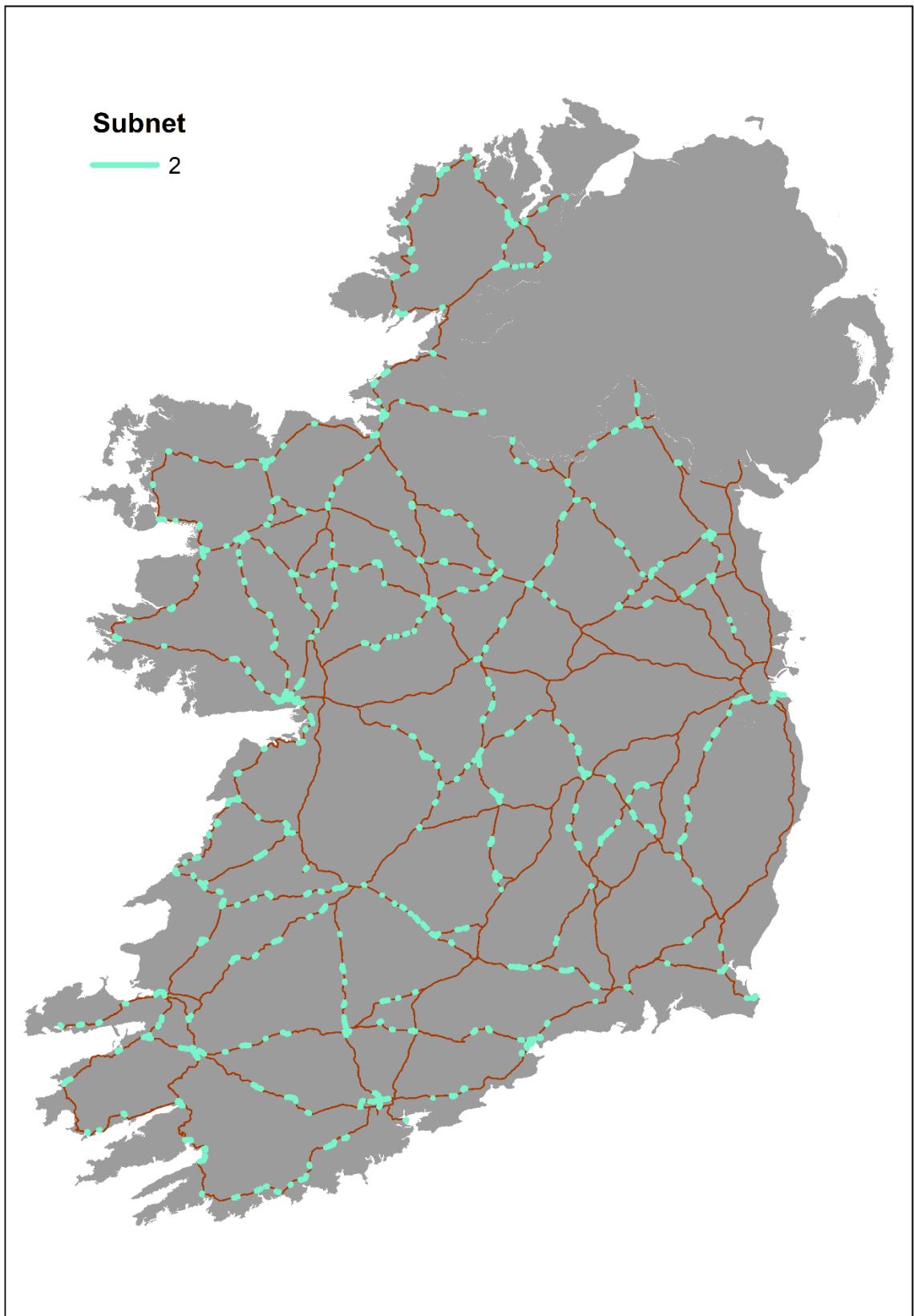
used in the emulsion should comply with the requirements for Penetration Grade Petroleum Bitumens and be within the grade range of 100 pen. to 200 pen.

Test methods will be in accordance with "I.P. standards for petroleum and its products" current edition, published by the Institute of Petroleum, or, where stated, in accordance with the "Annual Book of A.S.T.M. Standards" current edition, published by the American Society for Testing and Materials.

## **Appendix B:** Subnetwork Location Maps




Subnetworks 0, 1, 3 and 4



Subnetwork 2





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