Smart Motorways Programme

M4 Junctions 3 to 12

M4 DCO Re-Discharge of Requirement 14
Drainage Strategy Report

Section 2 Junctions 3 to 8/9

HA514451-CHHJ-HDG-SZ_ZZZZZZZZZZ-SP-ZZ-5302

September 2022

Arcadis Jacobs Report

P02

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Working on behalf of National Highways

REVISION SCHEDULE						
Rev	**Reason**	**Author**	**Checker**	**Technical Reviewer**	**Approver**	**Issue Date**
P01	Re-discharge Req 14	K Jutley	W LI	-	D Pilsworth	30/04/2021
P02	Re-discharge Req 14,Section 2	Rohit Asthana	Wendy Li	-David Pilsworth	David Pilsworth	September 2022

Contents

1 Introduction

The M4 Junctions 3 to J12 Smart Motorway Project is split into two sections: Section 1 is from Junctions 8/9 to 12 and Section 2 is from Junctions 3 to 8/9. This report is a subsequent update to the previously issued 2018 Discharge of Requirement 14 Drainage Strategy Report (DSR) and covers only Section 2 of the Scheme. Section 1 of the Scheme is covered in a separate DSR.

The original text of the made Development Consent Order (DCO) 2016 version of the DSR is reproduced in black text within this report. Updates which were made to the DSR at the 2018 Discharge of Requirement 14 are indicated in black text and outline box. Subsequent changes presented in this Section 2 2022 re-discharge proposal version of the DSR are indicated in blue text and outline box. Paragraphs within the 2018 DSR which were specific to Section 1 are not included in this Section 2 2022 DSR as they are part of the Section 1 DSR. Within this report, these deleted paragraphs have been replaced with text reading '*Deleted from this report and is part of the Section 1 DSR*'.

Made DCO (2016)

The original DSR formed part of the DCO for the M4 J3 to 12 Smart Motorway Project (document TR010019-002122, Volume 7.0, doc ref 7.5, dated January 2016).

The DCO commitments relating to surface water drainage, including reference to the DSR, is presented in Requirement 14 of Part 1, Schedule 2 of the M4 Motorway (Junctions 3 to 12) (Smart Motorway) Development Consent Order. This requirement is reproduced below:

> **Surface water drainage**
>
> **14.**—(1) No part of the authorised development is to commence until a surface and foul water drainage scheme has been submitted to and approved by the Secretary of State, following consultation with the relevant lead local flood authority and South East Water Limited. The surface and foul water drainage scheme must—
>
> (a) include a survey of the existing drainage system in the Order land to identify areas affected by the works where repair or replacement of existing drainage infrastructure is required; and
>
> (b) reflect the mitigation measures in the drainage strategy report (Application Document Reference No. 7.5) and include means of pollution control.
>
> (2) The surface and foul water drainage system must be constructed in accordance with the approved surface and foul water drainage scheme.

The Secretary of State for Transport granted the DCO for the Scheme on 2 September 2016.

2018 Discharge of DCO Requirement 14

A revised version of the DSR was issued to stakeholders on 22 December 2017 (document HA514451-CHHJ-HDG-SZ_ZZZZZZZZZZ-SP-ZZ-5300) as part of the consultations for the Discharge of DCO Requirement 14. This version of the DSR informed stakeholders of the drainage proposals developed during detailed design so that Requirement 14 could be discharged.

Following consultations with stakeholders, the Discharge of Requirement 14 was confirmed by the Secretary of State for Transport on 22 May 2018.

2022 Re-discharge Proposals

The surface and foul water drainage scheme that formed the 2018 discharged Requirement 14 application was based upon the design at the time, however a re-discharge application is now presented to incorporate the further design development undertaken during the construction phase, to date including:

- Further surveys of existing drainage and topographical surveys to provide accurate positions and heights of existing highway features and boundaries that were not available until full site clearance was carried out.
- Re-use of the existing filter drain in the central reserve of balanced carriageway sections.
- Removal of retaining walls resulting in more earthwork slopes encroaching into ditches and resulting in more piped ditches.
- Rationalisation and relocation of localised verge widening (blips) following review of gantries, lighting and ITS equipment.
- Validation of statutory undertakers' apparatus locations and C4 notices (detailed estimates) received from the Utility companies. This information enabled the proposals to be adjusted to avoid or reduce the impact on the statutory undertakers' apparatus by altering foundation details, realigning retaining walls, or moving gantry bases and therefore revising the drainage design.
- Changes to construction materials, such as a revised slot drain profile has been adopted which enables its use in the central reserve as well as the verge. As a result, the maximum slot drain outlet spacings in the central reserve has increased to 160m, with intermediate maintenance access points at 40m intervals.
- Surface water channels replaced with slot drains.
- Changes to construction details, such as piped ditches, slot drain outlet chambers, combined carrier and filter drain pipe sizes. These changes resulted in modifications to the spacing of chambers, quantities of pipes and overall drainage layouts.
- Revision to hydraulic design parameters, such as pipe roughness coefficients which changed pipe sizes at some locations.

This report includes schematic plans of the proposed 2022 re-discharge drainage strategy in Appendix A. These drawings show two viewports providing a comparison with the 2018 Discharge of Requirement 14 drainage strategy. Records of existing drainage from drainage surveys are provided in Appendix B. These existing drainage drawings have not been revised since the 2018 Discharge of Requirement 14. The other Annexes referred to in the made DCO version of the DSR are not amended and reference to the original 2016 DSR should be made for these.

The discharge plans have also been updated in respect of outfalls to reflect the amended design and additional baseline surveys that were carried out to inform it. As such, some of the outfalls on the plans have been removed (to reflect that the existing outfalls are not present, or that previously proposed outfalls are not now being brought forward); added (to reflect additional outfalls that have been confirmed during the additional surveys); have a revised location; or have been renamed; as set out in the table below:

Outfalls removed	O38A, O38B, O43A, O43B, O51A, O51C, O52C, O58A, O58B, O58C, O58E, O59E, O70B, O70C
Outfalls added	O59M, O63B, O71D
Outfalls renamed	043F
Outfall locations revised	O46D, O51B, O51D, O53A, O53B, O58D, O59A, O59G, O59H, O59K, O61C, O61D, O61E, O65A, O68A, O68B, O70A, O72A, O73A, O74C

These revised proposals reflect the mitigation measures set out in the original DSR:

- as per the Water Framework Directive, to protect water resources and promote sustainable water use;
- that the Scheme will not produce additional discharge in flow rate or volume at existing outfalls;
- 20% allowance for climate change for additional paved areas;
- no net increase in discharge;
- runoff volumes and peak flow rates of surface water leaving the site are no greater than the rates prior to the proposed Scheme; and
- prevention of pollution to the water environment to ensure that existing water quality is maintained.

It is noted that there is no change in impact on risk to groundwater or accidental spillage risk as a result of the revised drainage proposals presented in the DSR report.

As such, in relation to the provisions of Requirements 14 and 27(3)(c), it is confirmed that the re-discharge proposals reflect the mitigation measures in the original DSR and they do not give rise to any new or materially worse environmental effects in comparison with those reported in the Environmental Statement.

1.1 Overview

1.1.1 The Highways Agency submitted an application[1] ("Application") for development consent to improve the M4 motorway ("M4") to a smart motorway between junction 12 (Theale), which is near Reading, and junction 3 (Hayes), in west London (the "Scheme") as shown on Figure 1 below.

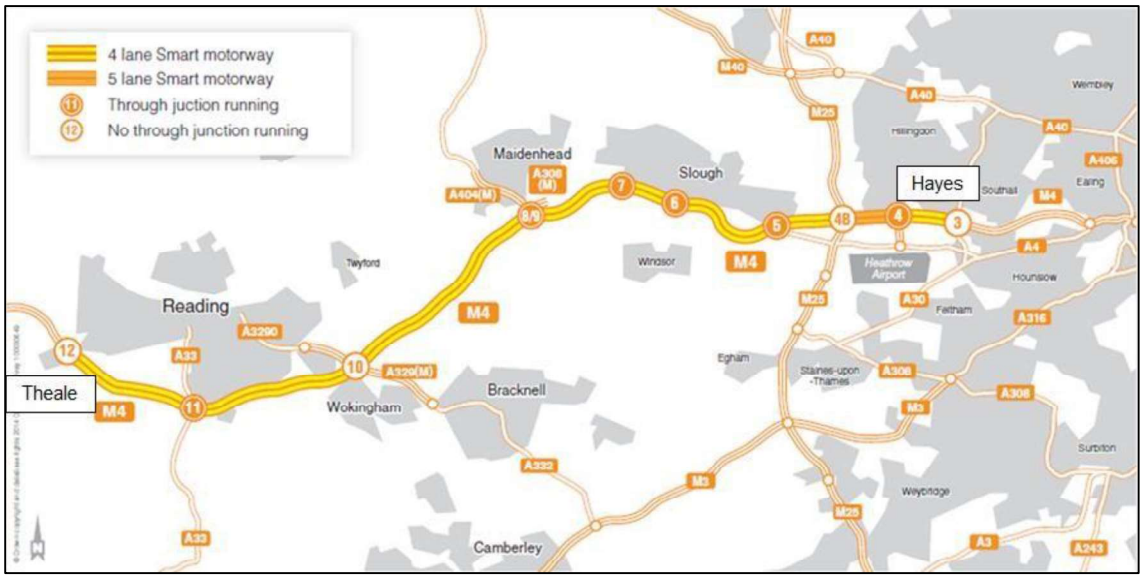


Figure 1: Scheme location plan

1.2 Drainage strategy concept

1.2.1 A Drainage Strategy was submitted as part of the DCO Application. The 2018 discharged DSR document is an updated Drainage Strategy Report (the "Strategy"), which is provided to address items raised during the Examination of the Application regarding the drainage proposals relating to the Scheme. This 2022 re-discharge proposal DSR document is a subsequent update to the Strategy.

1.2.2 The Strategy has been developed to guide the design of the drainage elements which will manage surface water runoff generated by the Scheme. The Strategy outlines suitable mitigation measures to manage additional runoff when:

a) impermeable areas are increased as a result of widening of the carriageway and creation of emergency areas ("EAs", previously referred to as emergency refuge areas, ERAs) and;

b) the catchment area of the existing drainage systems change (i.e. where the existing hard shoulder slopes in the opposite direction to the carriageway camber and this is amended as part of the proposed Scheme to slope towards the carriageway).

[1] The application was made on 31 March 2015 and was submitted by the then Highways Agency. The powers and duties of the agency now reside with National Highways, which is the statutory successor to the Highways Agency.

1.2.3 The Strategy has been prepared in accordance with the best practice documents listed below:

a) Agency Interim Advice Note ("IAN") 161/13. "Managed Motorways, All Lane Running", which sets out the design parameters and the associated infrastructure and technology requirements for the scheme;

b) Design Manual for Roads and Bridges ("DMRB") Volume 4 (Section 2) Part 3 (HD33/06 Surface and Sub-surface Drainage Systems for Highways) (Highways Agency, 2006) and in accordance with government policy on the use of Sustainable Drainage Systems ("SuDS");

c) the National Networks National Policy Statement ("NN NPS"), provides guidance for promoters of nationally significant infrastructure projects on the road and rail networks, and the basis for the examination by the Examining Authority and decisions by the Secretary of State. In line with the strategic objectives set out in the NN NPS, one of the Scheme's objectives is to deliver environmental improvements and mitigation where appropriate and required; and

d) The Water Framework Directive ("WFD") that was given effect in England by the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 SI 2003/2901. This report has been compiled to promote the fundamental principle of the WFD to protect water resources and to promote sustainable water use.

1.2.4 The criteria set out below were used in preparing the Strategy:

a) design edge of pavement pipe size to contain a 1:1 year storm without the pipe crown being surcharged;

Hydraulic modelling was carried out in Detailed Design to ensure that pipes have sufficient capacity for the 1:1 year storm event

b) design drainage systems serving additional paved areas to only allow surcharge within the drainage system, avoiding flooding the carriageway of the motorway, during a 1:5 year return period storm event (inclusive of 20% increase in peak rainstorm intensity to take account of climate change);

Hydraulic modelling was carried out at every catchment where paved areas have increased with checks for no flooding on the carriageway for the 1:5 year storm event. A 20% allowance for climate change was applied to extra paved areas only in accordance with Section 3.1.4 of this report.

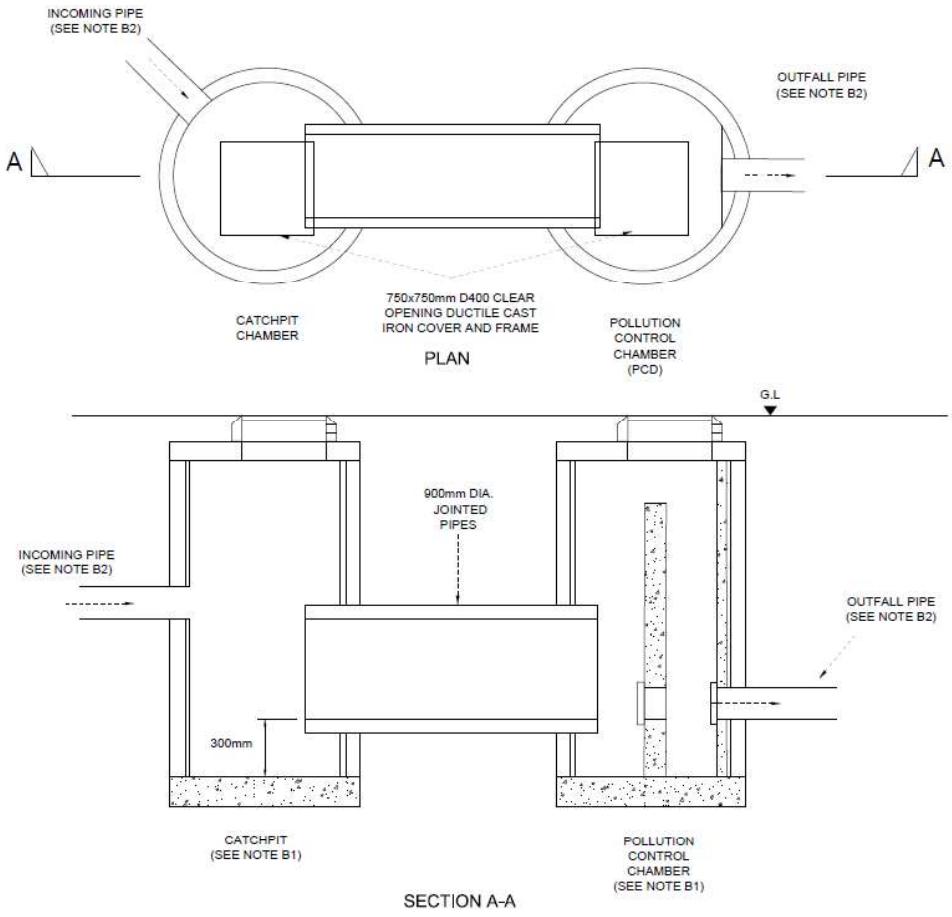
c) ensure that the road cross section will normally contain storm water in the event of a 1:100 year event (6 hour storm) without spilling onto adjacent land. Hydraulic calculations are based upon the Flood Estimation Handbook method, published by the Centre for Ecology and Hydrology (CEH, 1999). Standard road cross

sections are as depicted in National Highways Construction Drawings – B Series drawings;

Hydraulic modelling was carried out at every outfall with checks for no flooding on adjacent land for the 1:100 year storm event

d) appropriate spillage control measures will be included in the EA design. Guidance is set out in HD33/06;

Spillage containment facilities consisting of a shut-off device and a 900mm diameter pipe capable of holding 5 m³ of liquid are provided at every EA as indicated in the schematic below



B ERA POLLUTION CONTROL DETAIL
1. CHAMBERS TO BE AS INDICATED IN THE SCHEDULES OF THE 500 SERIES SPECIFICATION
2. ORIFICE PLATE DIAMETER, INCOMING PIPES AND OUTFALL PIPE SHALL BE AS DETAILED IN THE 500 SERIES SPECIFICATION SCHEDULES.

At some locations where levels are constrained, pipes smaller than 900mm diameter will be used to provide the containment volume of 5 m³

e) no nett additional discharge from the Scheme. In other words, existing outfalls will continue to discharge water at existing, established rates. This is limited by the diameter of the existing outfall pipe and therefore represents no change to the current situation. Where necessary, the Scheme will introduce additional

positive drainage within the existing system for the purpose of carrying additional water generated from the additional impermeable areas. Flow attenuation measures in the form of oversized pipes, chambers and soakaways (which all represent forms of SuDS) will also be incorporated to ensure discharge rates and volumes at existing outfalls are not worsened (i.e. increased) relative to the existing situation. It is considered that currently there is no need for any additional outfalls;

Flow control / attenuation in verges and the central reserve will be provided by orifice plates and oversized pipes in downstream chambers which will accommodate the peak volumes predicted in the hydraulic modelling. Flow control in ditches will be provided by v-notch weirs which will enable them to be used to attenuate the peak volumes encountered in the hydraulic modelling No additional outfalls have been identified.

f) Where minor pavement area increases are required, for example, by creating the EAs and the additional paved area associated with the central reservation, attenuation is required to ensure existing discharge rates and volumes are not increased. The design will be in accordance with the National Planning Policy Framework.

1.3 Scheme and associated drainage details

Scheme details

1.3.1 The M4 is the main strategic route between London and the West of England and Wales, connecting with the M25 and Heathrow Airport. Major towns and cities along the M4 include London, Reading, Swindon, Bristol, Newport, Cardiff and Swansea.

1.3.2 The Scheme is approximately 51km (32 miles) in length from junction 12 (Theale) to junction 3 (Hayes).

1.3.3 The M4 between junctions 12 and 3 carries over 130,000 vehicles per day, and more in places. At peak times, traffic flows on many links are close to or exceed the total flow that the link is designed to handle and traffic on the M4 therefore suffers from heavy congestion, which leads to unpredictable journey times. Traffic flows are forecast to increase to an average of 160,000 vehicles per day over the next 20 years, which will result in more severe congestion without road improvements.

1.3.4 The Scheme will help relieve congestion by permanently converting the hard shoulder to a running lane and using technology to vary speed limits and manage traffic. Signs and signals will be used to inform drivers of conditions on the highway network, when and where variable speed limits are in place, and when lanes are closed.

1.3.5 The current design is for 15 EAs between Junctions 3 to 8/9 up to 2.5km apart and measuring 100m long and a minimum of 4.6m wide as indicated in 5.36 of IAN

161/13, with the exception of EA reference E1-B1, which is 4m wide. These EAs would be built within the highway boundary.

1.3.6 Operation of the Smart Motorway will be controlled via gantry mounted Light-Emitting Diode ("LED") signs.

1.3.7 New drainage systems will be required in the central reserve and the verges where appropriate. Drainage in the central reserve will largely be replaced with linear drains in sloped/cambered sections of carriageway.

1.3.8 In the verge, it is proposed to replace the existing kerb and gully system with linear drains and combined kerb and gully systems where appropriate. Verges are typically 1.5-2m wide. On that basis, it is likely that there will be a requirement to provide a bound surface above filter drains to prevent stone scatter. Therefore, an alternative surface water collection system (i.e. surface water channel or slot drain) will be required. These slot drains provide additional storage capacity compared to the existing kerb and gully system and therefore provide greater attenuation for runoff compared to the existing drainage infrastructure.

Filter drains are proposed where the hardstrip is at least 0.5m wide. The detail is in accordance with the Highway Construction Details and involves a minimum 0.5m wide compacted sub-base between the filter media and edge of hardstrip.

Filter drains have also been provided where the hardstrip width is 0.3m. The loose stone is to be at least 1.0m away from the running carriageway in accordance with section 11.1 of IAN 161/13.

1.3.9 Non-coplanar lengths of hard shoulder (areas of existing hard shoulder that currently slopes in the opposite direction to the carriageway) will be changed to slope in the same direction as carriageway camber. In these areas modelling of the existing drainage system will be undertaken to confirm the extent of any upgrade requirements.

1.3.10 At EAs, discharge rates will be restricted by flow controls and spillage control devices will also be provided. The additional volumes of runoff generated from new paved areas are to discharge, by soil infiltration, into underlying soils or additional attenuation provided in the form of oversized kerb units; pipes and/or manhole chambers, all of which represent SuDS techniques that are suitable for Smart motorway Schemes. Attenuation will discharge at 2 litres per second per hectare, during a 6 hour storm event (in accordance with Section 3-7 of the CIRIA (Construction Industry Research and Information Association) C697 SuDS (Sustainable Drainage System) Manual). These mitigation measures minimise the impact of flood risk following development of the Scheme.

1.3.11 Using available design information shown on the General Arrangement drawings (see Annex F1 of the Engineering Design Report, in Document Reference 7.4), Google Maps and LiDAR data of the existing carriageway, the total increase in impermeable area as a result of widening, creation of EAs and construction of the Reinforced Concrete Barrier ("RCB") is estimated to be 12.8ha. This represents

approximately 2.34% of the estimated total Scheme area of 547ha (excluding the central reserve area between chainage 14460 to 15790 where the motorway splits).

Level of design

1.3.12 Between junctions 12 and 3, indicative drainage layouts were developed at least as far as an indicative design, without completing gradient analysis or pipe network modelling or drainage schedules.

1.3.13 Between junctions 12 and 8/9, a more comprehensive drainage design has been undertaken by calculating gradients for linear drains, pipe network modelling and producing drainage schedules using data from the Highways Agency Drainage Data Management System ("HADDMS") which continue to be maintained by National Highways.

Drainage solutions have been developed using survey and proposed highway alignment information. The proposed drainage strategy drawings are shown in Appendix A.

The drainage proposals include of the following:

- Slot drain in verges and central reserve
- Surface water channel in verges
- Filter drain in verges
- Combined kerb drainage kerbs in verges
- Flow control and attenuation pipes in verges and central reserve
- Flow control and attenuation in ditches
- Piped ditches

The proposed drainage strategy drawings for the 2022 re-discharge proposal are provided in Appendix A. These drawings show design development during construction and incorporate the following principal changes to drainage since the 2018 Discharge of Requirement 14.

- The slot drain profile has been changed which allows the same unit to be used in the verges and central reserve. This enables the outlet spacing in the central reserve to be increased.
- Use of filter drains in verges has been increased to include locations with a 0.3m hardstrip width where a 1m buffer zone to the loose stone can be provided.
- Separate pipes for filter drains and carrier drains have been combined to a single, larger pipe in one trench, which has reduced verge widening at some locations.
- Sub-surface drainage in the central reserve of balanced carriageway sections will be provided by re-use of the existing filter drain instead of providing new narrow filter drains/fin drains.

- Removal of retaining walls resulting in more earthworks slopes encroaching into ditches and more piped ditches.

Water quality

1.3.14 Spillage risk following the Scheme will be confirmed during the detailed design phase of the Scheme, as it is not appropriate to carry out an assessment of spillage risk before the design has been finalised. However, a worst case scenario appraisal has been carried out and where the more detailed spillage risk appraisal indicates that a significant modification of the drainage system is required, a further Highways Agency Water Risk Assessment Tool ("HAWRAT") assessment will be undertaken for all outfalls within the Scheme boundary.

1.3.15 When considering mitigation of potential impacts to surface waters using the HAWRAT, particular attention will be paid to paragraphs A.19 to A.21 of HAWRAT regarding the interpretation of required treatment, dilution (flow attenuation) and sediment removal.

1.3.16 The Scheme is to include additional pollution control measures to augment existing systems within the Scheme Order limits, providing enhancements within the Scheme. Pollution control enhancement measures will be tailored to site specific soil and topographical conditions and in accordance with the space available within the Order limits. The measures could be either active or passive in operation, and may include:

a) active systems (which require intervention by operators): penstocks, valves, notched weirs; downstream defenders, and

b) passive systems such as silt traps, filter drains, soakaways and oil separators.

As part of Detailed Design, HD45/09 assessments incorporating HAWRAT (risk assessment on surface watercourses), groundwater risk assessments and accidental spillage risk assessments were carried out at all outfalls.

The drainage proposals include the use of flow control weirs in ditches which have the benefit of encouraging sedimentation as well as biological / chemical processes to remove soluble metal pollutants such as dissolved zinc and copper. This is a form of pollution treatment passive system.

The water quality assessment work indicates that the drainage proposals provide mitigation against the risk of contamination of surface watercourses from routine run-off so additional pollution control measures are not needed at the existing outfalls.

The accidental spillage risk assessments indicate that the risk level is acceptable and no further spillage containment measures are necessary at existing outfalls. Accidental spillage measures are provided at all EAs as described in 1.2.4 d).

The groundwater risk assessments have concluded that the ditches over the Bray Gravels Source Protection Zone at the Thames (at Bray) are potentially at risk of groundwater contamination. The ditches need to be lined to protect the groundwater at this location but 2017 survey information has indicated that they are already partly

lined. The extents and condition of the existing lining is to be investigated further and mitigation proposals will include for the repair / replacement or extension of the existing lining. Some of the existing ditches have been replaced with flood plain compensation area ditches which are proposed to be lined channels. In other locations within the Source Protection Zone, the ditches are already lined. The remaining sections will be lined.

The HD45 Water Quality Assessment report has been completed (document HA514451-CHHJ-HDG-SZ_ZZZZZZZZZZ_Z-RP-CD-5110) as part of the Detailed Design work in 2017.

The HD45 Water Quality Assessment report has been updated to reflect the revised drainage proposals (document HA514451-CHHJ-HDG-SZ_ZZZZZZZZZZ_Z-RP-CD-5130 for Section 2 2022 assessments).

The HD45 water quality assessments demonstrated that long-term, statutory water quality standards defined by the Environmental Quality Standards (EQS) for dissolved copper and zinc are met. In some instances, this was achieved after performing metal bioavailability assessments for copper and zinc which revised the default threshold limits to consider the naturally occurring concentrations found in the watercourses. The bioavailability assessments are part of the HD45 process and were carried out using the Bioavailability Assessment Tool (BAT) from the UK Technical Advisory Group (UK TAG).

The HAWRAT assessments indicated exceedances at some outfalls for short-term impacts defined by runoff specific thresholds (RSTs) for dissolved copper and zinc. These RSTs are set by National Highways in agreement with the Environment Agency and are not part of the statutory requirements to meet water quality standards which are defined by the EQSs. The HAWRAT assessments also calculate the amount of settlement needed to reduce the volume of sediment to an acceptable level and some outfalls were predicted to exceed the calculated settlement requirements. Assessment of sediment bound contaminants is part of the HAWRAT calculation and like RSTs, this is not part of the statutory water quality standards (EQSs).

As noted in 1.3.15, the guidance in HD45 paragraphs A.19 to A.21 has been considered when determining mitigation requirements, in particular, paragraph A.20 which states that the drainage proposals should try to achieve compliance with both RSTs and EQSs but at locations where this is difficult, then the design should at least be sufficient to comply with EQSs. In accordance with Table 5.2 of the design standard, the results of the HAWRAT (RSTs and sediment) assessments and EQS assessments have been considered in conjunction with the following factors:

- **Impact of RST exceedances on ditches**. Assessment of the ecological importance of the highway ditches was identified from the 2017 walkover ecological surveys (aquatic review). Ongoing ecological site supervision, which has been in progress across the Scheme since 2017, has not identified any

additional protected or notable species within the ditches that would be at risk of exceedances of RSTs.

- **Scheme Order Limits.** As noted in 1.3.16, there are constraints on land available within the Scheme limits to provide enhanced mitigation measures such as wetlands and swales/grassed channels in verges. Another method of improving compliance with RSTs and sedimentation is to limit the discharge rates by provision of flow attenuation measures which will improve the dilution of contaminants in the receiving watercourse. Attenuation ditches with v-notch weirs and oversized pipes with orifice plates are provided as part of the commitment not to exceed existing discharge rates. It was not possible to restrict flows any further within the Scheme order limits with additional storage structures to improve dilution rates.
- **Water Framework Directive (WFD) Classification.** The ordinary watercourses receiving highway runoff are highway ditches which are not naturally formed waterbodies. None of the locations where there were exceedances of RSTs are at WFD defined watercourses.

After consideration of the three factors described above, and in accordance with the procedures described in HD45 (Table 5.2 and A.19 to A.21), meaning that further treatment, dilution (flow attenuation) and sediment removal processes are not possible to provide. Therefore, a review of the impact of run-off on the affected surface watercourses was carried out. This review considers the WFD classification of the receiving watercourse and considers the impact of run-off on aquatic life in these watercourses. From this review, it is concluded that many of the receiving watercourses are unnamed streams or ditches and none of the surface water receptors that were subject to Step 3 HAWRAT / further assessment are WFD classified. The distance from the highway drainage outfall at the watercourse to the first downstream WFD watercourse ranges from a few hundred metres to several kilometres. On this basis, the effects of the calculated RST exceedances for copper and zinc on the water environment is likely to be low. Also, compliance with EQS requirements have been met for all the outfalls. It is concluded from the HAWRAT and EQS assessments that no additional mitigation works are proposed to address the predicted short-term exceedances of RSTs and settlement requirements from routine runoff at some outfalls.

The HD45 water quality assessment also includes methods to determine impacts from routine runoff on groundwater and impact from spillages. The revised drainage proposals presented in this report did not change the design parameters used in the 2017 assessments for these additional assessment methods. Therefore, there is no additional impact on risk to groundwater or accidental spillage risk as a result and no further mitigation measures are necessary to address impacts of changes to these.

Maintenance

1.3.17 Between junctions 12 and 4b, regular maintenance of the existing and proposed drainage system will be undertaken, by the Asset Support Contract (“ASC”), using the outcome based approach to maintenance based on Asset Maintenance and Operational Requirements ("AMOR") and the Technology Maintenance Management Manual ("TMMM"). Between junctions 4b and 3, regular maintenance is undertaken, by the Design Build Finance Operate (“DBFO”) contract, in accordance with the Network Management Manual (“NMM”) and Routine and Winter Service Code (“RWSC”). The maintenance regime will need to take into account the nature of the proposed linear drains and combined kerb drainage systems within the Scheme. The maintenance regime may be changed from time to time, but the Scheme can be anticipated to be maintained in accordance with standards applicable to special road and motorways.

1.3.18 National Highways will also ensure that the enhancement or remediation measures, identified by CCTV surveys of the existing drainage system during the detailed design phase, and secured as part of the Scheme (including replacement or relocation of carrier drains and chambers and provision of pollution control measures) and which are required to ensure the existing drainage system functions correctly during storm events, will be completed during the construction phase of the Scheme.

A CCTV drainage survey of existing drainage in the verges was carried out in 2016 and the updated existing drainage drawings are provided in Appendix B.

Where existing pipes can be retained, their condition has been reviewed from the drainage survey. Remediation measures required to address pipe defects are proposed in Detailed Design and are indicated in Appendix A.

The retention of existing pipes was confirmed as part of the Detailed Design hydraulic modelling which considers their capacity to accommodate the increased flow due to additional paved areas.

All existing drainage in the central reserve is to be replaced as it will be difficult to retain and protect it from damage whilst the central reserve works for paving, lighting and concrete barrier take place. The condition of existing drainage is also expected to be poor due to existing steel safety barrier posts located over it.

The existing filter drain in the central reserve is to be replaced with a slot drain and carrier drain and attenuation provided where necessary. Existing cross drains are to be retained where possible.

According to information obtained from survey records held on National Highways Drainage Data Management System (DDMS), the central reserve’s existing drainage has been found to be at a depth that can be protected whilst the construction works for paving, lighting and concrete barrier are being carried out. To increase sustainability and minimise new construction work, it is designed to maintain and utilise the existing filter drain for sub-surface drainage at some locations of section 2 with in central

reserve of balanced carriageway sections rather of constructing new, narrow filter drains or fin drains. The proposed drainage strategy drawings in Appendix A show this retained drainage. The existing drainage assets in central reserve are not shown on existing drainage drawings (Appendix B) as these drawings incorporate the 2016 drainage survey which captured only the existing verge drainage and the cross carriageway drains between the verge and central reserve drainage.

Ditches

1.3.19 Existing ditches that are affected by the widening works comprised within the Scheme are to be re-aligned or hydraulically connected to upstream and downstream ditches using pipe culverts where required.

As part of the works, existing ditches will be cleared and cleaned so that they can be restored to their original capacity. Ditches will also be used for flow control and attenuation where this is feasible.

Due to DCO land constraints, it was not possible to realign all ditches so hydraulic connections are proposed. Locations of piped ditches based on the earthworks proposals and ground survey information are shown in the drawings in Appendix A.

1.3.20 The Scheme's proposed works will not culvert, divert or re-align Frog's Ditch (see Sheet 59 of the General Arrangement drawings, Annex F1 of the Engineering Design Report, in Document Reference 7.4), which is crossed by the M4 motorway near to Junction 3. Engineering options are currently being explored by National Highways. Options include a possible cantilever slab over part of the ditch or the construction of a gabion type retaining wall (approximately 1m in height) or similar solution. During the detailed design phase of the Scheme the final solution will be designed and approval sought pursuant to the requirements attached to the Development Consent Order.

As part of further design development during construction, proposals along the Frog's Ditch area consist of horizontal realignment of the eastbound carriageway to provide sufficient room in the westbound carriageway to accommodate the new EA without impacting the existing Frog's Ditch channel.

Runoff volumes

1.3.21 NN NPS paragraph 5.113 states: *"The surface water drainage arrangements for any project should be such that the volumes and peak flow rates of surface water leaving the site are no greater than the rates prior to the proposed project, unless specific off-site arrangements are made and result in the same nett effect"*.

1.3.22 The Scheme is expected to increase the volume of surface water runoff entering the drainage system, due to an increase in road pavement area (as indicated in 1.3.10 above), if not mitigated. Mitigation will therefore be incorporated within the Scheme's drainage system, by designing attenuation to largely mimic/replicate the surface water runoff response of the existing highway drainage catchment area to ensure no nett additional discharge flow or volume increase in the existing surface water runoff from the Scheme.

1.3.23 Using a sample drainage system, the hydraulic assessment, as discussed in section 3.4 of this report, shows how additional volumes generated by additional paved areas would be managed within the Scheme.

Flow control / attenuation in verges and the central reserve will be provided by orifice plates and oversized pipes in downstream chambers which will accommodate the peak volumes predicted in the hydraulic modelling. Flow control will be provided by v-notch weirs which will enable the existing ditches to be used to attenuate the peak volumes encountered in the hydraulic modelling.

Outfalls

1.3.24 The outfalls provided in the new drainage systems designed for the Scheme will include:

a) the connection point where EAs drainage systems connect into an existing drainage system's carrier pipe;

b) a new soakaway; or

c) the existing drainage systems' outfall to a watercourse or soakaway

1.3.25 No existing outfalls have been identified which would require relocation as a result of the Scheme.

1.4 Consultation and impacts of the Scheme on the water environment

1.4.1 Consultation undertaken has included relevant consultee groups between junction 12 and junction 3. In particular, this includes consultation with the EA and the Lead Local Flood Authorities whose jurisdiction is crossed by the Scheme to discuss the approach to be taken to the assessment of flood risk and the management of routine rainfall runoff and spillage risk. A scoping opinion was requested from the EA and Lead Local Authorities. These have formed part of the wider consultations for the Scheme proposals as set out in the Consultation Report (Document Reference 5.1).

1.4.2 An Environmental Information Workshop was held in January 2015 to give stakeholders further opportunity to familiarise themselves with the Preliminary Environmental impact (“PEI”) Report, the findings of the environmental assessments, and to discuss the Statements of Common Ground and the Development Consent Order ("DCO") process.

1.4.3 Further consultation with the EA and Lead Local Flood Authorities relating to road drainage and the impact of the Scheme on the water environment is to be undertaken before the design is approved.

1.4.4 The assessment of impacts of the Scheme on the water environment has been undertaken and is reported in the chapter 15 of the Environmental Statement (Document Reference 6.1).

2 Existing Highway Drainage

2.1 Existing highway drainage between junction 12 and 8/9

2.1.1	Deleted from this report and is part of the Section 1 DSR
2.1.2	Deleted from this report and is part of the Section 1 DSR
2.1.3	Deleted from this report and is part of the Section 1 DSR
2.1.4	Deleted from this report and is part of the Section 1 DSR
2.1.5	Deleted from this report and is part of the Section 1 DSR
2.1.6	Deleted from this report and is part of the Section 1 DSR

2.2 Existing highway drainage between junction 8/9 and 3

2.2.1 The existing highway drainage along the M4 between junctions 8/9 and 3 is mainly kerb and gullies and a positive drainage system with some over the edge systems is located in the verge. The central reserve drainage mainly consists of a filter drain system. The majority of highway runoff is discharged via outfalls to watercourses. However, in some areas there are also soakaways which facilitate some drainage to groundwater. For the purposes of the assessment, it has been assumed that the existing drainage system is sufficient for the existing motorway or can be made to perform as such by an enhanced maintenance scheme or repairs. The condition of the existing drainage system has not been confirmed, but for the purposes of assessment is assumed to be properly maintained and operational on the above basis.

2.2.2 Base drainage network drawings were created in CAD format between junction 8 to junction 3 of the M4 using the following data sources:

a) HADDMS for the existing pipe network; and

b) Mksurveys Closed Circuit Television ("CCTV") drainage drawings for the drainage between junction 5 to junction 1 of the M4, dated July 2013.

2.2.3 Where there are no as-built drawings for recent drainage works additional drainage asset surveys are to be completed during the detailed design stage of the Scheme.

2.2.4 Existing drainage layout drawings for junctions 8/9 to 3 are provided at Appendix B.

The Appendix B drawings incorporate the 2016 drainage survey that was undertaken within the DCO boundary. This survey captures the existing verge drainage and the crossdrains between the verge and central reserve drainage.

The survey of ditches was carried out as part of a topographical survey in 2017 and this is also shown in the Appendix B drawings. As noted in 1.3.18, the existing central reserve drainage is proposed to be replaced as part of the scheme and was therefore not surveyed in 2016 and is not shown in the Appendix B drawings.

Drainage that was not captured in the 2016 CCTV survey that is proposed to be retained is shown in the proposed drainage drawings in Appendix A.

As part of further design development during construction to improve treatment potential and sustainability on the scheme, the existing filter drain in the central reserve of balanced carriageway sections is now proposed to be retained instead of being replaced with new sub-surface drainage. The proposed drainage strategy drawings in Appendix A show the information available for this existing drainage which was obtained from survey records held on National Highways's Drainage Data Management System (DDMS)

2.3 Category B pollution risk drainage outfalls

2.3.1 An assessment of outfalls was undertaken using data extracted from HADDMS to determine outfalls with a pollution risk classed as Category B. The HADDMS outfalls register indicates only one outfall is classed as a Category B outfall within the Scheme.

2.3.2 The outfall discharges into The Cut watercourse at chainage 36155 between junctions 10 and 8/9, and has a drainage catchment area of approximately 470m^2 on the eastbound carriageway and 7200m^2 on the westbound carriageway.

HD45 water quality assessments have been carried out as part of Detailed Design. The outcome of these assessments supersede the Priority Outfalls assessment recorded in HADDMS. The HD45 water quality assessments indicate five outfalls on Section 1 and three outfalls on Section 2 as a category B outfall. Further information on Section 2 outfalls can be found in Appendix A of HD45 water quality assessment report (HA514451-CHHJ-HDG-SZ_ZZZZZZZZZZ_Z-RP-CD-5120).

3 Proposed Highway Drainage Designs

3.1 Drainage design principles to be used for detail designs

Climate change

3.1.1 NN NPS 5.90 notes: *"Climate change over the next few decades is likely to mean milder wetter winters and hotter drier summers in the UK, while sea levels will continue to rise. Within the lifetime of nationally significant infrastructure projects, these factors will lead to increased flood risks in areas susceptible to flooding, and to an increased risk of flooding in some areas which are not currently thought of as being at risk. The applicant, the Examining Authority and the Secretary of State (in taking decisions) should take account of the policy on climate change adaptation in paragraphs 4.36 to 4.47"*.

3.1.2 NN NPS 4.41 also states that *"Where transport infrastructure has safety critical elements and the design life of the asset is 60 years or greater, the applicant should apply the UK Climate Projections 2009 (UKCP09) high emissions scenario (high impact, low likelihood) against the 2080 projections at the 50% probability level"*.

3.1.3 Interpolation of figures from the UK Climate Projections: Briefing report, dated December 2010, indicates that a climate change allowance of between 10 to 30% can be used to predict winter storm impacts on the M4 between junctions 12 to 3.

3.1.4 A 20% allowance for climate change has been applied in accordance with HD33/06. The climate change allowance has been applied to runoff calculations for all additional paved areas, but not to runoff from existing paved areas within the Scheme that are unchanged, as this is not considered "development".

3.1.5 Additional paved areas are those impermeable areas created by carriageway widening, the construction of EAs, or existing paved areas within the Scheme that are not currently captured by an existing drainage pipe system but will be following development.

SuDS

Within the Scheme, whilst space availability severely restricts the feasibility of using above ground SuDS features, such as ponds, reed beds and swales, the drainage strategy for the Scheme includes soakaways, oversized pipes and chambers, all of which qualify as SuDS features.

3.1.6 Sites have been put forward by Buckinghamshire County Council and the London Borough of Hillingdon for use in accommodating above ground SuDS features. Of the seven sites offered four of these, at Cranford Park, Watery Lane, Moat Cottage and in the vicinity of Junction 4 Heathrow Spur, are located beyond the Order limits.

3.1.7 At present, National Highways does not have powers over the offered land at these four sites, nor has use of the land for this purpose been assessed as part of the Scheme's Environmental Impact Assessment. Moreover, there are no agreements

in place with local authorities in respect of the land, no Section 253 agreements or acquisition by private treaty to enable the land to be used outside the Scheme.

3.1.8 Further, the use of such land for above ground SuDS drainage solutions could prevent other uses coming forward and as the land is outside the confines of both the Scheme, and land under National Highways' control, creates issues surrounding securing the future management and maintenance of the SuDS systems.

3.1.9 For these reasons it is concluded that it is not appropriate or feasible to use land outside of the Order limits to accommodate above ground SuDS such as swales, reed beds and ponds.

3.1.10 The remaining sites, located at Junction 4b and at Junction 7 of the M4 and Lake End Road are located within the Order limits and use of these sites to accommodate above ground SuDS has been subject to an initial feasibility assessment.

3.1.11 Areas of land located centrally within Junction 4b are illustrated in Figure 2. The scheme does not include any proposals to undertake carriageway widening or drainage works within the vicinity of Junction 4b. If the areas suggested were to be used for above ground SUDS to provide attenuation for the additional paved areas only (in accordance with the drainage strategy), runoff from the nearest areas of widening would have to be conveyed over significant distances (approximately 400m from the widening at Old Slade Lane and 1400m from the nearest EAs), significantly increasing scheme costs. Further, the transportation of surface water over such distances is unlikely to be feasible as the topography of the land in this location is relatively flat.

3.1.12 There are no watercourses within the footprint of Junction 4b therefore the outfalls of any SUDS would also have to be culverted underneath the existing interchange links to connect into adjacent watercourses (National Highways' records indicate that areas within Junction 4b may be subject to ground water flooding and therefore use of soakaways in this location is not considered to be a viable option). This would significantly increase scheme costs.

3.1.13 It would be necessary to provide maintenance access to all SUDS installed as part of the scheme. As these areas are located between high speed interchange links, such as at Junction 4b, there would be significant safety risks to maintenance operative associated with leaving and joining the interchange links to undertake maintenance works. It is therefore likely that significant works would be required to ensure safe maintenance access could be provided, potentially requiring additional bridges and maintenance access routes outside of the Order Limits.

3.1.14 Further, the land currently has a dense tree/vegetation cover so extensive clearance work would be required to provide space for and allow maintenance access to any SuDS system. This work has the potential to adversely impact on other environmental receptors and has not been assessed as part of the schemes environmental impact assessment.

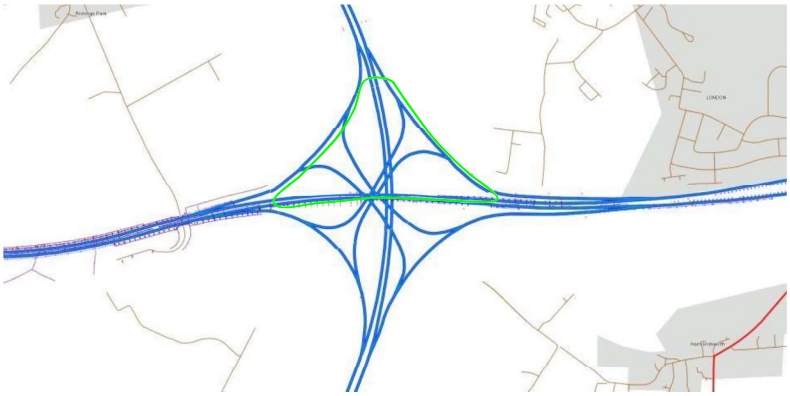


Figure 2: Junction 4b

3.1.15 Land at Junction 7 and Lake End Road is illustrated in Figure 3. The suggested areas of land within the footprint of the junction to both the north and south of the M4 mainline are generally significantly higher than the mainline (due to tying in to the adjacent slip roads which link in to the Junction 7 overbridge). Therefore, construction of above ground SUDS would require deep excavations, potentially requiring additional retaining walls. This would involve a significant additional construction cost and ongoing maintenance costs and therefore the use of these areas is not considered to be feasible.

3.1.16 The suggested area to the south of the Junction 7 loop is located within the Order Limits. However, this land is required only temporarily for access and working space for the realigned Junction 7 alignment. The permanent use of such land for above ground SuDS would create issues relating to securing the future management and maintenance of the SuDS systems (and access for maintenance). Therefore, excavation of a SuDS in this location is not considered to be an appropriate or viable option.

3.1.17 The areas located to the south of the Junction 7 are proposed to accommodate construction compound 6, which rules out use of this land to accommodate above ground SuDS features. National Highways's records indicate that areas located to the north of junction 7 may be subject to ground water flooding. Excavating a SuDS in this location may therefore not be a viable option for this additional reason. SUDS north of the junction may also have the potential to adversely impact on other environmental receptors and as such would need to be subject to additional environmental assessments.

3.1.18 National Highways only has temporary land ownership rights for the area highlighted on the eastern side of Lake End Road, so creating permanent SuDS in this area would need to be secured under a separate agreement to the DCO. Due to the performance of existing ditches set out in 3.1.20, no agreements have been followed up for the use of this land permanently to create SUDs. The implementation of SuDS at the western side of the existing Lake End Road alignment is not possible as Lake End Road is to be re-aligned. Above ground SUDS at junction 7 and Lake End Road may also create additional maintenance liabilities, which would be an additional

burden on the public purse and that would not be in the public interest given the existence of other acceptable drainage options which would not carry such an additional burden. The proposals consist of conventional drainage options in the form of slot drains, filter drains and ditches that achieve the objectives for drainage, described in 1.3.14 to 1.3.16 and 1.3.21 to 1.3.23, without the need for additional land.

3.1.19 At Lake End Road, the suggested area to the west of the road is not feasible for construction of above ground SUDS as this land is required to accommodate the realignment of Lake End Road.

3.1.20 The suggested area to the east of Lake End Road is located within the Order Limits. However, the existing drainage ditches have provided the required attenuation and have achieved the project objective of not exceeding existing flows at the outfalls and hence, this land is required only temporarily for access and working space for the new Lake End Road bridge. The permanent use of such land for above ground SuDS would create issues relating to securing the future management and maintenance of the SuDS systems (and access for maintenance). Hence, no further land agreements were necessary.

Figure 3: Junction 7 and Lake End Road

3.1.21 Initial reviews therefore conclude that lands offered/proposed within the Order limits are subject to a significant number of constraints with regard to implementing above ground SuDS. It is also considered that use of these lands is not necessary to deliver a drainage design that mitigates all impacts of the proposed Scheme on drainage and associated flood risk in accordance with planning policy requirements.

Discharge

3.1.22 The principle that there should be no nett increase in discharge as a result of the Scheme has been applied to drainage design within the Scheme. This means that the existing discharge is to be maintained at current rates and volumes (refer to paragraphs 1.3.21, 1.3.22 and section 3.4) to mimic the response of the existing highway drainage catchment area.

3.1.23 So far as practicable, discharge rates will be restricted to less than 5 l/s by flow control devices. To reduce the risk of blockages within the system, flows will not be restricted at small drainage system outfalls.

3.1.24 Where proposed impermeable areas increase the surface area compared to the existing impermeable areas, oversized pipes or manhole chambers are to be used to provide attenuation when flows are restricted, to ensure, so far as practical, that existing discharge at outfalls is not exceeded.

3.1.25 Attenuation and surface water runoff flow restrictions to existing discharge rates at outfalls, where additional impermeable areas are collected by the existing drainage system, would minimise the impact of flood risk from the Scheme to surrounding sites.

3.1.26 Within the Scheme, an outfall from a drainage system could be where a new drainage pipe system connects with an existing downstream drainage pipe system, a watercourse or a soakaway. Alternatively, it could be where an existing drainage pipe system, that has new paved areas, connects with an existing downstream pipe system that has an unchanged paved catchment area, a watercourse or a soakaway.

Runoff volumes

3.1.27 The drainage system is to be designed in accordance with NPS 5.113 principle that: *"The surface water drainage arrangements for any project should be such that the volumes and peak flow rates of surface water leaving the site are no greater than the rates prior to the proposed project, unless specific off-site arrangements are made and result in the same nett effect"*.

3.1.28 Additional volumes of surface water runoff generated from additional paved areas are to be mitigated by increased attenuation and use of overflow outfalls to systems such as soakaways as detailed in section 3.4.

Flow control / attenuation in verges and the central reserve will be provided by orifice plates and oversized pipes in downstream chambers which will accommodate the peak volumes predicted in the hydraulic modelling.

Flow control will be provided by v-notch weirs which will enable the existing ditches to be used to attenuate the peak volumes encountered in the hydraulic modelling.

The hydraulic modelling confirms that soakaways are not required for overflow outfalls.

Existing system

3.1.29 For this drainage strategy it has reasonably been assumed that the existing pipework is sufficient for the existing motorway. Where surface water flooding is reported to have occurred from blocked drainage, it can also be assumed that

maintenance/repair or localised substitution/replacement of the systems is capable of providing a satisfactorily functioning system as stated in paragraph 1.3.18.

3.1.30 The London Borough of Hillingdon identified residential properties located adjacent to the existing Junction 4b eastbound on-slip, illustrated in Figure 4, which it says have experienced flooding on a number of occasions. The London Borough of Hillingdon has stated that flooding occurred before any floodwater overtopped the banks of the local watercourse, indicating that a combination of sources contribute to the flooding issues experienced at these properties. National Highways will investigate the outfall connection from their drainage system to the nearest watercourse and ensure the system is fit for purpose, implementing any mitigation measures that may be required in accordance with paragraph 1.3.18 above.

Changes to the Junction 4b eastbound on-slip are not proposed as part of the scheme proposals. However, any connections from this slip road drainage system to the downstream system have been reviewed as part of the hydraulic design and improvements undertaken to address flooding issues.

A CCTV drainage survey of existing drainage in the verges was carried out in 2016. Remediation measures required to address pipe defects are proposed in Detailed Design and shown in Appendix A.

In addition, as part of the works, existing ditches will be cleared and cleaned so that they can be restored to their original capacity.

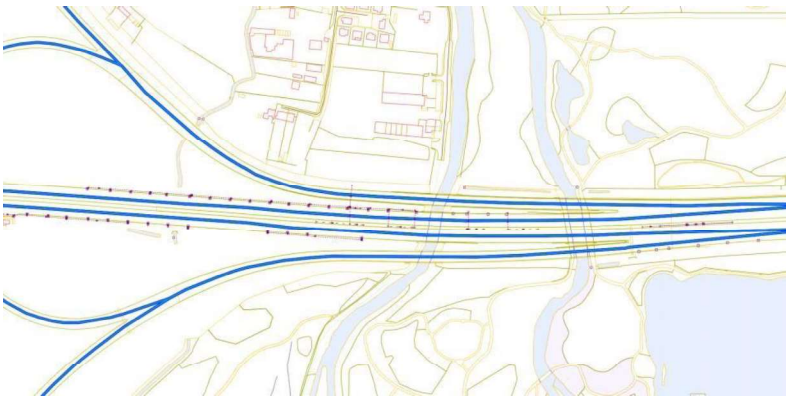


Figure 4: Junction 4b Eastbound on-slip

3.1.31 The London Borough of Hillingdon also raised the issue of how the existing M4 drainage system connects with the nearest watercourse in the vicinity of Moat Cottage. National Highways will confirm the position and will implement any remedial measures that may be required to ensure the drainage system is fit for purpose, in accordance with paragraph 1.3.18.

The nearest water course in the vicinity of Moat cottage is Frog's ditch. The M4 mainline drainage system outfalls into Frogs ditch. The proposed drainage strategy

is consistent with the existing drainage route, which is supported by as-built information from 1962. According to the as-built data and current proposal, the M4 drainage system connects to the 36-inch headwall of the Thames Water Surface Sewer (EXOU73A-072), which eventually empties into Frogs ditch. The proposed discharge rate on this outfall has been restricted to pre scheme discharge rate to minimise the flood risk from the scheme to surrounding sites. The scheme Contractor is unable to carry out a CCTV Investigation into the condition of the Thames Water pipe that outfalls into Frogs Ditch because of current high water levels on Frog's ditch. According to most recent discussions with Connect Plus Services (Area Asset Manager) and London Borough of Hillingdon, the water holdback is being caused by a small collapsed stone bridge further downstream of Frog's ditch. London Borough of Hillingdon is in process to commission contractor to resolve the Frog's ditch high water level issue, following this CCTV surveys will be conducted to identify any requirements of remedial work measures on existing Thames Water Sewers.

Water quality

3.1.32 The drainage design is based on the principle of not polluting the water environment, to ensure that existing water quality is maintained by augmenting or replacing the existing drainage system in the motorway where required. Further details of assessment methods and measures are discussed in Chapter 16 of the Scheme's Environment Statement.

Water Quality assessments were carried out in accordance with HD45/09 as described in 1.3.14 to 1.3.16

Mainline and central reserve

3.1.33 On embankments, at grade situations or where a kerb has been provided, a linear slot drain is proposed in the verges.

3.1.34 Maximum drainage length for slot drains ("Lp") between outfall connections has been calculated using Manning Resistance equation, given in HA 113/05, using the 315mm x 410mm oval linear slot drain.

3.1.35 In accordance with DMRB, at 0% pipe or carriageway gradient, the formulae from the HA 113/05 (Clauses 7.1 and 7.2) are not suitable to calculate the Lp value.

3.1.36 Therefore, Micro Drainage software, based on the Rational Modified Method, is to be used to simulate the water flow within the pipe. This method is recognised by the Highways Agency Standard HD33/06 as a part of the Wallingford Procedure, the most commonly used procedure in the UK for drainage analysis.

3.1.37 The results of Micro Drainage modelling, carried out on the basis of a 375mm circular pipe, show that the capacity of that pipe in 0% or very close to 0% gradient in situations necessitates the provision of downstream outfalls at approximately 80m spacing.

3.1.38 This length is understood to be the maximum length of the 375mm pipe that is able to contain the design run-off without surcharging. Considering the fairly irregular

character of the existing longitudinal gradient and anticipated pipe siltation, which is very likely to occur where carriageway gradients are low, the maximum spacing between outfalls in these sections (0% or very close to 0%), has been taken as 40m.

The slot drain capacity is assessed within hydraulic models and is designed to ensure no flooding for the 1:5 year event.

A slot drain profile equating to approximately a 375mm diameter pipe is proposed in the verges. The slot drain outlet spacings have been shown to work to lengths in excess of 160m in verges for the gradients encountered. The proposed drainage design using slot drains in verges will increase the outlet spacing to 160m. Intermediate maintenance access points are proposed at 40m intervals along the slot drain runs in verges.

The slot drains in the central reserve consist of 300mm diameter and 200mm diameter internal dimensions depending on the central reserve width, with the 200mm diameter slot drain being implemented where the central reserve is 2.6m wide, between J5 and J8/9. The outlet spacings for the 300mm and 200mm diameter slot drains are less than the verge slot drains as a result of their reduced capacities. An 80m outlet spacing is proposed for the 300mm diameter slot drain and the 200mm diameter slot drain has a minimum outlet spacing of 40m.

As part of further design development during construction, a new slot drain profile has been adopted which enables its use in the central reserve as well as the verge. This revised slot drain profile has an equivalent diameter of 375mm. As a result of the increased capacity, the maximum slot drain outlet spacings in the central reserve have increased to 160m, with intermediate maintenance access points at 40m intervals. This matches the outlets and access spacing proposed in the verges.

Emergency Areas (EA)

3.1.39 When EA drainage is independent of an existing drainage system and there are ditches or existing pipe network in the vicinity of the EA, then the discharge is restricted by an orifice plate with a minimum diameter of 100mm. Due to increased risks of blockages and possible higher maintenance requirements, smaller diameter orifice plates are not considered appropriate.

3.1.40 If an EA is to be part of an augmentation of the existing drainage network, then the proposed EA drainage system is to be modelled in Micro Drainage using existing carriageway plus EA catchment areas for 1 in 5 year and 1 in 1 year return period rainfall events with runoff released at existing discharge rates.

3.1.41 Run-off from an EA catchment is to be collected and attenuated by Combined Kerb Drainage Units ("KDUs") before discharging into a drainage ditch or existing pipe network.

In addition, EA drainage will connect to new pipe networks proposed in verges at some locations, as indicated in the proposed drainage strategy drawings in Appendix A.

Junctions

3.1.42 At junctions where existing drainage catchments increase the existing drainage systems capacity will be checked using DMRB to ensure that surface water runoff during 1 in 5 year storm events (plus climate change allowance in accordance with paragraph 3.1.4), will not increase flood risk from surface water flooding. Where required, attenuation will be provided within the drainage system to maintain the current rate and volume of discharge at the outfall. It is considered that the pollution risk is unchanged as a result of the changes to the junctions, and therefore no additional pollution control measures are currently proposed as part of the design.

Flow control / attenuation in verges and the central reserve will be provided by orifice plates and oversized pipes in downstream chambers which will accommodate the peak volumes predicted in the hydraulic modelling.

Flow control will be provided by v-notch weirs which will enable the existing ditches to be used to attenuate the peak volumes encountered in the hydraulic modelling.

The flow control / attenuation proposals are in progress as part of Detailed Design.

Water Quality assessments were carried out at all outfalls in accordance with HD45/09 as described in 1.3.14 to 1.3.16

As part of further design development during construction, through-junction-running has been removed from Junctions 5, 6 and 8/9. These changes are the subject of a Non-material Change application that has been consulted upon separately. At these locations the existing drainage has been retained where feasible, as indicated in the drawings in Appendix A.

Underbridges

3.1.43 For underbridges, a 1 in 5 year return period rainfall event and 20% increase in rainfall intensity (HD 33/06) allowance for climate change design criteria has been assessed for new paved areas only.

3.2 Proposed highway drainage designs - junction 12 to junction 8/9

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3.3 Proposed highway drainage designs - junction 8/9 to junction 3

3.3.1 A preliminary drainage assessment was undertaken between Junction 8/9 to Junction 3 to provide an initial appraisal, in order to indicate possible drainage system types and the extent that they may be required for the Scheme.

3.3.2 Linear slot drains are proposed where the current hard shoulder is being turned into a running lane, widening and in the central reserve. These provide additional storage capacity compared to the existing kerb and gully system and therefore provide greater attenuation for runoff compared to the existing drainage infrastructure. Linear slot drains are generally not required on slip roads unless slip lanes are widened within the Scheme.

3.3.3 Filter drains may need to be replaced by linear slot drains if it is considered that they pose a safety risk to vehicles. This will be the case where filter stone on the surface is within 3.2m of the carriageway.

Filter drains are proposed where the hardstrip is at least 0.5m wide. The detail is in accordance with the Highway Construction Details and involves a minimum 0.5m wide compacted sub-base between the filter media and edge of hardstrip.

Filter drains have also been provided where the hardstrip width is 0.3m. The loose stone is to be at least 1.0m away from the running carriageway in accordance with section 11.1 of IAN 161/13.

3.3.4 Linear drain locations have been located at the low side of the carriageway using flow arrows produced from Lidar. Where the position of outfalls in the current drainage system is known, linear drainage outfalls have been located to coincide with existing outfalls, however where no existing drainage information exists, the outfall locations have been assumed (these will be verified on site during construction). They have not been used where there is an EA or an underbridge as alternative collector systems such as beany blocks or bridge deck drainage units are to be used.

The 2016 drainage survey has indicated that the majority of the existing outlets are damaged and blocked so they will be replaced.

3.3.5 Linear slot drain outfalls ("LDOs") have been indicated approximately every 30m as a conservative approach. This is less than the calculated minimum spacing distance for LDOs on a flat gradient of 80m and the recommended 40m. Using Lidar-generated contours, high and low points have been identified. At high points in a linear drain run, a linear slot drain access point ("LDA") has been shown.

The slot drain capacity is assessed within hydraulic models and is designed to ensure no flooding for the 1:5 year event.

A slot drain profile equating to approximately a 375mm diameter pipe is proposed in the verges. The slot drain outlet spacings have been shown to work to lengths in excess of 160m in verges for the gradients encountered. The proposed drainage design using slot drains in verges will seek to increase the outlet spacing to 160m.

Intermediate maintenance access points are proposed at 40m intervals along the slot drain runs in verges.

The slot drains in the central reserve consist of 300mm diameter and 200mm diameter internal dimensions depending on the central reserve width, with the 200mm diameter slot drain being implemented where the central reserve is 2.6m wide, between J5 and J8/9. The outlet spacings for the 300mm and 200mm diameter slot drains are less than the verge slot drains as a result of their reduced capacities. An 80m outlet spacing is proposed for the 300mm diameter slot drain and the 200mm diameter slot drain has a minimum outlet spacing of 40m.

As part of further design development during construction, a new slot drain profile has been adopted which enables its use in the central reserve as well as the verge. This revised slot drain profile has an equivalent diameter of 375mm. As a result of the increased capacity, the maximum slot drain outlet spacings in the central reserve have increased to 160m, with intermediate maintenance access points at 40m intervals. This matches the outlets and access spacing proposed in the verges.

3.3.6 The assumed outfall connections for linear slot drains will be confirmed and any necessary adjustments made following detailed drainage asset surveys.

The 2016 drainage survey has indicated that the majority of these existing outlets are damaged and blocked so they will be replaced.

3.3.7 Combined bridge and kerb drains have been placed on underbridges on either the verge or central reserve – depending on whether the carriageway is in super elevation or if it is balanced.

3.3.8 Kerb Drains have been placed around EAs based on the design principle of all EAs sloping towards the verge.

3.3.9 Outfalls and access points for kerb drains and bridge drains ("KDOs/KDAs" and "BDAs/BDOs") were assessed using the same principles as used for linear slot drains. ~~Indicative~~ Outfalls have been located where current outfalls are available.

3.3.10 Based on interpolation of existing carriageway drainage records and Lidar data showing existing carriageway surface levels, drainage outfalls from three EAs may need to cross the carriageway to connect with existing drainage, as there is no available verge drainage system to connect to the EA drainage. This design solution is subject to confirmatory soakaway testing and detailed drainage surveys at the following locations:

a) ch 15050 – ch 15150 (EB);

b) ch 15065 – ch 15135 (WB); and

c) ch 24400 – ch 24500 (EB).

The 2016 and 2017 surveys show existing ditches and adjacent drainage at these EA locations which have been used to collect run-off at these locations

3.3.11 In sections of slips roads where contours are missing or not available, the flow direction of the drainage network is interpolated from contours slopes within those sections/parts of upstream or downstream slip road where contours are available.

3.3.12 ~~Indicative~~ Drainage drawings for proposed highway drainage designs between junction 8/9 to junction 3 are provided at Appendix A.

3.4 New paved area surface water volumes

3.4.1 A sample drainage pipe work system within the Scheme near to junction 8/9 was assessed using Micro Drainage 2014 software. The CIRIA (Construction Industry Research and Information Association) C697 SuDS Manual (Sustainable Drainage System Manual) "rule of thumb" storm duration of 360 minutes was selected to assess the long-term storage volume discharging from the system during a 1 in 5 year storm event. This storm event was chosen for the assessment as highway drainage carrier pipes are designed to capture runoff from a 1 in 5 year event (HD33/06 design guidance). The results of the modelling are show in Table 1 below.

3.4.2 Hydraulic modelling of the sample pipe work (see Annex I & J B of the DCO version of this Report - TR010019-002122) was completed for the following scenarios, namely:

a) EXISTING DRAINAGE: Modelling existing pipes and existing impermeable catchments areas;

b) ADDITIONAL PAVED AREAS: Additional paved areas are new areas created when the carriageway is widened or paved areas that are not currently captured by the existing drainage pipe system but will be captured following development i.e. changing existing hard shoulders slopes to match carriageway camber. Additional paved areas were modelled to show the volume of water that will be generated from these areas only; and

c) PROPOSED DRAINAGE: Modelling a modified pipe system with existing and additional paved catchment areas using attenuation and restricted flows to existing outfall discharge rates and volumes. Modelling results showed that attenuation is required to ensure surface water volumes discharged at outfalls do not increase when additional areas of impermeable area are captured by an existing drainage system. An allowance for climate change was applied by increasing additional paved impermeable areas by 20%.

Table 1 MICRO DRAINAGE 1 in 5 YEAR PROBABILTY 360 MINUTE DURATION STORM EVENT

Modelling	Maximum Flow at Outfall pipe (l/s)	Maximum Discharge Volume at outfall (m^3)
EXISTING DRAINAGE	34.8	230
ADDITIONAL PAVED AREAS.	5.2	33.7
PROPOSED DRAINAGE	29.7	236

Table 1: Micro drainage 1 in 5 year probability 360 minute duration storm event

3.4.3 As shown in the table above, the maximum discharge rate at the existing outfall will be reduced from the existing 34.8 l/s to 29.7 l/s with the maximum volume discharge increasing slightly from 230m^3 to 236m^3 during a 1 in 5 year 360 minute duration storm event. The slight increase in volume shown in the hydraulic modelling results can be mitigated by the relative decrease in flow rates. This restriction of flows and volumes to best mimic existing outfall discharge conditions was achieved by providing an overflow pipe upstream of the outfall pipe that discharges into a soakaway.

3.4.4 The additional paved areas model was created by using the existing drainage pipe system and only inputting the increase impermeable area following development of the Scheme. The modelling results show the discharge rate and volume that is generated by the additional paved areas and indicates attenuation requirements to best mimic existing outfall discharge.

3.4.5 The table demonstrates that when additional paved areas discharge into, or are augmented with, an existing system that through increased attenuation and using overflow pipes to SuDS outfalls such as a soakaway, flows can be restricted to best mimic the existing response of the catchment area, and thereby lessen flood risk in comparison to the existing flood risk.

Flow control / attenuation in verges and the central reserve will be provided by orifice plates and oversized pipes in downstream chambers which will accommodate the peak volumes predicted in the hydraulic modelling.

Flow control will be provided by v-notch weirs which will enable the existing ditches to be used to attenuate the peak volumes encountered in the hydraulic modelling.

4 Conclusions

4.1.1 The Drainage Strategy has been produced to ensure that suitable mitigation measures are used to manage additional runoff where impermeable areas are increased as a result of the Scheme. It will be secured by a requirement attached to the Development Consent Order that authorises construction of the Scheme. That in turn will ensure that the detailed drainage design secures the necessary mitigation.

4.1.2 Drainage mitigation measures are to be implemented in accordance with design principles set out in IAN161/13, DMRB HD33/06, and the requirements of the NN NPS and the WFD.

4.1.3 The fundamental principle of the Strategy is that the Scheme will not produce additional discharge in flow rate or volume at existing outfalls.

4.1.4 All new drainage system designs will use the size of pipes required to contain a 1 in 1 year storm without pipe crown surcharging and to provide conveyance of 1 in 5 year surface water flows with surcharge but no flooding during a 1 in 5 year storm event.

4.1.5 A climate change allowance of 20% has been applied to the assessment of additional paved areas when designing new or augmenting existing drainage systems affected by increased impermeable as a result of the Scheme.

4.1.6 Using the principles within this drainage strategy it is considered that suitable mitigation measures can be implemented within and are secured for the Scheme's drainage system to manage surface water runoff from the Scheme.

The further design development during construction described in this report reflects the mitigation measures set out in the original DSR:

- as per the Water Framework Directive, to protect water resources and promote sustainable water use; that the Scheme will not produce additional discharge in flow rate or volume at existing outfalls;
- 20% allowance for climate change for additional paved areas;
- no nett increase in discharge;
- run-off volumes and peak flow rates of surface water leaving the site are no greater than the rates prior to the proposed project; and
- prevention of pollution to the water environment to ensure that existing water quality is maintained.

It is noted that there is no change in impact on risk to groundwater or accidental spillage risk as a result of the revised drainage proposals presented in the DSR.

As such, in relation to the provisions of Requirements 14 and 27(3)(c), it is confirmed that the re-discharge proposals reflect the mitigation measures in the original DSR.

5 References

IAN 161/13 – Managed Motorways All Lane Running.

DMRB Vol 4 Section 2 Part 6 – HA 113/05 – Combined Channel and Pipe System for Surface Water Drainage.

DMRB Vol 4 Section 2 Part 3 – HA 33/06 – Surface and Sub-surface Drainage Systems for Highways.

MCHW Volume 1 - Specification for Highways Works – Series 500 – Drainage and Service Ducts.

MCHW Volume 2 – Notes for Guidance – Series NG 500 – Drainage and Service Ducts.

MCHW Volume 4 – Bills of Quantities for Highway Works (Sections 1, 2 and 3).

Linear slotted drain Manufacturers Details (Britpave).

6 Abbreviations

Term	Meaning
ALR	All Lane Running
BDA	Bridge Deck unit Access
BDO	Bridge Deck unit Outlet
CCTV	Closed Circuit Television
CEMP	Construction Environmental Management Plan
DMRB	Design Manual for Roads and Bridges
EIA	Environmental Impact Assessment
EA	Environment Agency
EA	Emergency Area, previously called Emergency Refuge Area (ERA)
EAR	Environmental Assessment Report
EB	East Bound Carriageway
ES	Environmental Statement
FRA	Flood Risk Assessment
HA	Highways Agency
HADDMS	Highways Agency Drainage Data Management
IAN	Interim Advice Note
J	Junction
KDA	Combined Kerb and Drainage unit Access point
KDU	Combined Kerb and Drainage Unit
KDO	Combined Kerb and Drainage unit Outlet
LDA	Linear Drain Access
LDO	Linear Drain Outlet
LED	Light-Emitting Diode
Lp	Drainage length for slot drains
NSIP	Nationally Significant Infrastructure Projects
OS	Ordnance Survey
PPGs	Pollution Preventions Guidelines
RCB	Rigid Concrete Barrier
WB	West Bound Carriageway

7 Glossary

Term	Meaning
Associated Development	Associated Development is development associated with a NSIP. The IPC decides whether development is associated development. This can include development in England and in water adjacent to England.
CEMP	Construction Environmental Management Plan. A site-specific plan developed to ensure that appropriate environmental management practices are followed during the construction phase of a project.
EAR	An Environmental Assessment Report documents the findings of an Environmental Assessment.
EIA	Environmental Impact Assessment is an assessment of the impacts on the environment of a development project.
Flood Zone Three	This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
Flood Zone Two	This zone comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year.
Mitigation	Measures including any process, activity, or design to avoid, reduce, remedy or compensate for negative environmental impacts or effects of a development.
NSIP	Nationally Significant Infrastructure Projects are large scale developments such as certain new harbours, power generating stations (including wind farms), highways developments and electricity transmission lines, which require a type of consent known as 'development consent' under procedures governed by the Planning Act 2008 (and amended by the Localism Act 2011).
Coplanar / Non-coplanar	Coplanar surfaces are surfaces that are in alignment with each other e.g. surfaces in hard shoulder areas slope in the same direction as the main carriageway. Non-coplanar surfaces are those where the surfaces slope in the opposite direction.

Appendix A: Proposed Drainage Strategy Drawings (J3 to J8/9)

Drawing Number	Drawing title
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5361	DCO Requirement 14 Drainage Strategy Legend & Notes
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5334	DCO Requirement 14 Drainage Strategy Sheet 34 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5335	DCO Requirement 14 Drainage Strategy Sheet 35 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5336	DCO Requirement 14 Drainage Strategy Sheet 36 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5337	DCO Requirement 14 Drainage Strategy Sheet 37 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5338	DCO Requirement 14 Drainage Strategy Sheet 38 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5339	DCO Requirement 14 Drainage Strategy Sheet 39 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5340	DCO Requirement 14 Drainage Strategy Sheet 40 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5341	DCO Requirement 14 Drainage Strategy Sheet 41 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5342	DCO Requirement 14 Drainage Strategy Sheet 42 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5343	DCO Requirement 14 Drainage Strategy Sheet 43 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5344	DCO Requirement 14 Drainage Strategy Sheet 44 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5345	DCO Requirement 14 Drainage Strategy Sheet 45 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5346	DCO Requirement 14 Drainage Strategy Sheet 46 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5347	DCO Requirement 14 Drainage Strategy Sheet 47 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5348	DCO Requirement 14 Drainage Strategy Sheet 48 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5349	DCO Requirement 14 Drainage Strategy Sheet 49 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5350	DCO Requirement 14 Drainage Strategy Sheet 50 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5351	DCO Requirement 14 Drainage Strategy Sheet 51 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5352	DCO Requirement 14 Drainage Strategy Sheet 52 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5353	DCO Requirement 14 Drainage Strategy Sheet 53 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5354	DCO Requirement 14 Drainage Strategy Sheet 54 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5355	DCO Requirement 14 Drainage Strategy Sheet 55 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5356	DCO Requirement 14 Drainage Strategy Sheet 56 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5357	DCO Requirement 14 Drainage Strategy Sheet 57 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5358	DCO Requirement 14 Drainage Strategy Sheet 58 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5359	DCO Requirement 14 Drainage Strategy Sheet 59 of 60
HA514451-CHHJ-HDG-SZ_DGZZZZZZ_Z-DR-CD-5360	DCO Requirement 14 Drainage Strategy Sheet 60 of 60

Appendix B: Existing Drainage Drawings - (J3 to J8/9)

Drawing Number	Drawing title
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5350	DCO Requirement 14 Existing Drainage Legend & Notes
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5367	DCO Requirement 14 Existing Drainage Sheet 17 of 30
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5368	DCO Requirement 14 Existing Drainage Sheet 18 of 30
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5369	DCO Requirement 14 Existing Drainage Sheet 19 of 30
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5370	DCO Requirement 14 Existing Drainage Sheet 20 of 30
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5371	DCO Requirement 14 Existing Drainage Sheet 22 of 30
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5372	DCO Requirement 14 Existing Drainage Sheet 22 of 30
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5373	DCO Requirement 14 Existing Drainage Sheet 23 of 30
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5374	DCO Requirement 14 Existing Drainage Sheet 24 of 30
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5375	DCO Requirement 14 Existing Drainage Sheet 25 of 30
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5376	DCO Requirement 14 Existing Drainage Sheet 26 of 30
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5377	DCO Requirement 14 Existing Drainage Sheet 27 of 30
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5378	DCO Requirement 14 Existing Drainage Sheet 28 of 30
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5379	DCO Requirement 14 Existing Drainage Sheet 29 of 30
HA514451-CHHJ-HDG-SZ_DGZZZZZZZZ_Z-DR-CD-5380	DCO Requirement 14 Existing Drainage Sheet 30 of 30