

## Appendix 10.2

Additional Geology, Soils and Contamination  
Assessment of Flood Compensation Areas and  
Cresswell Flash Deep Wetland



**Stafford Western Access Route Environmental Statement  
Volume 3 – Technical Appendices  
Appendix 10.2: Additional Geology, Soils and Contamination Assessment of  
Flood Compensation Areas and Cresswell Flash Deep Wetland**



## REVISION SCHEDULE

Rev	Date	Details	Prepared by	Reviewed by	Approved by
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2	June 2015	Final	Katrina Blair Graduate Environmental Scientist	David Cragg Technical Director Environment and Ground Engineering	David Cragg Technical Director Environment and Ground Engineering

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## TABLE OF CONTENTS

1	INTRODUCTION .....	6
1.1	Background.....	6
1.2	Assessment Methodology.....	6
2	BASELINE .....	7
2.2	Current Land Use.....	7
2.3	Historical Setting and Summary of Potential Historical Sources of Contamination.....	7
2.4	Published Geology and Ground Conditions .....	10
2.5	Historical Borehole Records .....	10
2.6	Hydrogeology.....	11
2.7	Hydrology .....	12
2.8	Sensitive Sites .....	12
2.9	Preliminary Geotechnical Assessments .....	13
3	CONCEPTUAL SITE MODEL.....	13
3.2	Potential Sources.....	13
3.3	Potential Receptors .....	15
3.4	Potential Pathways .....	17
4	POTENTIAL IMPACTS AND SIGNIFICANT ENVIRONMENTAL EFFECTS....	22
4.2	Northern FCA and Cresswell Flash .....	23
4.3	Southern FCA.....	26
5	PROPOSED MITIGATION AND RESIDUAL EFFECTS.....	29
5.1	Northern FCA and Cresswell Flash- Operation Phase .....	29
5.2	Northern FCA and Cresswell Flash- Operation Phase .....	32
5.3	Southern FCA- Construction Phase .....	33
5.4	Southern FCA- Operation Phase .....	35
5.5	Residual Effects.....	37
6	CONCLUSIONS.....	41
7	REFERENCES .....	41

## TABLES

Table 2.1: Historical setting of the Northern FCA

Table 2.2: Historical setting of the Southern FCA

Table 2.3: Historical setting of Cresswell Flash

Table 3.1: Potential Sources Northern FCA

Table 3.2: Potential Sources Cresswell Flash

Table 3.3: Potential Sources Southern FCA

Table 3.4: Potential Receptors Northern FCA

Table 3.5: Potential Receptors Cresswell Flash

Table 3.6: Potential Receptors Southern FCA

Table 3.7: Potential Pathways Northern FCA

Table 3.8: Potential Pathways Cresswell Flash

Table 3.9: Potential Pathways Southern FCA

Table 3.10: Northern FCA

Table 3.11: Cresswell Flash

Table 3.12: Southern FCA

Table 4.1 Northern FCA excavations and re-use in Cresswell Flash

Table 4.2 Critical receptors and their sensitivities

Table 5.1 Summary of Residual Effects for the Northern Flood Compensation Area and Cresswell Flash

Table 5.2: Summary of Residual Effects for the Southern Flood Compensation Area

## **1 INTRODUCTION**

### **1.1 Background**

1.1.1 Since undertaking the previous assessment of the proposed development area for Stafford Western Access Route (SWAR), three further areas have been identified that require assessment. These areas lie outside of the previous study area. The location and further details of the Storage Areas can be found on drawing SWAR/PLANNING/24. These areas comprise the locations of two (2) proposed excavated Flood Compensation Areas (FCA) and an existing pond known as a “flash” (the Cresswell Flash). The proposed excavated FCAs are:

- Storage Area 1: A Flood Compensation Area of elevated land situated to the north of the floodplain within Doxey and Tillington Marshes SSSI, from which circa. 9,800m<sup>3</sup> of material will be generated during excavation. This material is proposed to be deposited in existing deep wetland of Cresswell Flash.
- Storage Area 2: An existing car park situated to the west of the route from which circa. 8,000m<sup>3</sup> of material (consisting of bound material/tarmac) will be generated during excavation. It is proposed that this area be returned to use as floodplain.

1.1.2 The material generated from the excavation of the proposed FCA to the North of the floodplain (Storage Area 1) is proposed to be deposited within Cresswell Flash. Cresswell Flash is situated within Doxey and Tillington Marshes SSSI. This is an existing area of deep pond / wetland adjacent to the FCA in the North located on the floodplain of the river Sow. The Cresswell Flash is understood to originate from ground subsidence caused by underground brine extraction. Therefore Cresswell Flash and the associated access route of an existing track comprise the third area which requires further assessment.

1.1.3 This appendix assesses the impact of the proposed formation of the storage areas on the ground conditions, land quality and soil contamination, and on the conditions in the Cresswell Flash. In addition, this chapter considers the impacts of the existing ground conditions and potential contamination on the proposed FCAs and the Cresswell Flash. In particular, it describes the existing ground conditions and known and / or suspected contamination and considers the potential impacts of the proposed development during the demolition, construction and operation phases. It also considers strategies to avoid, minimise or control the impacts.

### **1.2 Assessment Methodology**

1.2.1 The assessment methodology used is the same as that outlined in Section 10.3 of the Stafford Western Access Route Environmental Statement.

## **2 BASELINE**

2.1.1 The baseline conditions first set out the current and historical context of the three assessment areas, followed by their environmental setting and sensitivity. A review of any previous contamination or ground related assessments, together with details of any existing remedial measures in place across the sites then follows. The location and further details of the Storage Areas can be found on drawing SWAR/PLANNING/24. The environmental setting is important because the topography, geology, hydrogeology and hydrology of the site are the main factors that influence the way in which contaminants in the soil or groundwater can be transported on or off site and the ways in which contamination can impact upon receptors.

### **2.2 Current Land Use**

2.2.1 Storage Area 1 and Cresswell Flash are located within the flood plain of the River Sow and Doxey and Tillington Marshes SSSI. This land is bounded to the south by the River Sow and a railway line, to the north by a residential area and the A5013 and to the west by Junction 14 of the M6. East of these two areas lies a stretch of the River Sow floodplain and the Doxey and Tillington Marshes Nature Reserve, until Castletown and Stafford are reached. The current land use of Storage Area 1 and Cresswell Flash is nature reserve/grazed pastures and marsh. The Darling stream flows into Cresswell Flash, and the River Sow flows through Storage Area 1.

2.2.2 Storage Area 2 is located in Stafford to the west of the A518 with Doxey Road to the south, the current land use being a car park.

### **2.3 Historical Setting and Summary of Potential Historical Sources of Contamination**

2.3.1 Historical mapping has been reviewed to assess the potential for past activities, both on and adjacent to the FCAs and flash, to have impacted upon the environmental conditions and land quality. Historical Ordnance Survey (OS) maps of the site were obtained as part of the Envirocheck Report. Copies of the maps are provided in Appendix A of the Phase 1 Desk Study Report (URS, July 2014).

2.3.2 When reviewing historical maps only the changes deemed to be significant, either within or close to the assessment area, have been reported. Tables 2.1 to 2.3 show the past activities for the FCAs and Cresswell Flash.

**Table 2.1: Historical setting of the Storage Area 1**

Date	Map scale	Significant changes to site	Significant changes to surrounding area
1888-1889	1:10,560	Site consists of fields with a small un-named building and track.	Surrounding fields, The Darling water course to the North and the railway to South
1901-1902	1:10,560	Small building in field no longer shown	No significant change
1954	1:10,000	Small track in field no longer shown	No significant change
1960-1968	1:10,000	No significant change	M6 built to the West
No significant changes noted up to and including recent maps (2010).			

**Table 2.2: Historical setting of the Storage Area 2**

Date	Map scale	Significant changes to site	Significant changes to surrounding area
1881	1: 1,250	Site consists of fields with a gas works just inside the southern boundary.	Houses and railway south of site and river just north and east of site.
1923	1: 1,250	No significant change	Doxey road goods and coal just South of gasworks.
1954	1: 10,560	Small drains no longer in fields, just one drain running from north to south.	No significant change
1958 - 1959	1: 1,250	Gas board service depot buildings near south boundary of site.	No significant changes
1959	1: 1,250	Gasholder within north of site. Pond within south of site.	No significant change.

Date	Map scale	Significant changes to site	Significant changes to surrounding area
1968 - 1987	1: 1,250	Refuse tip now near centre of site. Gas board service depot buildings changed. Electricity cable bridge on east side of site.	No significant change
1981-1982	1:10,000	Road now in centre of site to the bottom of refuse tip.	No significant change
1985 - 1986	1: 1,250	Refuse tip no longer on site.	No significant change
1992	1:1 1,250	Site now has a large car park on it and a road forming the eastern boundary running south to north.	No significant change
No significant changes noted up to and including recent maps (2010).			

**Table 2.3: Historical setting of Cresswell Flash**

Date	Map scale	Significant changes to site	Significant changes to surrounding area
1888-1889	1:10,560	Cresswell Flash was not in existence, being a field with a drain leading into a watercourse named The Darling. The site is bounded by a drain to the North.	Fields to the North and railway to South. Ground Pit in Eastern adjacent field
1901-1902	1:10,560	Small drain in field no longer shown	Minor road in close proximity. Ground Pit no longer marked.
1925	1:10,560	No significant change	An Old Marl Pit is marked in the Eastern adjacent field
1954	1:10,000	Drain to North no longer shown.	No significant change

Date	Map scale	Significant changes to site	Significant changes to surrounding area
1970-1973	1:10,000	Drain to North is shown again.	Pond or possibly a pit is shown in Eastern adjacent field. Old marl pit no longer shown.
1981-1982	1:10,000	Cresswell Flash marked on site	Boundary Pool marked
No significant changes noted up to and including recent maps (2010).			

## 2.4 Published Geology and Ground Conditions

2.4.1 It can be seen from the BGS website that all three areas are situated upon superficial Alluvium deposits comprised of clay, silt, sand and gravel interbedded with peat. There are some areas of Glacio fluvial deposits, which underlie the Alluvium, within the Storage Areas and Cresswell Flash. The underlying solid strata comprise mudstones of the Mercia Mudstone Group. A detailed description of the superficial deposits and solid geology is given in Paragraphs 10.4.18 and 10.4.23 of the Stafford Western Access Route ES.

## 2.5 Historical Borehole Records

2.5.1 Three historic borehole are located in close proximity to Storage Area 1 on the BGS website. The references are SJ92SW109, SJ92SW110 and SJ92SW111. These are also the closest boreholes to Creswell Flash and so the ground conditions encountered are considered to apply for both of these areas.

2.5.2 The BGS boreholes in the locality of Storage Area 1 record that Alluvium deposits of soft silty clay were encountered to between 1.10 and 1.40m bgl. These were proved to overlie very soft brown/black Peat deposits encountered to between 3.5 and 10.00m bgl. A layer of Alluvium was again encountered beneath the Peat deposits to depths between 4.4 and 14.4m bgl. Below these Alluvium and Peat deposits lie Glacio-fluvial deposits of dense, fine -coarse, red-brown sands and gravels to depths between 11.20 and 24.7m bgl. Underlying these superficial Glacio-fluvial deposits the Mercia Mudstone was encountered as mudstone fragments to a maximum depth of 13.20 (base not proven).

2.5.3 Within Storage Area 2 (existing car park) numerous historical borehole records are present across the site. Extensive Ground Investigation has been undertaken for the scheme and is included in Appendix 10.1. Made Ground is present across the southern FCA site to between 1.4 and 3.9m bgl. To south of the site the Made ground is present to 1.4m bgl, comprised of a tarmac layer overlying loose orange-brown gravel and clay.

- 2.5.4 In boreholes located toward the middle of Storage Area 2 site Made Ground is also present, to depths between 0.8 and 2.70m bgl. This also consists of a layer of tarmac overlying gravel and clay. However, the gravel and clay contains pockets of clinker, ash and slag, plastic and porcelain. The Made Ground within the borehole of BGS reference SJ92SW470 contains slag, brick, coal, and burnt shale, having a slight gas works odour reported between 0.5 and 1.8mbgl. Surrounding trial pits also contain Made Ground but the slag, brick, coal, and burnt shale and gas works odour appears to be confined to one borehole only. The Made Ground to the North of the site contains loose black ash, gravel and glass fragments to 3.9m bgl.
- 2.5.5 In the southern and mid areas of the Storage Area 2 site the tarmac and Made Ground is underlain by Alluvial Deposits consisting of dark brown/black clay/silt to between 14.3 and 15.00m bgl with organic odour noted between 10.5 and 13.5m bgl. Glacio-fluvial deposits of Sand and Gravel underlie the Alluvium Deposits proven to a maximum depth of 20m bgl. These become denser with depth, the Gravel consisting of quartzite and igneous rocks.
- 2.5.6 To the north of the Storage Area 2 site the Made Ground is underlain by soft, black Peat deposits to 5.65m bgl (thickness 1.75m), below which are Glacio-fluvial Deposits of Sand and Gravel proven to 10.5m bgl. A review of these historic boreholes indicates that they are in broad agreement with the published geology.

## **2.6 Hydrogeology**

- 2.6.1 The alluvium and underlying glaciofluvial sheet deposits are designated as Secondary A aquifers. Secondary A aquifers are permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers. It is considered that the shallow groundwater in the alluvium is in direct hydraulic connection with the streams, drains and ponds in the floodplain of the river Sow. The Cresswell Flash is understood to be relatively deep as it originates from ground subsidence. The Flash is therefore likely to be directly connected to shallow groundwater in the Alluvium as well as being fed by surface drains.
- 2.6.2 The Mercia Mudstone is designated as a Secondary B aquifer. Secondary B aquifers are predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers
- 2.6.3 The sites are not in a groundwater source protection zone (SPZ) as defined by the EA and there are no SPZ limits within 1km of the site.

2.6.4 The current chemical quality of the River Sow in the locality of all three sites is 'good' and current ecological quality being 'poor potential'. The 2015 predicted chemical quality is 'good' and the predicted 2015 ecological quality is 'poor potential', (EA 'What's in your backyard? Website accessed 28/05/2015). The EA status objectives are good ecological potential by 2027 and good chemical status by 2015 (EA, 2009).

2.6.5 Soils of high leaching potential (H1) have been identified across all three sites. A 'H1' classification relates to soils which readily transmit liquid discharges because they are either shallow, or susceptible to rapid by-pass flow directly to rock, gravel or groundwater.

## **2.7 Hydrology**

2.7.1 Cresswell Flash is situated within a network of surface water features. Tippington Drain flows into Cresswell Flash and a stream named The Darling flows eastwards out of it. Multiple drain branch off from the Tippington Drain and The Darling. Cresswell Flash is considered to have originated as a subsidence feature caused by historical salt brine extraction in the area and as outlined above is likely to be directly connected to shallow groundwater in the Alluvium as well as being fed by the surface water features.

2.7.2 Within Storage Area 1 no surface water features are present except for a stretch of the River Sow located to the south of the site. No water abstractions are recorded within 250m of the two FCA sites according to the Envirocheck report. Storage Area 1 and Cresswell Flash are noted as being located within both a Flood Zone 2 and Flood Zone 3 according to the EA and are therefore likely to receive flood waters in a flood event. The likelihood of flood waters reaching the Storage Area 2 is also high, and this FCA site is categorised as a Flood Zone 3.

2.7.3 The River Sow is located to the north of the Storage Area 2 and multiple unnamed drains associated with the River Sow are present in close proximity (within 5m) to the west of the site. One surface water abstraction is located within 100m to the east of the site, associated with the River Sow. Two discharge consents are located onsite within the northern area, relating to trade waste and process water being discharged to land for soak away, and to groundwater. Two discharge consents are located approximately 150m from the site, one located south of Doxey Road, the other located within the car park to the east of the site. Both of these discharge consents are to the River Sow and relate to Sewage Discharges from a Pumping Station and cooling water.

## **2.8 Sensitive Sites**

2.8.1 According to the Envirocheck Report, the sites are located within a Nitrate Vulnerable Zone.

- 2.8.2 Storage Area 1 and Cresswell Flash lie within the Doxey & Tillington Marshes Site of Special Scientific Interest (SSSI). The south eastern tip of the SSSI encroaches into the southern FCA. The remainder of the SSSI extends off site to the north west for approximately 2km as far as the M6 Motorway.
- 2.8.3 The SSSI is recorded as 'Does Not Require Assessment' with regards to chemical quality in terms of compliance with the environmental standards specified in the Environmental Quality Standards Directive 2008/105/EC. The chemicals listed in this Directive and which do not require assessment at the SSSI include Priority Substances, Priority Hazardous Substances and eight other pollutants carried over from the Dangerous Substance Daughter Directives. The SSSI is described as having moderate potential with regards to ecological quality.

## 2.9 Preliminary Geotechnical Assessments

- 2.9.1 A ground investigation was undertaken by SCC in 2014 and the Ground Investigation Interpretative Report (URS, 2014) has been summarised within Section 10.5 of the SWAR ES. Part of this investigation was located in close proximity to Storage Area 2.
- 2.9.2 There are no ground investigations relating to areas nearby Storage Area 1 or Cresswell Flash.

## 3 CONCEPTUAL SITE MODEL

- 3.1.1 The potential sources of contamination, potential receptors and potential pollutant pathways are identified for the three sites.

### 3.2 Potential Sources

**Table 3.1: Potential Sources Storage Area 1**

Potential Source	Description
<b>Natural Strata</b>	The natural strata consist of Peat, Alluvium and Glaciofluvial deposits overlying Mercia Mudstone Group. Sources of contamination are therefore likely to be limited to natural background concentrations.
<b>Ground Gas</b>	Concentrations of ground gas (methane and carbon dioxide) and volatile gases may originate from the natural deposits, especially Peat, dependent on the organic matter content of these deposits.
<b>Access Route</b>	The Access Route to the area is likely to be via the existing track. Sources associated with construction traffic include potential fuel spill and the generation of dust.
<b>Offsite Sources</b>	Leaks, spills and emissions from surrounding sources e.g., the railway and the M6.

**Table 3.2: Potential Sources Cresswell Flash**

Potential Source	Description
<b>Natural Strata</b>	The natural strata consist of Peat, Alluvium and Glaciofluvial deposits overlying Mercia Mudstone Group. Sources of contamination are therefore likely to be limited to natural background concentrations.
<b>Ground Gas</b>	Concentrations of ground gas (methane and carbon dioxide) and volatile gases may originate from the natural deposits dependent on the organic matter content of these deposits.
<b>Offsite Sources</b>	Leaks, spills and emissions from surrounding sources e.g, the railway and the M6. Given that the proposed development is to excavate material from Storage Area 1 and deposit it within Cresswell Flash the natural strata of Storage Area 1 could be considered a potential offsite source. However, considering the historic and current use and the absence of Made Ground within Storage Area 1 it is unlikely that contamination will be present which would be transferred to Cresswell Flash.

**Table 3.3: Potential Sources Storage Area 2**

Potential Source	Description
<b>Made Ground</b>	Present across the majority of the site to depth of up to a maximum 3.9m bgl. Ash, slag, clinker and brick was identified in the majority of boreholes, along with burnt shale and a slight gas works odour noted in the middle of the site. Given the historical industrial nature of the site including the former use as a gas works, the presence of contamination in the made ground is considered likely. The potential for underground pipes, ducts and tanks also cannot be ruled out which may have contaminated the site via leakage, or through corrosion. Contamination associated with gas works includes mobile contaminants such as ammonia, phenol, benzene and toluene. Cyanide, sulphates and PAH may also be present along with alcohols, glycols and synthetic resins associated with natural gas processing. Metals including chromium, cobalt, iron and nickel, mercury and molybdenum are also associated with gas works. Asbestos may also be present associated with the demolition of previous industry.
<b>Natural Strata</b>	The natural strata consist of Peat, Alluvium and Glaciofluvial deposits overlying Mercia Mudstone Group. Sources of contamination in natural strata may be limited to natural background concentrations. However there is the potential for contaminants in the overlying made ground to have migrated to the natural strata.

Potential Source	Description
<b>Soil Leachate</b>	Potential contaminants may be leached from Made Ground sources at the site.
<b>Groundwater</b>	Shallow groundwater was found to be present within the made ground across the site. There is a potential that the groundwater may contain a dissolved phase of the contaminants associated with the Made Ground.  Shallow groundwater is also present within the Glacio-lacustrine deposits. There is a potential that the groundwater may contain a dissolved phase of mobile contaminants originating in the made ground.
<b>Ground Gas</b>	Concentrations of ground gas (methane and carbon dioxide) and volatile gases may originate from the Made Ground and / or the underlying natural deposits dependent on the organic matter content of these deposits.
<b>Offsite Sources</b>	Leaks, spills and emissions from surrounding sources e.g. industrial properties, the railway and historical landfills.

### 3.3 Potential Receptors

**Table 3.4: Potential Receptors Storage Area 1**

Potential Receptor	Description
<b>Human Receptors</b>	This Includes; <ul style="list-style-type: none"> <li>• Visitors to the wetland after development;</li> <li>• Occupants of residential properties to the north of the area;</li> <li>• Construction and maintenance workers.</li> </ul>

Potential Receptor	Description
<b>Controlled Waters</b>	<p>The main receptor is the River Sow which runs along the southern area of the site. There is also the Tillington Drain and The Darling Drain in close proximity. Cresswell Flash, as well as being assessed as a separate site, can also be considered a receptor due to its close proximity to Storage Area 1. Storage Area 1 can itself be considered a receptor.</p> <p>The proposed FCA will be excavated into natural superficial deposits designated as a Secondary A aquifer, overlying bedrock designated as a Secondary B aquifer.</p>
<b>Flora and Fauna</b>	<p>Sensitive receptors include flora of marsh and open water habitats, reptiles, amphibians and breeding and wintering birds.</p> <p>The excavation of Storage Area 1 is intended to create a low-lying wetland with ecological benefits. It is therefore considered to be beneficial to the flora and fauna of the area.</p>

**Table 3.5: Potential Receptors Cresswell Flash**

Potential Receptor	Description
<b>Human Receptors</b>	<p>This Includes;</p> <ul style="list-style-type: none"> <li>• Visitors to the wetland after development;</li> <li>• Occupants of residential properties to the north of the area;</li> <li>• Construction and maintenance workers.</li> </ul>
<b>Controlled Waters</b>	<p>Creswell Flash itself is the main receptor. Other receptors include the River Sow which is located offsite to the south, and the The Darling stream, into which water from Creswell Flash flows.</p> <p>The Flash is located in natural superficial deposits designated as a Secondary A aquifer, overlying bedrock designated as a Secondary B aquifer.</p>
<b>Flora and Fauna</b>	<p>Potential receptors are aquatic plant communities, aquatic invertebrate communities, amphibians, fish.</p> <p>The material excavated from the Storage Area 1 is intended to be deposited within Cresswell Flash, leading to the raising of the level of the flash bed.</p>

**Table 3.6: Potential Receptors Storage Area 2**

Potential Receptor	Description
<b>Human Receptors</b>	<p>This Includes;</p> <ul style="list-style-type: none"> <li>• Occupants of residential properties to the south of the site;</li> <li>• Construction and maintenance workers.</li> </ul>

Potential Receptor	Description
<b>Controlled Waters</b>	<p>The main receptor is the River Sow, which is located just north of the site, and the network of drains associated with the River Sow to the West of the site.</p> <p>The site overlies a deposit of made ground containing potential mobile contaminants, in turn overlying natural superficial deposits designated as a Secondary A aquifer, overlying bedrock designated as a Secondary B aquifer.</p> <p>One surface water abstraction is located within 100m to the East of the site, associated with the River Sow</p>
<b>Offsite Receptors</b>	<p>Receptors include flora of marsh and open water habitats, reptiles, amphibians and breeding and wintering birds.</p> <p>The material excavated (the Tarmac car park surface) may be re-used within the scheme earthworks, disposed to landfill or if required returned to the floodplain, subject to meeting chemical acceptability criteria for re-use on the floodplain, meaning that the floodplain to the East of the site can be considered a receptor.</p>

### 3.4 Potential Pathways

3.4.1 The tables below present a summary of the potential pathways by which the identified sources may come into contact with identified receptors that are considered most appropriate to the site in its developed condition.

**Table 3 .7: Potential Pathways Storage Area 1**

Potential Pathway		Description
<p><b>Soil Pathway</b> Including the following sources</p> <ul style="list-style-type: none"> <li>• Natural Strata</li> <li>• Soil Derived Leachate</li> </ul>	<b>Dermal Contact</b>	<p>Dermal contact with contaminated soils, soil derived dust, soil leachate and perched groundwater by the construction (FCA excavation and earthworks) workers. It is anticipated that there will be no dermal contact with ground by the end users.</p>

Potential Pathway		Description
	<b>Ingestion</b>	Direct or indirect ingestion of soil and soil derived dust. It is anticipated that there will be negligible potential for ingestion of soils at the site as they will be excavated from the FCA and re-used directly to raise the level of the bed in Cresswell Flash. The excavation process will be controlled to minimize dust generation.
	<b>Inhalation</b>	Inhalation of soil derived dust, organic vapours or ground generated gas. It is anticipated that there will be negligible potential for inhalation of soils or vapours at the site as the soils will be excavated from the FCA and re-used directly to raise the level of the bed in Cresswell Flash. The excavation and re-use process will be controlled to minimize dust and vapour generation.
<b>Groundwater Pathways</b> Including the following sources: <ul style="list-style-type: none"> <li>• Soil Leachate</li> <li>• Perched Groundwater</li> </ul>	<b>Rainfall Infiltration &amp; Vertical / Lateral migration via permeable strata</b>	<p>Rainfall infiltration can generate and mobilise soil-derived leachate impacting on surface waters and groundwater.</p> <p>Shallow groundwater in the natural superficial deposits is likely to flow towards the River Sow which spans the southern limit of the site; but is also likely to connect directly to and feed Cresswell Flash.</p>
	<b>Lateral Migration through Aquifer</b>	As well as being a receptor, the natural superficial deposits being a Secondary A aquifer can allow transportation of contaminants through the permeable strata.
<b>Gas Pathways</b> Including the following sources: <ul style="list-style-type: none"> <li>• Ground gas</li> </ul>	<b>Vertical / Lateral Migration via permeable strata.</b>	The generation of ground gas may occur due to high organic matter content within the Peat and Alluvial deposits. The permeable Glacio-fluvial strata may allow lateral migration of ground gases off site.

**Table 3.8: Potential Pathways Cresswell Flash**

Potential Pathway		Description
<p><b>Soil Pathway</b> Including the following sources</p> <ul style="list-style-type: none"> <li>• Natural</li> <li>• Soil Derived Leachate</li> </ul>	<p><b>Dermal Contact</b></p>	<p>Dermal contact with contaminated soils, surface water, soil derived dust, soil leachate and perched groundwater by the construction (earthworks infilling of the Flash) workers. It is anticipated that there will be no dermal contact with surface water or ground by the end users.</p>
	<p><b>Ingestion</b></p>	<p>Direct or indirect ingestion of soil and soil derived dust. It is anticipated that there will be negligible potential for ingestion of soils at the site as soils which could be potential sources will be excavated from Storage Area 1 and re-used directly to raise the level of the bed in Cresswell Flash. The excavation, transfer and re-use of soils to raise the bed of the flash will be controlled to minimise generation of dust</p>
	<p><b>Inhalation</b></p>	<p>Inhalation of soil derived dust, organic vapours or ground generated gas. It is anticipated that there will be negligible potential for inhalation of soils or vapours at the site as they will be excavated from Storage Area 1 and re-used directly to raise the level of the bed in Cresswell Flash. The excavation, transfer and re-use of soils to raise the bed of the flash will be controlled to minimise generation of dust and vapours.</p>
<p><b>Groundwater Pathways</b> Including the following sources:</p> <ul style="list-style-type: none"> <li>• Soil Leachate</li> <li>• Perched Groundwater</li> </ul>	<p><b>Rainfall Infiltration &amp; Vertical / Lateral migration via permeable strata</b></p>	<p>Rainfall infiltration can generate and mobilise soil-derived leachate impacting on surface waters and groundwater. Groundwater beneath the site is likely to flow towards the River Sow which is located south of the site.</p>
	<p><b>Lateral Migration through Aquifer</b></p>	<p>As well as being a receptor, the natural superficial deposits being a Secondary A aquifer can allow transportation of contaminants through the permeable strata.</p>
<p><b>Gas Pathways</b> Including the following sources:</p> <ul style="list-style-type: none"> <li>• Ground gas</li> </ul>	<p><b>Vertical / Lateral Migration via permeable strata.</b></p>	<p>The generation of ground gas may occur due to high organic matter content within the Peat and Alluvial deposits. The permeable Glacio-fluvial strata may allow lateral migration of ground gases off site.</p>

**Table 3.9: Potential Pathways Storage Area 2**

<b>Potential Pathway</b>		<b>Description</b>
<b>Soil Pathway</b> Including the following sources <ul style="list-style-type: none"> <li>• Made Ground</li> <li>• Soil Derived Leachate</li> </ul>	<b>Dermal Contact</b>	Dermal contact with contaminated soils, surface water, soil derived dust, soil leachate and perched groundwater by the construction workers. Potential contaminants in the made ground may be encountered during the earthworks to excavate the FCA.
	<b>Ingestion</b>	Direct or indirect ingestion of soil and soil derived dust. Potential contaminants in the made ground may be encountered during the earthworks to excavate the FCA.
	<b>Inhalation</b>	Inhalation of soil derived dust, organic vapours or ground generated gas. Potential contaminants in the made ground may be encountered during the earthworks to excavate the FCA. .
<b>Groundwater Pathways</b> Including the following sources: <ul style="list-style-type: none"> <li>• Soil Leachate</li> <li>• Perched Groundwater</li> </ul>	<b>Rainfall Infiltration &amp; Vertical / Lateral migration via permeable strata</b>	Rainfall infiltration can generate and mobilise soil-derived leachate impacting on surface waters and groundwater. Groundwater beneath the site is likely to flow towards the River Sow which is located East of the site.
	<b>Lateral Migration through Aquifer</b>	As well as being a receptor, the natural superficial deposits being a Secondary A aquifer can allow transportation of contaminants through the permeable strata.
<b>Gas Pathways</b> Including the following sources: <ul style="list-style-type: none"> <li>• Ground gas</li> </ul>	<b>Vertical / Lateral Migration via permeable strata.</b>	The generation of ground gas may occur due to the presence of contaminants in the made ground and / or high organic matter content within the Peat and Alluvial deposits. The permeable Glacio-fluvial strata may allow lateral migration of ground gases off site.

3.4.2 The potential plausible contaminant linkages and associated risks identified for the separate sites in their proposed use as flood compensation areas (Storage Areas 1 & 2) and area of material deposition (Cresswell Flash) with associated infrastructure and landscaping are summarised below in Tables 3.10 to 3.12.

**Table 3.10: Storage Area 1**

Source		Pathway		Receptor
Ground Gases within Natural Strata	➔	Migration and diffusion via permeable strata	➔	Construction Workers Flora and Fauna Off-site receptors
Excavation of material	➔	Ingestion of contaminated soil Inhalation/ingestion of soil derived dust Inhalation of organic vapours Direct contact with soils/dusts	➔	Construction Workers Off-site receptors Future Site Users
<b>Groundwater Pathways</b> Including the following sources: <ul style="list-style-type: none"> <li>• Soil Leachate</li> <li>• Perched Groundwater</li> </ul>	➔	Rainfall Infiltration & vertical / lateral migration via permeable strata	➔	Surface water and shallow groundwater in superficial deposits
		Lateral Migration through Aquifer		Shallow groundwater in superficial deposits

**Table 3.11: Cresswell Flash**

Source		Pathway		Receptor
Deposition of excavated material into Cresswell Flash from Storage Area 1.	➔	Leaching of potential contaminants into groundwater and migration to surface watercourses	➔	Surface Watercourses (River Sow and The Darling) The Cresswell Flash itself The Secondary A Aquifer (shallow groundwater in the superficial deposits) Flora and fauna local to and in the Flash
Ground Gases (within Natural Strata)	➔	Migration and diffusion via permeable strata	➔	Construction Workers Flora and Fauna Off-site receptors
<b>Groundwater Pathways</b> Including the following sources: <ul style="list-style-type: none"> <li>• Soil Leachate</li> <li>• Perched Groundwater</li> </ul>	➔	Rainfall Infiltration & Vertical / Lateral migration via permeable strata	➔	Surface water and shallow groundwater in superficial deposits
		Lateral Migration through Aquifer		Shallow groundwater in superficial deposits

**Table 3.12: Storage Area 2**

Source		Pathway		Receptor
Diffuse metal, inorganic and organic contamination within the Made Ground	➡	Ingestion of contaminated soil Inhalation/ingestion of soil derived dust Inhalation of organic vapours Direct contact with soils/dusts	➡	Future Site Users Construction Workers Development Infrastructure Flora and Fauna Off-Site Receptors
Generated leachate from Made Ground	➡	Leaching into groundwater and migration to surface watercourses Plant uptake	➡	Surface Watercourses (River Sow and associated drains) Secondary A Aquifers Off-site Flora and Fauna
Contaminants in groundwater	➡	Migration and diffusion	➡	Surface Watercourses Single abstraction points in the vicinity of the site
Ground Gases (within Made Ground and Natural Strata)	➡	Migration and diffusion via permeable strata	➡	Construction Workers Flora and Fauna Off-site receptors

## 4 POTENTIAL IMPACTS AND SIGNIFICANT ENVIRONMENTAL EFFECTS

4.1.1 For the areas of the FCAs and the Cresswell Flash and for the purpose of identifying impacts from the proposed excavation of the FCAs, the re-use of the Storage Area 1 arisings in the Flash, and the potential re-use of Storage Area 2 arisings in the scheme earthworks, or floodplain if required, the sources/hazards can be refined into the following categories:

- Soil Contamination; specifically contaminants in the excavated materials to be re-used;
- Groundwater Contamination; specifically contamination potentially mobilised and / or caused to migrate as a result of the excavations, transport and re-use of the arisings;
- Ground Gas; and
- Surrounding current and historical land use; specifically the potential impacts on surrounding current land as a result of the works, and the implications of historical land use including former industrial uses on the quality of the land at and surrounding the proposed FCAs and the Flash.

## 4.2 Storage Area 1 and Cresswell Flash

4.2.1 The critical receptors identified for the Storage Area 1 and Cresswell Flash sites and their sensitivities for both the construction and operational phases are presented in Table 4.1:

**Table 4.1 Storage Area 1 excavations and re-use in Cresswell Flash: critical receptors and their sensitivities**

Receptor	Phase		Sensitivity (as defined in Table 9.1 of the SWAR ES)
	C	O	
Construction Workers	✓	✗	Medium
Future Site Users	✗	✓	Low
Groundwater	✓	✓	Medium
Surrounding Land Use - some residential	✓	✓	Low
Surface Waters	✓	✓	Medium
Land use (SSSI)	✓	✓	Medium

4.2.2 The type of impacts applicable to construction, and operation are described below. The assessment methodology used is the same as that outlined in Section 10.3 of the Stafford Western Access Route ES.

### Construction Phase

4.2.3 The proposed project involves the excavation of the elevated Storage Area 1 to create a wetland that will have ecological benefits. The excavated material will be deposited within an area of deep wetland (Cresswell Flash) adjacent to the FCA, or alternatively removed and disposed of off-site. This section assesses the potential impacts that could occur during the construction works.

4.2.4 During the construction phase, the use of heavy equipment and activities for excavation of Storage Area 1 and the subsequent backfilling of material into Cresswell Flash may disturb the soil and mobilise potential contaminants which have the potential to impact sensitive human receptors.

### *Impacts on Humans*

4.2.5 The human receptors that could be affected during the construction phase include construction workers, residents of surrounding properties, and members of the general public visiting/using surrounding sites. These receptors are potentially at risk from soil dust or inhalation of soil dust/vapours unless mitigation is implemented.

- 4.2.6 Residents and visitors of surrounding properties are at risk from wind-blown dust and subsequent inhalation or direct contact with dusts generated by the construction activities unless mitigation is implemented. The residents and visitors of properties between 150m and 250m are considered to be of a Medium sensitivity.
- 4.2.7 The magnitude of impact on residents and visitors of surrounding properties prior to mitigation is considered as Negligible. This is because the excavated area is comprised of natural strata and potential contamination is considered unlikely based on the ground conditions and historic/current land use. Mitigation measures will be implemented to minimise dust generation as part of the earthworks operations. As a result the impact significance prior to mitigation is classed as Negligible.
- 4.2.8 The risk to construction workers from ground gas and direct contact with contaminated leachate is considered to be Minor due to the absence of Made Ground. As a result, the impact significance prior to mitigation is classed as Minor Adverse.

*Impacts on Controlled Waters*

- 4.2.9 The groundwater beneath the site is considered to be of Medium importance. The underlying Superficial Deposits (Alluvium and Glaciofluvial deposits) and the Mercia Mudstone are classified as Secondary A and Secondary B Aquifers respectively.
- 4.2.10 The River Sow, Tillington Drain and The Darling and Creswell Flash are the main surface water receptors in the vicinity of site and they are considered to be of Medium importance. Impact assessment on the ecology of Cresswell Flash is detailed within Chapter 5, part 5.8 of the Stafford Western Access Route ES.
- 4.2.11 Potential contaminants could be mobilised during the FCA excavation and re-use works and could impact the controlled waters receptors by a combination of the following; the disturbance or exposure of contaminated materials, the direct release of contaminants or through the creation of preferential pathways.
- 4.2.12 During the construction (earthworks) phase it will be necessary to fuel and maintain a fleet of mobile plant. Potential impacts on soil and groundwater quality may arise from the uncontrolled release of fuel and oils, either by leakages/spillages from storage areas or by incorrect disposal of waste or surplus material. Impacts from physical pollution (sediments) are discussed and assessed in the Drainage and the Water Environment Chapter of the Stafford Western Access Route ES, and will be controlled by implementation of standard control measures as detailed in the Outline Construction Environmental Management Plan (OCEMP) and Contractors CEMP.

- 4.2.13 The sensitivity of the controlled waters is considered to be medium and the magnitude of impact prior to mitigation is Minor. This could lead to impacts of Minor Adverse significance if mitigation actions are not carried out.
- 4.2.14 The potential placement of excavated material, considered to consist of only natural deposits (Peat, Alluvium and Glacio-fluvial Sands and Gravel) into Cresswell Flash is considered to be of minor impact. The overall impact is considered to be Minor Adverse.

*Impacts on Areas of Planting/Landscaping*

- 4.2.15 Storage Area 1 and Cresswell Flash are located within the Doxey & Tillington Marshes SSSI.
- 4.2.16 The sensitivity of the site is therefore considered high, however the potential for vegetation and fauna to be affected by direct contact / uptake of any potential contaminants present in the natural strata and leachate is considered to be minor.
- 4.2.17 As a result the impact significance prior to mitigation is classed as Minor Adverse.

Operation Phase

- 4.2.18 This section assesses potential impacts that could occur during operation of the site as a Flood Compensation Area following completion of the works.

*Impacts on Humans*

- 4.2.19 The risk to future site users from direct contact with the underlying soils is considered Negligible due to absence of Made Ground.
- 4.2.20 Receptors which may be impacted upon during operation include maintenance workers. The risk to future users of the site has been classed as minor, considering the limited exposure to potentially contaminated soils or groundwater. Any maintenance workers involved in ground works are considered to be at risk of exposure through direct contact, inhalation or ingestion of contaminated soils, groundwater, dust or vapour.
- 4.2.21 The risk to maintenance workers from ground gas is considered to be Minor within the operation phase. As a result the impact significance prior to mitigation is classed as Minor Adverse.
- 4.2.22 The sensitivity of human receptors during the operation phase is Low to Medium and the magnitude of impact prior to mitigation is Negligible. Therefore the impact significance on human receptors prior to mitigation is Negligible.

*Impacts on Controlled Water*

- 4.2.23 The proposed development does not include activities that are likely to generate contaminants that could pose substantial risk to the soil or controlled waters.
- 4.2.24 The sensitivity of the controlled waters is medium and the magnitude of impact prior to mitigation is minor and thus the impact on controlled water is considered to be of Minor Adverse significance.

*Impacts on Areas of Landscaping*

- 4.2.25 The proposed scheme is to provide a Flood Compensation Area. The sensitivity of landscape, being an existing floodplain and a SSSI, is considered high and the magnitude of impact prior to mitigation is to be Minor. This could lead to impacts of Minor Adverse significance, although the ultimate end use is considered beneficial, which is the aim of the construction of the Flood Compensation Area.

**4.3 Storage Area 2**

- 4.3.1 The critical receptors identified for Storage Area 2 sites and their sensitivities for both the construction and operational phases are presented in Table 4.2:

**Table 4.2 Critical receptors and their sensitivities**

Receptor	Phase		Sensitivity (as defined in Table 9.1 of the SWAR ES)
	C	O	
Construction Workers	✓	✗	Medium
Future Site Users	✗	✓	Low
Groundwater	✓	✓	Medium
Surrounding Land Use – some surrounding residential and commercial and also undeveloped fields and the Doxey & Tillington Marshes SSSI.	✓	✓	Medium
Surface Waters	✓	✓	Medium
Land use- end use as a flood compensation area	✗	✓	High

Construction

- 4.3.2 The proposed project involves the excavation of bound material (the tarmac surface layer) from the car park in order to create a Flood Compensation Area. The excavated material will be re-used within the scheme earthworks, disposed to landfill or if required and chemically acceptable within the surrounding floodplain. This section assesses the potential impacts that could occur during the construction works.

*Impacts on Humans*

- 4.3.3 The potential areas and sources of contamination within the vicinity of the scheme have been described in Sections 2 and 3.
- 4.3.4 During the construction phase, the use of heavy equipment and activities such as demolition of structures and excavation may disturb the soil and mobilise potential contaminants which may impact sensitive human receptors.
- 4.3.5 The human receptors that could be affected during the construction phase include construction workers, residents of surrounding properties, and members of the general public visiting/using surrounding sites. These receptors are at risk from direct contact / ingestion of potentially contaminated soil / soil dust or inhalation of potentially contaminated soil dust / vapour.
- 4.3.6 Residents and visitors of surrounding properties are at risk from wind-blown dust and subsequent inhalation or direct contact with dusts or vapours generated by the construction activities. The residents and visitors of properties within 50m are considered to be of a Low sensitivity, while the residents and visitors of properties between 50m and 250m are considered to be of a Medium sensitivity.
- 4.3.7 The Made Ground present on site has been reported to have a slight gas works odour and to contain gas works waste of ash and burnt shale. Since the tarmac overlying the Made Ground will be removed it is likely that construction workers will come into contact with the Made Ground. The magnitude of impact on construction workers prior to mitigation is considered as moderate. As a result the impact significance prior to mitigation is classed as Moderate Adverse.
- 4.3.8 The magnitude of impact to residents of surrounding properties, and members of the general public visiting/using surrounding sites prior to mitigation is considered as minor. As a result the impact significance prior to mitigation is classed as Negligible.
- 4.3.9 The risk to construction workers from ground gas is considered to be Moderate. As a result the impact significance prior to mitigation is classed as Moderate Adverse.
- 4.3.10 The risk to construction workers from direct contact with contaminated leachate or groundwater is also considered Moderate.

*Impacts on Controlled Water*

- 4.3.11 The groundwater beneath the site is considered to be of Medium importance. The underlying Superficial Deposits (Alluvium and Glaciofluvial deposits) and the Mercia Mudstone are classified as Secondary A and Secondary B Aquifers respectively. The River Sow and associated drains to the West of the site are the main surface water receptors in the vicinity of site and they are considered to be of Medium importance.

- 4.3.12 Potential contaminants could be mobilised during construction works and could impact the controlled waters receptors by a combination of the following; the disturbance or exposure of contaminated materials, the direct release of contaminants or through the creation of preferential pathways.
- 4.3.13 During the construction phase it will be necessary to fuel and maintain some mobile plant. Potential impacts on soil and groundwater quality may arise from the uncontrolled release of fuel and oils, either by leakages/spillages from storage areas or by incorrect disposal of waste or surplus material. Impacts from physical pollution (sediments) are discussed and assessed in the Drainage and the Water Environment Chapter of the Stafford Western Access Route ES, and will be controlled by implementation of standard control measures as detailed in the Outline Construction Environmental Management Plan (OCEMP) and Contractors CEMP.
- 4.3.14 The sensitivity of the controlled waters is Medium and the magnitude of impact prior to mitigation is Moderate. This could lead to impacts of Moderate Adverse significance if mitigation actions are not carried out.
- 4.3.15 The re-use of excavated tarmac/bound material, which is currently in direct contact with the underlying made ground which contains gas works contaminants, within the scheme earthworks is considered to be of Moderate magnitude. This gives an overall impact significance of Moderate Adverse.

*Impacts on Areas of Planting/Landscaping*

- 4.3.16 Various areas of planting / landscaping including undeveloped fields and the Doxey & Tillington Marshes SSSI are present in the vicinity of the site.
- 4.3.17 The potential for vegetation and fauna to be affected by direct contact / uptake of contaminants potentially present in Made Ground soils, and leachate may exist. The sensitivity of the areas of planting / landscaping is considered to be High and the magnitude of impact prior to mitigation is minor. As a result the impact significance prior to mitigation is classed as minor adverse.

Operation Phase

- 4.3.18 This section assesses potential impacts that could occur during operation of the scheme after the completion of the excavation and creation of a Flood Compensation Area.

*Impacts on Humans*

- 4.3.19 Receptors which may be impacted upon during operation include maintenance workers. The risk to future users of the site has been classed as Moderate, considering the presence of Made Ground which will be exposed once the tarmac has been removed. This means that future site users may be exposed to potentially contaminated soils or groundwater. Any maintenance workers involved in ground works are considered to be at risk of exposure through direct

contact, inhalation or ingestion of contaminated soils, groundwater, dust or vapour and are also considered to be at moderate risk.

- 4.3.20 The sensitivity of human receptors during the operation phase is Medium and the magnitude of impact prior to mitigation is Moderate. Therefore the impact significance on human receptors prior to mitigation is Moderate Adverse.
- 4.3.21 The risk to maintenance workers from ground gas is considered to be Moderate within the operation phase. As a result the impact significance prior to mitigation is classed as Moderate Adverse.

#### *Impacts on Controlled Water*

- 4.3.22 The proposed development includes activities that have the potential to generate contaminants that could pose substantial risk to the soil or controlled waters.
- 4.3.23 The sensitivity of the controlled waters is Medium and the magnitude of impact prior to mitigation is considered Moderate due to the presence of Made Ground containing gas works contaminants. The absence of hardstanding means that the possible contamination may be able to migrate into the underlying Secondary A aquifers and runoff into surface watercourses. Thus the impact on controlled water is considered to be of Moderate Adverse significance.

#### *Impacts on Areas of Landscaping*

- 4.3.24 The Flood Compensation Area will be planted with landscaping to complement SSSI habitats. This will include wet woodland and scrub and wet grassland/swamp see planning drawing SWAR/PLANNING/26.
- 4.3.25 The sensitivity of landscape vegetation of the site in its proposed end-use is considered to be High and the magnitude of impact prior to mitigation is Moderate. This is because the potential contamination with the Made Ground could potentially affect fauna via root uptake. This could lead to impacts of Moderate Adverse significance if mitigation actions are not carried out.

## **5 PROPOSED MITIGATION AND RESIDUAL EFFECTS**

### **5.1 Storage Area 1 and Cresswell Flash- Construction Phase**

#### Impacts on Human Receptors

- 5.1.1 The mitigation process will include undertaking ground investigation works in Storage Area 1 to allow for a quantitative risk assessment to be undertaken. Following the results of the ground investigation and quantitative risk assessment a remediation and / or reclamation strategy may need to be developed to mitigate hazards in natural strata such as the Peat Deposits, which contain a high organic matter content associated with the production of ground gases that can pose a risk to human health.

- 5.1.2 Potential impacts specific to construction workers during construction will be mitigated by the following measures and through working in accordance with CIRIA C692 3rd Edition 'Environmental Good Practice On Site' (2010):
- measures to minimise dust generation;
  - provision of personal protective equipment (PPE), such as gloves, barrier cream, overalls etc. to minimise direct contact with soils;
  - provision of adequate hygiene facilities and clean welfare facilities for all construction site workers;
  - monitoring of confined spaces for potential ground gas accumulations, restricting access to confined spaces, i.e. by suitably trained personnel, and use of specialist PPE, where necessary; and
  - preparation and adoption of a site and task specific health and safety plan.
- 5.1.3 The potential impacts to off-site receptors will be addressed through the adoption of the following measures:
- damping of ground with water to minimise dust;
  - sheeting of lorries transporting spoil off site and the use of dust suppression equipment on plant;
  - temporary groundwater level controls (as required);
  - adequate fuel/chemical storage facilities e.g. bunded tanks, hard standing and associated emergency response/spillage control procedures;
  - well maintained plant and associated emergency response/spillage control procedures; and,
  - any temporary onsite storage of contaminated material, although unlikely to be necessary, will be stored on sheeting and covered to minimise the potential for leachate and run off from the stockpile being generated.
- 5.1.4 Works will be controlled by implementation of standard control measures as detailed in the Outline Construction Environmental Management Plan (OCEMP) and Contractors CEMP.
- 5.1.5 It is recommended that gas monitoring is conducted prior to works to ascertain the potential risk to human health, and, if necessary, to find a plausible remediation solution.
- 5.1.6 The sensitivity of the human receptors is Low to Medium and the magnitude of impact after mitigation is Negligible. Therefore, the impact on human receptors after mitigation is considered to be of Negligible significance.

#### Impacts on Controlled Waters

- 5.1.7 Part of the mitigation process for potential impacts on controlled waters will be to undertake additional ground investigation for the scheme to include installation of

monitoring wells with targeted response zones, groundwater level monitoring and chemical testing to determine the presence of any leachable contaminants in groundwater.

- 5.1.8 The mitigation measures would aim at ensuring the surface water run-off from the site during the site preparation and excavation works does not have a detrimental effect on the receiving watercourse (River Sow, Creswell Flash, Tillington Drain and The Darling) and the underlying Secondary Aquifers. The surface water run-off would be controlled using appropriate drainage measures and infiltration into the ground would be minimised. The principal risk during the works is the generation of suspended solids causing turbidity and associated contamination in surface waters. Mitigation should therefore aim to minimize turbidity and should take measures to settle out suspended solids in any water disturbed by the works. This would also minimise the potential for any soil-borne contaminants to migrate to controlled waters.
- 5.1.9 In addition the prevention of pollution of controlled waters will comply with the requirements of the following Environment Agency Pollution Prevention Guideline documents:
- PPG1 General Guide to the Prevention of Pollution (2013);
  - PPG5 Works or Maintenance in or near Water (2007);
  - PPG6 Working at Construction and Demolition Sites (2012);
  - PPG21 Incident Response Planning (2009).
- 5.1.10 Works will be controlled by implementation of standard control measures as detailed in the Outline Construction Environmental Management Plan (OCEMP) and Contractors CEMP.
- 5.1.11 The sensitivity of the controlled waters is Medium and the magnitude of impact after mitigation is Negligible. Therefore, the impact on controlled waters after mitigation is considered to be of Negligible significance.
- 5.1.12 The impact of the placement of excavated material from Storage Area 1 into the Cresswell Flash is considered to be of Moderate magnitude. This gives an overall impact significance that is Moderate. However, depending on the ecological impact of depositing material within Cresswell Flash (addressed within chapter 5, part 5.8 of ES) a possible mitigation strategy would be to despatch the excavated bound material to landfill, or alternatively to incorporate the material into the general Earthworks associated with the Stafford Western Access Route Development. A re-use of the material in the highway earthworks could place the material relatively remote from surface waters and / or shallow groundwater. Following such mitigation measures the impact would be considered to be Negligible.

#### Impacts on Areas of Planting / Landscaping

- 5.1.13 Potential impacts specific to contamination impacting on vegetation along the route will be mitigated by the following measures and following the guidance within the Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (DEFRA, 2009).
- The source of 'soil material' shall be investigated carefully with respect to its suitability for the intended use.
  - 'Soil material' shall be handled only in the appropriate conditions of weather and soil moisture, and with suitable machinery.
  - The stockpiling of 'soil materials' shall be avoided whenever possible. Where stockpiling is unavoidable, heaps shall be tipped loosely and the surface firmed and shaped to shed water.
- 5.1.14 The sensitivity of areas of landscaping along the route is considered to be medium and the magnitude of impact prior to mitigation is Minor but dependent on findings of further work. Therefore, the impact significance following the implementation of mitigation measures is considered likely to be Negligible.

## **5.2 Storage Area 1 and Cresswell Flash- Operation Phase**

### Impacts on Human Receptors

- 5.2.1 For maintenance workers during the operation phase, any maintenance works should be carried out in accordance with CIRIA C692 3rd Edition 'Environmental Good Practice on Site' (2010). Maintenance workers should be provided with appropriate personal protective equipment (PPE) such as gloves and overalls to minimise direct contact with soils. Also any entry into excavations or confined spaces should comply with confined space legislation and assessed prior to entry. Should there be any changes to the proposed development to incorporate any confined spaces such as ducts, manholes and inspection chambers, it is recommended that a gas monitoring programme and gas risk assessment be undertaken to determine the site Characteristic Situation in accordance with CIRIA Report C665.
- 5.2.2 The sensitivity of the human receptors is Minor to Medium and the magnitude of impact after mitigation is Negligible. Therefore, the impact on human receptors after mitigation is considered to be of Negligible significance.

### Impacts on Controlled Waters

- 5.2.3 The proposed development does not include activities that are likely to generate contaminants that could pose substantial risk to controlled waters. The sensitivity of the controlled waters is medium and the magnitude of impact prior to mitigation is minor. Depending on the results of a ground investigation and contamination assessment, the impact on controlled waters could be considered to be of Negligible significance.

Impacts on areas of Landscaping

- 5.2.4 The sensitivity of areas of vegetation and fauna is considered to be medium and the magnitude of impact prior to mitigation is Minor. The potential for vegetation and fauna to be affected by direct contact / uptake of any potential contaminants present in the natural strata and leachate is considered likely to be minor.
- 5.2.5 Therefore, the impact on vegetation within areas of landscaping after mitigation has an objective to be of Negligible significance.

**5.3 Storage Area 2 - Construction Phase**

Impacts on Human Receptors

- 5.3.1 The mitigation process will include undertaking ground investigation works in Storage Area 2 to allow for a quantitative risk assessment to be undertaken. A remediation and / or reclamation strategy informed by the ground investigation and qualitative risk assessment may be necessary to mitigate materials associated with Made Ground within Storage Area 2 that pose a risk to human health and/or controlled waters depending on the findings of the additional ground investigation. It is noted that the tarmac surfacing of the existing car park is in direct contact with made ground containing gas works contaminants.
- 5.3.2 Any asbestos contaminated material encountered during the earthworks would require an appropriate Health and Safety Plan to remove and dispose of it in a safe manner in accordance with the Construction (Design and Management) Regulations 2015.
- 5.3.3 Potential impacts specific to construction workers during construction will be mitigated by the following measures and through working in accordance with CIRIA C692 3rd Edition 'Environmental Good Practice On Site' (2010):
- measures to minimise dust generation;
  - provision of personal protective equipment (PPE), such as gloves, barrier cream, overalls etc. to minimise direct contact with soils;
  - provision of adequate hygiene facilities and clean welfare facilities for all construction site workers;
  - monitoring of confined spaces for potential ground gas accumulations, restricting access to confined spaces, i.e. by suitably trained personnel, and use of specialist PPE, where necessary; and
  - preparation and adoption of a site and task specific health and safety plan.
- 5.3.4 The potential impacts to off-site receptors will be addressed through the adoption of the following measures:
- damping of ground with water to minimise dust;

- sheeting of lorries transporting spoil off site and the use of dust suppression equipment on plant;
- groundwater level controls (as required);
- adequate fuel/chemical storage facilities e.g. bunded tanks, hard standing and associated emergency response/spillage control procedures;
- well maintained plant and associated emergency response/spillage control procedures; and,
- any temporary onsite storage of contaminated material will be stored on sheeting and covered to minimise the potential for leachate and run off from the stockpile being generated.

5.3.5 Works will be controlled by implementation of standard control measures as detailed in the Outline Construction Environmental Management Plan (OCEMP) and Contractors CEMP.

5.3.6 The sensitivity of the human receptors is Low to Medium and the magnitude of impact after mitigation is Negligible. Therefore, the impact on human receptors after mitigation is considered to be of Negligible significance.

#### Impacts on Controlled Waters

5.3.7 To mitigate the potential impacts on controlled waters, additional ground investigation for the scheme will need to include installation of monitoring wells with targeted response zones, groundwater level monitoring and chemical testing to determine the presence of any leachable contaminants in groundwater.

5.3.8 The mitigation measures would aim at ensuring the surface water run-off from the site during the site preparation and works does not have a detrimental effect on the receiving watercourse (River Sow and associated drains) and the underlying Secondary Aquifers. The surface water run-off would be controlled using appropriate drainage measures and infiltration into the ground would be minimised. The principal risk during the works is the generation of suspended solids causing turbidity in surface waters. Mitigation should therefore aim to minimize turbidity and should take measures to settle out suspended solids in any water disturbed by the works. This would also minimise the potential for any soil-borne contaminants to migrate to controlled waters.

5.3.9 This would minimise the potential for potential contaminants to migrate to controlled waters.

5.3.10 In addition the prevention of pollution of controlled water will comply with the requirements of the following Environment Agency Pollution Prevention Guideline documents:

- PPG1 General Guide to the Prevention of Pollution (2013);
- PPG5 Works or Maintenance in or near Water (2007);

- PPG6 Working at Construction and Demolition Sites (2012); and
- PPG21 Incident Response Planning (2009).

- 5.3.11 Works will be controlled by implementation of standard control measures as detailed in the Outline Construction Environmental Management Plan (OCEMP) and Contractors CEMP.
- 5.3.12 The sensitivity of the controlled waters is Medium and the magnitude of impact after mitigation is Negligible but dependent on findings of further work. Therefore, the impact on controlled waters after mitigation is considered likely to be of Negligible significance.
- 5.3.13 The re-use of excavated tarmac/bound material within the scheme earthworks is considered to be of Moderate magnitude. This gives an overall impact significance of Moderate Adverse. This will be mitigated by only using excavated materials that meet chemical acceptability criteria for reuse within the scheme and/or the disposal excavated bound material to landfill. The tarmac/bound material, if found to be acceptable following detailed quantitative risk assessment and those additional materials are required to raise site levels, may be placed onto the surrounding floodplain.. Following such mitigation measures the impact is considered to be Negligible.

#### Impacts on Areas of Planting / Landscaping

- 5.3.14 The sensitivity of areas of vegetation and fauna is considered to be medium and the magnitude of impact prior to mitigation is Minor but dependent on findings of further work. Therefore, the impact on vegetation within areas of landscaping after mitigation is considered likely to be of Negligible significance.

### **5.4 Storage Area 2- Operation Phase**

#### Impacts on Human Receptors

- 5.4.1 The risk to future site users from direct contact with the underlying soils, contaminated leachate or groundwater is considered Moderate. The proposed future development of the site as a Flood Compensation Area is unlikely to contain hardstanding, and therefore the potential contaminant linkage will not be reduced. As stated in paragraphs 5.1.1 to 5.1.6 the mitigation process could include undertaking ground investigation works in the Southern Flood Compensation Area to allow for a quantitative risk assessment to be undertaken. A remediation and / or reclamation strategy informed by the ground investigation and qualitative risk assessment may be necessary to mitigate materials associated with Made Ground.
- 5.4.2 For maintenance workers during the operation phase, any maintenance works should be carried out in accordance with CIRIA C692 3rd Edition 'Environmental Good Practice on Site' (2010). Maintenance workers should be provided with appropriate personal protective equipment (PPE) such as gloves and overalls to

minimise direct contact with soils. Also any entry into excavations or confined spaces should comply with confined space legislation and assessed prior to entry. Should there be any changes to the proposed development, incorporate any confined spaces such as ducts, manholes and inspection chambers, it is recommended that a gas monitoring programme and gas risk assessment be undertaken to determine the site Characteristic Situation in accordance with CIRIA Report C665

- 5.4.3 The sensitivity of the human receptors is low to medium and the magnitude of impact after mitigation is negligible. Therefore, the impact on human receptors after mitigation is considered to be of Negligible significance.

#### Impacts on Controlled Waters

- 5.4.4 As noted in Paragraph 4.3.22-23 the proposed development includes activities that have the potential to generate contaminants that could pose substantial risks to controlled waters. To mitigate the impacts on controlled waters from Made Ground during the operation stage, depending on the results of a ground investigation and contamination assessment, suitable drainage systems could be employed during the construction and this would largely limit infiltration of surface water or potential contaminants into the ground during the operation phase.
- 5.4.5 The sensitivity of the controlled waters is medium and the magnitude of impact after mitigation is negligible. Therefore, the impact on controlled waters after mitigation is considered to be of negligible significance.

#### Impacts on areas of Landscaping

- 5.4.6 Potential impacts specific to contamination impacting on vegetation along the route will be mitigated by the following measures and following the guidance within the Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (DEFRA, 2009).
- The source of 'soil material' shall be investigated carefully with respect to its suitability for the intended use.
  - 'Soil material' shall be handled only in the appropriate conditions of weather and soil moisture, and with suitable machinery.
  - The stockpiling of 'soil materials' shall be avoided whenever possible. Where stockpiling is unavoidable, heaps shall be tipped loosely and the surface firmed and shaped to shed water.
- 5.4.7 The sensitivity of areas of landscaping along the route is considered to be medium and the magnitude of impact prior to mitigation is Minor but dependent on findings of further work. Therefore, the impact significance following the implementation of mitigation measures is considered likely to be Negligible.

**5.5 Residual Effects**

5.5.1 The residual effects following the implementation of the mitigation measures are summarised in tables 5.1 to 5.3 below.

**Table 5.1: Summary of Residual Effects for Storage Area 1 and Creswell Flash**

<b>Effect</b>	<b>Duration</b>	<b>Sensitivity / Value</b>	<b>Effect Magnitude</b>	<b>Effect Significance Pre Mitigation</b>	<b>Mitigation Measures</b>	<b>Significance of Residual Effect*</b>
<b>Construction</b>						
Construction worker health and safety: exposure to potential contaminated land	Short Term	<b>Medium</b>	<b>Minor</b>	<b>Minor Adverse</b>	Refer to Mitigation Section 5.1	<b>Negligible</b>
Construction worker health and safety: exposure to ground gas	Short Term	<b>Medium</b>	<b>Minor</b>	<b>Minor Adverse</b>		<b>Negligible</b>
Surrounding land users: exposure to potential contaminated soil dust	Short Term	<b>Low</b>	<b>Negligible</b>	<b>Negligible</b>		<b>Negligible</b>
Surface Water Quality: reduction in quality from uncontrolled release of pollutants	Short and Long Term	<b>Medium</b>	<b>Minor</b>	<b>Minor Adverse</b>		<b>Negligible</b>
Surface Water Quality: reduction in quality due to earthworks and impacted groundwater migration	Short and Long Term	<b>Medium</b>	<b>Minor</b>	<b>Minor Adverse</b>		<b>Negligible</b>
Groundwater Quality: reduction in quality from uncontrolled release of pollutants	Short and Long Term	<b>Medium</b>	<b>Minor</b>	<b>Minor Adverse</b>		<b>Negligible</b>
Groundwater Quality: reduction in quality due to earthworks and disturbance of potential contaminated ground	Short and Long Term	<b>Medium</b>	<b>Minor</b>	<b>Minor Adverse</b>		<b>Negligible</b>
Doxey and Tillington Marshes SSSI exposure to contaminated soil dust	Short and Long Term	<b>High</b>	<b>Minor</b>	<b>Minor Adverse</b>		<b>Negligible</b>
Contamination of areas of planting / landscaping	Short Term	<b>High</b>	<b>Minor</b>	<b>Minor Adverse</b>		<b>Negligible</b>
Placement of excavated material into Creswell Flash	Long Term	<b>Medium</b>	<b>Minor</b>	<b>Minor Adverse</b>		<b>Negligible</b>

<b>Operation</b>						
Future site users and maintenance workers	Long Term	<b>Low to Medium</b>	<b>Negligible</b>	<b>Minor Adverse</b>	Refer to Mitigation Section 5.1	<b>Negligible</b>
Groundwater Quality: reduction in quality from the uncontrolled release of pollutants	Short and Long Term	<b>Medium</b>	<b>Minor</b>	<b>Minor Adverse</b>		<b>Negligible</b>
Surface Water Quality: reduction in quality due to impacted groundwater migration	Short and Long Term	<b>Medium</b>	<b>Minor</b>	<b>Minor Adverse</b>		<b>Negligible</b>
Contamination of areas of planting / landscaping	Short and Long Term	<b>High</b>	<b>Minor</b>	<b>Minor Adverse</b>		<b>Negligible</b>

\* *Based on current understanding and subject to further work*

**Table 5.2: Summary of Residual Effects for the Storage Area 2**

<b>Effect</b>	<b>Duration</b>	<b>Sensitivity / Value</b>	<b>Effect Magnitude</b>	<b>Effect Significance Pre Mitigation</b>	<b>Mitigation Measures</b>	<b>Significance of Residual Effect*</b>
<b>Construction</b>						
Construction worker health and safety: exposure to potential contaminated land	Short Term	<b>Medium</b>	<b>Moderate</b>	<b>Moderate Adverse</b>	Refer to Mitigation Section 5.2	<b>Negligible</b>
Construction worker health and safety: exposure to ground gas	Short Term	<b>Medium</b>	<b>Moderate</b>	<b>Moderate Adverse</b>		<b>Negligible</b>
Surrounding land users: exposure to potential contaminated soil dust	Short Term	<b>Low</b>	<b>Minor</b>	<b>Minor Adverse</b>		<b>Negligible</b>
Surface Water Quality: reduction in quality from uncontrolled release of pollutants	Short and Long Term	<b>Medium</b>	<b>Moderate</b>	<b>Moderate Adverse</b>		<b>Negligible</b>
Surface Water Quality: reduction in quality due	Short and Long	<b>Medium</b>	<b>Moderate</b>	<b>Moderate</b>		<b>Negligible</b>

to earthworks and impacted groundwater migration	Term			<b>Adverse</b>		
Groundwater Quality: reduction in quality from uncontrolled release of pollutants	Short and Long Term	<b>Medium</b>	<b>Moderate</b>	<b>Moderate Adverse</b>		<b>Negligible</b>
Groundwater Quality: reduction in quality due to earthworks and disturbance of potential contaminated ground	Short and Long Term	<b>Medium</b>	<b>Moderate</b>	<b>Moderate Adverse</b>		<b>Negligible</b>
Doxey and Tillington Marshes SSSI exposure to contaminated soil dust	Short and Long Term	<b>Medium</b>	<b>Minor</b>	<b>Minor Adverse</b>		<b>Negligible</b>
Contamination of areas of planting / landscaping	Long Term	<b>High</b>	<b>Minor</b>	<b>Minor Adverse</b>		<b>Negligible</b>
Placement of excavated material within scheme earthworks		<b>High</b>	<b>Moderate</b>	<b>Moderate Adverse</b>		<b>Negligible</b>
<b>Operation</b>						
Future users and maintenance workers	Long Term	<b>Low/ Medium</b>	<b>Moderate</b>	<b>Minor/Moderate Adverse</b>	Refer to Mitigation Section 5.2	<b>Negligible</b>
Groundwater Quality: reduction in quality from the uncontrolled release of pollutants	Short and Long Term	<b>Medium</b>	<b>Moderate</b>	<b>Moderate Adverse</b>		<b>Negligible</b>
Surface Water Quality: reduction in quality due to impacted groundwater migration	Short and Long Term	<b>Medium</b>	<b>Moderate</b>	<b>Moderate Adverse</b>		<b>Negligible</b>
Contamination of areas of planting / landscaping	Short and Long Term	<b>High</b>	<b>Moderate</b>	<b>Moderate Adverse</b>		<b>Negligible</b>

\* **Based on current understanding and subject to further work**

## **6 CONCLUSIONS**

- 6.1.1 A number of potential impacts of varying significance to receptors, associated with geology, soils and contamination have been identified for three sites related to the creation of two Storage Areas and the raising of the bed of Cresswell Flash. These potential impacts have been considered and assessed within the context of the proposed development of the two Storage Areas and their use, and also an assessment of the third feature, Cresswell Flash, into which some excavated material is proposed to be deposited. Mitigation that is designed to protect the identified receptors susceptible to impacts from contamination in soils, soil leachate and groundwater and ground stability has been set out. The residual significance of the impacts identified is considered to be negligible following the implementation of the mitigation measures.
- 6.1.2 It is recommended that ground investigation works are undertaken within both Storage Areas, to allow human health, controlled water and ground gas risk assessments and geotechnical assessment for the areas. A remediation and/or reclamation strategy may be necessary depending on the findings of the additional ground investigation.
- 6.1.3 Works will be controlled by implementation of standard control measures as detailed in the Outline Construction Environmental Management Plan (OCEMP) and Contractors CEMP. These will include mitigation measures determined following detailed site investigation and agreed with NE and SWT.

## **7 REFERENCES**

- 7.1.1 References as the same as per those set out in Chapter 10, section 10.12 of the SWAR Environmental Statement with the addition of;
- DOE Industry Profile: Gas works, coke works and other coal carbonisation plants (1995)
- Environment Agency (2009) Annex B Humber River Basin District.
- DEFRA, 2009 Construction Code of Practice for the Sustainable Use of Soils on Construction Sites