

9. GEOLOGY HYDROLOGY AND HYDROGEOLOGY

Introduction

- 9.1 This chapter details the local geology, hydrogeology and hydrology of the application site and surrounding area and identifies potential geological, hydrogeological and hydrological impacts associated with the proposed development.
- 9.2 Ardley Quarry Landfill currently has a valid planning permission and PPC permit for the landfilling of controlled wastes. The proposed EfW development will require amendments to the approved landfill form and phasing, but does not involve an increase in the 'footprint' of the landfill; the landfill footprint will actually be reduced under the proposals. The currently permitted landuse for landfilling is therefore not changed. A variation to the PPC permit will be required and potential impacts will be considered at that stage.
- 9.3 Impacts are considered for the initial assessment assuming that no mitigation is in place, before discussing appropriate mitigation measures and reassessing residual impacts. The assessment is based on a baseline description of the local hydrogeological and hydrological regimes. A flood risk assessment and surface water management scheme are also presented.

Site Setting

- 9.4 The proposed development is located at Ardley Quarry Landfill in Oxfordshire, approximately 20km north of Oxford, 4km north-east of Bicester and 1km south of the village Ardley. Limestone was extracted from the quarry creating a void that is currently being restored by landfilling. The landfill is licensed to accept non-hazardous and stable non-reactive hazardous waste in the form of asbestos only. Historically the site has accepted hazardous waste but this ceased on the 16th of July 2004¹ in accordance with the Landfill (England and Wales) Regulations 2002. The EfW will be located in the south-eastern part of the quarry void and when landfilling is complete will be surrounded by waste. The footprint of the EfW itself will not, however, be located on waste material.

¹ SLR Consulting Ltd, August 2007, Ardley Landfill Site: PPC Permit Variation Supporting Statement, Ref 402.0036.00295

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- 9.5 A railway cutting and active limestone quarry lie adjacent to the northern boundary of the landfill and the Gagle Brook and M40 are located to the east. An historic landfill in an old quarry, Ardley Wood, was run by three different operators from the 1940's to the 1980's. Ardley Wood accepted commercial, industrial, household and liquid sludge wastes and is situated approximately 2km to the north-west of the proposed EfW site. A large surface water lagoon is situated in the south-east corner of the current Ardley landfill site and is south-south-east of the proposed EfW location. It currently receives surface water drainage from the landfill site and is in hydraulic continuity with the groundwater. During wet periods water is pumped from the pond to the Gagle Brook under the conditions of the site's Environmental Permit.
- 9.6 The old quarry (Ardley Wood) and railway cutting to the north of the site have been designated a SSSI². It is designated for its geological and ecological features. The cutting shows the whole of the shallow geological sequence (the Bathonian lithology) and is a key site for its fossil marker horizons and sedimentary features. Due to the geological beds the flora has become distinctive in the different soil horizons. The limestone in the SSSI has important grassland which gives rise to rare flora and fauna for Oxfordshire but the grassland is declining due to inappropriate scrub control.²

Policy Context

- 9.7 The development of the proposed site would be undertaken using technical guidance, relevant Pollution Prevention Guidelines and other codes of best practice in order to limit the potential for contamination of ground and surface waters, the potential for flooding to be caused by the development, and other potential impacts. The development of the site would be in accordance with the following:
- Control of Pollution Act 1974;
 - Environment Act 1995;
 - the Environment Agency's statutory obligations over the management and control of pollution into water;
 - EC Water Framework Directive (2000/60/EC);
 - Environment Agency - Pollution Prevention Guidelines (see below);
 - The SUDS Manual - C697 (CIRIA, 2007);
 - Control of Water Pollution from Linear Construction Projects – C648 (CIRIA, 2007);
 - Code of Practice for Site Investigations, BS5930;
 - Environmental Good Practice on Site C650 (CIRIA 2005);
 - Planning Policy Statement 25: Development and Flood Risk, Published by Department for Communities and Local Government, December 2006.

² Natural England website, www.naturalengland.org.uk, visited 27/6/08.

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9.8 The Pollution Prevention Guidelines identified below are the principal documents used for guidance on preventing water pollution and erosion from construction activities and are jointly produced by the Environment Agency for England and Wales, Scottish Environment Protection Agency and the Environment and Heritage Service in Northern Ireland and are available via the EA's website (www.environment-agency.gov.uk):

- PPG1: General Guide to the Prevention of Pollution;
- PPG2: Above Ground Oil Storage Tanks;
- PPG3: Use and Design of Oil Separators in Surface Water Drainage Systems;
- PPG4: Disposal of Sewage where no Mains Drainage is Available;
- PPG5: Works in, Near, or Liable to Affect Watercourses;
- PPG6: Working at Construction and Demolition Sites;
- PPG8: Storage and Disposal of Used Oils;
- PPG18: Managing Firewater and Major Spillages;
- PPG21: Pollution Incident Response Planning;
- PPG22: Dealing with Spillages on Highways; and
- PPG23: Maintenance of Structures over Water.

Methodology

9.9 A qualitative risk assessment methodology has been applied, in which the probability that an impact occurs and the magnitude of the impact, if it were to occur, are considered. These are combined to determine the 'Significance' of the impact. This approach provides a mechanism for identifying the areas where mitigation measures are required, and for identifying mitigation measures appropriate to the risk presented by the development. This approach allows effort to be focused on reducing risk where the greatest benefit may result. Mitigation is considered necessary where the significance of the impact is assessed as 'medium' or higher. The assessment of significance is outlined in Table 9-1.

**Table 9-1
Matrix used to Identify the Significance of an Impact**

Probability of Occurrence	Magnitude of Potential Impacts			
	Severe	Moderate	Mild	Negligible
High	High	High	Medium	Low
Medium	High	Medium	Low	Near zero
Low	Medium	Low	Low	Near zero
Negligible	Low	Near zero	Near zero	Near zero

9.10 The definition of degrees of magnitude for various examples of potential impacts in terms of hydrogeology and hydrology are detailed in Table 9-2.

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**Table 9-2
Magnitude of Potential Hydrogeological and Hydrological Impacts**

Magnitude	Potential Impact
Negligible	No impact or alteration to existing important geological environs; No alteration or very minor changes with no impact to watercourses, hydrology, hydrodynamics, erosion and sedimentation patterns; No alteration to groundwater recharge or flow mechanisms; and No pollution or change in water chemistry to either groundwater or surface water.
Mild	Some loss of soils with no long term impact; Minor or slight changes to the watercourse, hydrology or hydrodynamics; Changes to site resulting in slight increase in runoff well within the drainage system capacity; Minor changes to erosion and sedimentation patterns; and Minor changes to the water chemistry.
Moderate	Slope failure or instability which may cause foundation problems, loss of extensive areas of peat or agricultural soil, damage to important geological structures/features; Some fundamental changes to watercourses, hydrology or hydrodynamics; Changes to site resulting in an increase in runoff within system capacity; Moderate changes to erosion and sedimentation patterns; and Moderate changes to the water chemistry of surface runoff and groundwater.
Severe	Slope failure or instability which causes loss of life, permanent degradation and loss of important geological feature. Wholesale changes to watercourse channel, route, hydrology or hydrodynamics; Changes to site resulting in an increase in runoff with flood potential and also significant changes to erosion and sedimentation patterns; and Major changes to the water chemistry or hydro-ecology.

Sources of Information

9.11 The following sources of information have been consulted in order to investigate the geology, hydrogeology and hydrology of the area surrounding the application site:

- British Geological Survey Sheet 1:50,000 scale, Sheet No. 219 (Solid and Drift Edition) – Buckingham, 2002;
- Environment Agency Groundwater Vulnerability Map 1:100,000 scale, Sheet 30, North Cotswolds;
- Environment Agency Website (www.environment-agency.gov.uk);
- Natural England Website (www.naturalengland.org.uk);
- Landmark Envirocheck report, May 2008;
- Centre of Ecology and Hydrology (CEH Wallingford), Flood Estimation Handbook CD ROM (2006);
- Ministry of Agriculture, Fisheries and Food (MAFF) Technical Bulletin 34 Climate and Drainage (1975);
- Cherwell District Council Environmental Health Department;
- The Physical Properties of Major Aquifers in England and Wales, BGS Technical Report WD/97/34, Environment Agency R & D Publication 8, 1997; and
- various previous SLR reports and site investigations.

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Baseline Conditions

Geology

- 9.12 The published geological map³ for the area indicates that the proposed development is underlain by the White Limestone Formation which is part of the Great Oolite Group of Middle Jurassic age. An extract of the published geological map is presented as Drawing 9/1.
- 9.13 Adjacent to the landfill site, the shallow deposits comprise a thin layer of soil overlying approximately 2m of weathered rock, which has been described as brown clay with varying amounts of silt, sand and limestone fragments⁴. Topsoil and subsoil has already been stripped from the proposed development area.
- 9.14 The White Limestone Formation comprises hard, fractured, fine, to medium grained oolitic limestones with sporadic marls, shale and sandy horizons. It consists of the following four units: the Massive Limestone and the Upper, Middle and Lower Flaggy Limestones⁴. Each Limestone layer is underlain by a marl horizon typically between 0.5m and 10m thick. A cross section through the sequence is shown on Drawing 9/2. The Formation is 7-18m thick³
- 9.15 The Hampen Formation⁴ (it is also known as the Rutland Formation) underlies the White Limestone Formation and comprises predominantly clays and marls 2 to 12m thick³.
- 9.16 The regional dip of the strata is typically less than 1° to the east and south-east. There is no evidence of significant geological faulting or folding.
- 9.17 A summary of the geology taken from the HRA⁴ is presented in Table 9-3 taken from the HRA⁴.

Table 9-3
Summary of Geology in the Vicinity of Ardley Quarry Landfill Site

Formation	Unit	Typical Thickness (m)	Description
White Limestone Formation	Massive Limestone	5	Cream coloured oolitic limestone
	Upper Flaggy Limestone	2-3	Sequence of fractured limestones with clay and marl horizons
	Middle Flaggy Limestone	4-5	Greyish green inter-bedded mudstones, siltstones, clays and subordinate limestones
	Lower Flaggy Limestone	Unknown	Blue grey argillaceous/oolitic limestones, mudstone and siltstones

³ British Geological Survey, Sheet 219, Buckingham (Solid and Drift), 2002.

⁴ SLR Consulting Ltd, January 2008, Ardley Quarry Landfill: Hydrogeological Risk Assessment Review. SLR Ref 402.0036.00304.03

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- 9.18 Drilling and excavation of the Massive Limestone has shown the first two metres are weathered and weak⁵.
- 9.19 Core samples obtained at the site indicate that there are frequent, closely spaced fractures in the weathered Massive Limestone which become less closely spaced with iron staining and clay partings as the rock becomes more competent⁵.
- 9.20 Fractures in the Upper Flaggy are sub horizontal and sub vertical. They consist of both opened and closed rough fissures.
- 9.21 The Massive Limestone has been quarried at Ardley, leaving the Upper Flaggy Limestone uncovered. Dinosaur footprints have been found in the Upper Flaggy Limestone and are thought to be 168Ma old⁶. The horizon contains over 40 different trackways, some of which show changes in speed and have provided invaluable evidence on the movement mechanics of some dinosaurs. Further details are given in Section 11 Palaeontology.

Hydrogeology

Aquifer Characteristics

- 9.22 The published Groundwater Vulnerability Map⁷ for the area classifies the White Limestone beneath the site as a Major Aquifer. An extract of the published map is presented as Drawing 9/3. The aquifer comprises a complex inter-bedded sequence of four water bearing units; the Massive Limestone, Upper Flaggy, Middle Flaggy and Lower Flaggy Limestones. These limestones are separated by marl bands that form aquicludes. The marls separate the various units but are fractured permitting limited groundwater flow between the units. The Massive Limestone has been totally removed by quarrying at the Ardley Site.
- 9.23 Major Aquifers are described⁷ as “*highly permeable formations usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public water supply and other purposes.*”
- 9.24 The site is located on a Major Aquifer but is not within a groundwater Source Protection Zone⁸. A small part of the south eastern corner of the site has been identified as being within the floodplain of the adjacent Gagle Brook⁹.
- 9.25 The Cotswolds Great Oolite has a high range of transmissivity values. Research¹⁰ indicates properly constructed wells and springs from the oolites can yield 5000m³/d if they intersect a good fracture system. However, flows over 1090m³/d can lead to turbulent flow and significant well losses due to

⁵ SLR Consulting Ltd, September 2003, Ardley Quarry Landfill: PPC Application, Environmental Setting and Installation Design, Ref 4B-036-081/ESID

⁶ Anatomy of a Jurassic Theropod Trackway from Ardley, Oxfordshire, U.K, Mossman, Bruning and Powell, 2003. *Ichnos, Taylor and Francis Ltd, Volume 10, pp195-207.*

⁷ EA, Groundwater Vulnerability Map, Sheet 30, Northern Cotswolds as cited in the Envirocheck Report.

⁸ Landmark, Envirocheck report, 8/05/08

⁹ SLR Consulting Ltd, April 2008 Ardley EfW – Request for Scoping Opinion. SLR Ref 409.0036.00349.001

¹⁰ The British Geological Survey, Physical Properties of Major Aquifers in England and Wales, 1997.

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inefficiency. The north Oxfordshire Oolites, which lie to the east of the Cotswold outcrop, tend to be poorer aquifers and have not been as extensively used for public supply.

Recharge Mechanisms

- 9.26 The Flood Estimation Handbook (FEH)¹¹ data shows that the average annual rainfall at the site was recorded as being 665mm between 1941 and 1999. Whilst the FEH data average annual rainfall between 1941 and 1970 was recorded as 677mm.
- 9.27 The proposed development area lies within MAFF Agroclimate¹² area 26 which suggests that the annual total rainfall varies from 580 to 900 mm/year, with the average rainfall being approximately 726mm/year. The effective rainfall reported by MAFF (winter excess rain) is 255mm per annum.
- 9.28 The Environment Agency has a rainfall gauge at Bicester located approximately 2.5km south-east from the site. The data covers the period 1st January 1997 until 2nd December 2007, the annual total rainfall varies between 473.8 and 835.6mm/year. The average rainfall for this period is approximately 646mm/year. These values are lower than reported by the MAFF report and the FEH data as shown in Table 9-4.

Table 9-4
Summary of Daily Rainfall Statistics from EA Rainfall Gauge

Year	Daily Rainfall (mm)				
	Count	Min	Average	Max	Sum
1997	365	0	1.51	28.6	551.6
1998	360	0	1.81	33.8	651.4
1999	360	0	1.70	18	610.2
2000	366	0	2.28	31	835.6
2001	364	0	1.89	23.8	688.8
2002	356	0	2.08	52	741.6
2003	365	0	1.30	20.6	473.8
2004	366	0	1.79	54.2	655.6
2005	365	0	1.44	50.2	525
2006	355	0	1.92	60	680.8
2007	335	0	2.07	47.8	866.6

- 9.29 The topography of Ardley Landfill site ranges from 130mAOD in the north-west to 98mAOD at the south-east of the site. A surface water lagoon that is in hydraulic continuity with groundwater in the Upper Flaggly Limestones is present in this area. The proposed EFW development site is north of the surface water lagoon and is proposed to be at 100mAOD elevation.

¹¹ The Institute of Hydrology, FEH CD ROM 2006.

¹² MAFF, 1976. Climate and Drainage. Technical Bulletin 34. HMSO, London.

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Groundwater Levels and Flows

- 9.30 Evidence from site investigations demonstrates that groundwater flow within the White Limestone Formation is predominantly via fracture and fissure flow. The Environment Agency does not monitor groundwater levels in the vicinity of the site¹³.
- 9.31 However, there is an extensive groundwater monitoring network associated with Ardley Landfill. Data obtained between January 1999 and February 2008 for the different aquifers is summarised in Tables 9-5 to 9-8 below and hydrographs for the data are included in Appendix 9-1. Borehole locations are shown on Drawing No. 9/4. The groundwater levels within the different aquifer units indicate comparable flow directions and have a typical seasonal variation of 1-2m.

**Table 9-5
Summary of Groundwater levels in the Massive Limestone**

Sample Point	Groundwater level (mAOD)				Range (m)
	Count	Min	Average	Max	
1AR006WM	8	111.29	111.99	113.26	1.97
1AR007WM	8	112.53	113.05	114.01	1.48
1AR008WM	8	111.75	112.40	113.20	1.45
1AR009WM	8	107.49	108.03	108.86	1.37
1AR026WM	5	112.47	113.25	114.50	2.03
1AR051WM	8	111.62	112.48	113.93	2.31
1AR060WM	8	108.37	109.14	110.06	1.69
1AR061WM	8	108.24	109.00	109.87	1.63

**Table 9-6
Summary of Groundwater levels in the Upper Flaggy Limestone**

Sample Point	Groundwater level (mAOD)				Range (m)
	Count	Min	Average	Max	
1AR001WM	8	111.67	112.70	113.89	2.22
1AR003WM	8	102.35	103.19	103.79	1.44
1AR012WM	19	111.27	112.42	114.27	3.00
1AR022WM	60	101.66	102.88	104.08	2.42
1AR023WM	67	100.00	101.13	102.02	2.02
1AR024WM	66	99.75	100.44	101.29	1.54
1AR027WM	8	111.17	112.46	114.27	3.10
1AR034WM	8	108.61	109.44	110.15	1.54
1AR039WM	8	102.81	103.09	103.39	0.58
1AR042WM	8	100.29	100.62	100.91	0.62
1AR046WM	8	97.07	97.64	98.24	1.17

¹³ Email from EA, Jean Fulker dated 3/6/08.

Table 9-7
Summary of Groundwater levels in the Middle Flaggy Limestone

Sample Point	Groundwater level (mAOD)				Range (m)
	Count	Min	Average	Max	
1AR005WM	68	101.74	103.06	104.05	2.31
1AR011WM	70	109.58	111.69	115.7	6.12
1AR028WM	6	112.34	113.37	114.69	2.35
1AR030WM	2	112.55	112.72	112.89	0.34
1AR036WM	8	107.69	108.41	109.14	1.45
1AR037WM	8	103.11	103.37	103.73	0.62
1AR038WM	8	102.86	103.07	103.44	0.58
1AR041WM	7	100.79	100.81	100.84	0.05
1AR047WM	70	96.76	98.44	100.65	3.89
1AR049WM	69	100.93	103.32	107.33	6.40
1AR052WM	8	110.05	112.00	113.64	3.59

Table 9-8
Summary of Groundwater levels in the Lower Flaggy Limestone

Sample Point	Groundwater level (mAOD)				Range (m)
	Count	Min	Average	Max	
1AR002WM	8	103.57	103.88	104.26	0.69
1AR004WM	65	102.39	103.36	105.19	2.80
1AR010WM	68	106.98	108.52	109.88	2.90
1AR029WM	7	111.64	113.20	114.58	2.94
1AR032WM	8	112.52	113.43	114.39	1.87
1AR033WM	8	108.58	109.29	110.21	1.63
1AR035WM	8	108.10	108.92	109.57	1.47
1AR048WM	70	95.85	98.29	99.39	3.54
1AR050WM	71	100.58	101.34	103.70	3.12
1AR053WM	8	110.10	112.04	113.65	3.55

- 9.32 Groundwater levels are highest in the north-west and lowest in the south-east. The groundwater levels within the Massive Limestone range between c114mAOD and c107mAOD, Upper Flaggy Limestone groundwater levels range from c114mAOD to c97mAOD, the Middle Flaggy Limestone groundwater levels range from c116mAOD to c96mAOD and the Lower Flaggy Limestone groundwater levels range from c115mAOD to c94mAOD over the monitoring period. The Massive Limestone records the smallest seasonal groundwater level fluctuation of up to 2.31m.
- 9.33 Vertical heads are present between the Massive and Flaggy limestones and are summarised in Table 9-9 below⁵. It is likely that the relative movement

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between the different aquifer units varies seasonally in response to variations in recharge and discharge from the aquifer system.

**Table 9-9
Summary of Vertical Groundwater Flow between Horizons**

Geological Unit/ Water-Bearing Horizon	Vertical Groundwater Flow
Massive Limestone	Downwards vertical groundwater movement into Upper Flaggy Limestone
Upper Flaggy Limestone	Receives groundwater from both the Massive and the Middle Flaggy Limestones
Middle Flaggy Limestone	Downward and upward groundwater movement is induced into the Lower Flaggy and Upper Flaggy Limestones respectively
Lower Flaggy Limestone	Receives groundwater from the Middle Flaggy Limestone

- 9.34 Drawing 9/5 presents inferred groundwater contours within the different units.
- 9.35 The groundwater contours have been drawn using data from January 2008, when the aquifer was being recharged and water levels were relatively high.
- 9.36 The nearest boreholes to the EfW site are 1AR024WM, 1AR041WM and 1AR042WM, which are all located to the north-east. These boreholes measure the Upper, Middle and Upper Flaggy respectively. The greatest range of groundwater levels is shown in 1AR024WM (the Upper Flaggy) which has recorded a range of 1.54m over the monitoring period. This borehole also shows the highest groundwater level (101.29mAOD) and the lowest (99.75mAOD) out of the three boreholes.
- 9.37 Drawing 9/5 shows the Lower Flaggy Limestone has a higher groundwater level in the EfW site location than the other two limestones on the date used for contouring.
- 9.38 Borehole 1AR027WM has an anomalous reading for the date used for Drawing 9/5 and has been left out for this reason. The Upper Flaggy Limestone groundwater contours show groundwater elevations of 101 - 102mAOD to the immediate north of the EfW dropping to 99mAOD to the south of the EfW location.
- 9.39 Groundwater levels in the Upper Flaggy limestone are the most critical for the operation of the EfW facility. Maximum groundwater levels in the Upper Flaggy Limestones are shown on Drawing 9/6. The inferred groundwater contours have been constructed for 14 December 2006, as levels were high at this time and data are available for most monitoring points.
- 9.40 The data indicates that the 100mAOD maximum groundwater contour passes through the middle of the proposed EfW platform and the 101mAOD contour through the northern part of the platform. The maximum estimated groundwater level in the vicinity of the pond to the south east of the EfW is c 99 to 99.5mAOD.

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Source Protection Zones, Groundwater Abstractions and Quality

- 9.41 The Envirocheck report⁸ has confirmed that the proposed development area does not fall within a Source Protection Zone.
- 9.42 There are no private groundwater abstractions within 3km of the site as confirmed by Cherwell District Council⁴.
- 9.43 There are three licensed⁸ groundwater abstractions reported within the vicinity of the site. However, the Thames Water Authority licence is reported as revoked. The other two are both for general agricultural, farming and domestic purposes. Details are presented in Table 9-10.

Table 9-10
Groundwater Abstractions within 2km of the Site

Operator	Location	Easting	Northing	Daily Qty (m ³)	Annual Qty (m ³)	Water Bearing Geological Horizon
Thames Water Authority*	Ardley	454300	227600	40	109090	Great Oolite
C. Hilsdon	Manor Farm, Middleton Stoney	452700	225200	20	7319	Unknown
C. Hedges & E. Milligan	Manor Farm, Bucknell	456400	226300	5	22	Great & Inferior Oolite

* Revoked

- 9.44 Groundwater quality data from the network of perimeter boreholes at Ardley landfill site for the period July 2007 to February 2008 are summarised in Appendix 9-2.
- 9.45 A review of the data shows:
- ammoniacal nitrogen levels are elevated in the Upper Flaggy Limestone which contains the highest recorded concentrations (maximum concentration 205mg/l recorded in 1AR001WM in October 2007);
 - ammoniacal nitrogen concentrations in Middle and Lower Flaggy Limestone's (maximum concentration 150mg/l recorded in 1AR032WM (Lower Flaggy) in November 2007) are typically less than 20mg/l. There are a few boreholes with high single values which are possibly erroneous; however up-gradient borehole IAR032WM which measures Lower Flaggy Limestone is consistently high. All Flaggy Limestone ammoniacal nitrogen concentrations are typically above the Drinking Water Standard (DWS) of 0.39mg/l;
 - chloride concentrations are typically below the DWS of 250mg/l. Boreholes which exceed this are 1AR001WM, 1AR039WM (both measuring the Upper Flaggy Limestone quality) and 1AR038WM (which measures the Middle Flaggy Limestone Quality). The highest recorded concentration was 383mg/l in 1AR039WM in October 2007. Upper Flaggy Limestone concentrations are again generally higher in concentrations than the other Flaggy Limestone groundwater; and

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- mecoprop concentrations are above the DWS of 0.1ug/l in all horizons. Typically concentrations are lowest in the Middle Flaggy Limestone (maximum concentration 4.24ug/l in 1AR052WM recorded in September 2007), with the Massive Limestone and Lower Flaggy Limestones having similar concentrations (maximum recorded concentrations are 9.7ug/l from borehole 1AR007WM in February 2008 and 10.3ug/l from borehole 1AR032WM in September 2007 respectively). The Upper Flaggy Limestone has the higher concentrations with the highest recorded concentration of 39.1ug/l in borehole 1AR001WM in September 2007.
- 9.46 Most of the boreholes identified above are up-gradient of the proposed EfW site and the highest concentrations of contaminants are found in boreholes adjacent to the old unlined phases of the site or adjacent to the Gagle Brook. The three down-gradient boreholes, 1AR046WM to 1AR048WM, record lower levels of contaminants.
- 9.47 Elevated concentrations of mecoprop, in leachate, surface water and groundwater over the site, have been addressed in two previous reports¹⁴. The pattern of mecoprop concentrations shows that Gagle Brook is contaminated with mecoprop and appears to be influencing the groundwater boreholes on the eastern boundary of the site. Elevated concentrations are also found in a borehole close to the unlined Phases A and B. Potential sources of mecoprop within the Gagle Brook are Ardley Landfill, the restored Ardley Wood Landfill, adjacent farmland and the M40 and associated infrastructure¹⁵. Further investigation is scheduled to explore the sources.
- 9.48 The restored landfill at Ardley Wood, which is up-gradient of Ardley landfill and the EfW site, appears to be strongly influencing the Middle and Upper Flaggy Limestone chemistry. However, data over the years shows the influence slowly reducing.⁵
- 9.49 An indication of the ammoniacal nitrogen concentrations in the groundwater in the vicinity of the EfW can be gained from the quality of water in the surface water lagoon in the south east of the site. This lagoon is in direct hydraulic continuity with groundwater in the Upper Flaggy Limestones. Appendix 9/2 shows the ammoniacal nitrogen concentrations in the lagoon, in the discharge from the lagoon and in the groundwater drainage in the base of the quarry, from April 2005 to January 2008. The maximum ammoniacal nitrogen concentration recorded was 6.09mg/l.

¹⁴ 1) SLR Consulting Ltd, December 2005, Ardley Landfill: Initial Assessment of the Presence of Mecoprop in Ground and Surface Waters, Ref 402.0036.00181 and 2) SLR Consulting Ltd, May 2007, Ardley Landfill: Assessment of the Presence of Mecoprop, Ref 402.0036.00280

¹⁵ SLR Consulting Ltd, May 2007, Ardley Landfill: Assessment of the Presence of Mecoprop, Ref 402.0036.00280

Hydrology

Local Hydrology and Surface Water Quality

9.50 Surface water runoff from the landfill is currently collected by a series of drainage ditches which convey flows into a lagoon in the south east corner of the site. The lagoon is unlined and sits within the fractured limestone and during routine rainfall conditions, surface water infiltrates from the lagoon to the underlying groundwater. The hydraulic connection between the lagoon and groundwater means that there is always water within the lagoon and the level is an expression of the surrounding groundwater levels. During intense rainfall events, levels within the lagoon rise and water is discharged from the lagoon via a pumped discharge to Gagle Brook. This discharge is covered by the PPC Permit Variation RP3631UF. The terms of the permit are set out in Table 9-11 below. To date during 2008 there has been no discharge from the lagoon to Gagle Brook.

Table 9-11
Permit Conditions for Surface Water Lagoon Discharge into the Gagle Brook

Emission point Ref. & Location	Source	Parameter	Limit	Monitoring Frequency	Monitoring Standard or Method
Surface Water Drainage into the Gagle Brook through point SWD	Surface water drainage	Ammoniacal Nitrogen (mg/l)	7*	Monthly	To be agreed in writing with the Agency
		BOD (mg/l)	45	Monthly	
		COD (mg/l)	55	Monthly	
		Chloride (mg/l)	250	Monthly	
		pH	>6 - <9	Monthly	
		Suspended Solids (mg/l)	60	Monthly	

*: Limit based at a maximum discharge rate of 50 l/s from the site, with a minimum receiving flow in the Gagle Brook of 10 l/s.

9.51 To the north of the main infiltration pond there is a series of small ponds within which the water level is fairly constant indicating that they are likely to be hydraulically connected to groundwater as well as receiving runoff from the surroundings.

9.52 The Gagle Brook runs along the eastern boundary of the site and flows in a southerly direction. The brook originates 1km north-east of the site and is culverted beneath the M40 and the main railway line and cutting upstream of the site. Gagle Brook ultimately flows into the River Ray approximately 20km to the south of the site⁵. The local hydrology is presented on Drawing No. 9/3.

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- 9.53 Flow monitoring data indicates that Gagle brook starts losing surface water to the Upper Flaggy Limestone beyond surface water monitoring point GB6, which is approximately half way along the eastern site boundary.⁵
- 9.54 The Environment Agency has not measured flow or quality within the Gagle Brook as it is designated as non main river.¹³
- 9.55 Viridor routinely monitor surface water quality in the vicinity of the landfill site in accordance with the site permit and data from July 2007 to February 2008 are summarised in Appendix 9-3. The surface water monitoring locations are shown on Drawing 9/4. Review of the data shows:
- ammoniacal nitrogen concentrations are typically above the DWS of 0.39mg/l but below 5mg/l. The highest concentration recorded during the period (23.9mg/l) was found in the track drain north, located upstream of the EfW site in October 2007;
 - chloride concentrations are all significantly below the DWS of 250mg/l. The highest recorded concentration was 90.6mg/l at GB2 also upstream of the EfW site in October 2007;
 - mecoprop concentrations are typically below detection limit and hence below the DWS of 0.1ug/l. However, three surface water monitoring points exceed this, GB2, GB6 and GB10. The highest concentration of 3.09ug/l being recorded at upstream monitoring point GB2 in September 2007; and
 - the highest concentrations of the majority of determinands are located along the railway line, and railway drains which enter the Gagle Brook upstream of the site.
- 9.56 Most of the surface water monitoring points are upstream of the proposed EfW site with GB10 and SWD being downstream. GB10 is located on the Gagle Brook and SWD is the discharge pipe into the Gagle Brook from the surface water lagoon.
- 9.57 There are no licensed surface water abstraction within 2km of the site and no private surface water abstractions^{4,8}.

Surface Water Flows and Discharge Consents

- 9.58 The Environment Agency does not hold any records of flow for any watercourses in the vicinity of the site¹³.
- 9.59 There are no discharge consents within a 1km radius of the site⁸, except for the one from the site itself.
- 9.60 Flows in the Gagle Brook are intermittent being virtually dry in periods of dry weather but responding rapidly to rainfall events.
- 9.61 The Gagle Brook receives run-off from the M40, the M40 services and the railway line, with about 75% of the flow in the brook coming from the railway line drains. This makes the stream extremely flashy and it has very little baseflow in dry conditions.⁵

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- 9.62 SECOR¹⁶ carried out a flow gauging exercise of the Gagle Brook in December 1997 and found flows ranging from 0.001m³/s to 0.06m³/s. Details are shown on Drawing 9/4.
- 9.63 SLR also carried out flow gauging in March and September 2007. Flows of up to 0.122m³/s were recorded. Details are shown on Drawing 9/4.
- 9.64 The stream bed consists of grey, green and blue, silty clay adjacent to Phase B of Ardley landfill. This is thought to represent the upper marl band between the Upper Flaggy Limestone and the Massive Limestone. Downstream of Phase B the brook loses significant volumes of water to the Upper Flaggy Limestone with the maximum recorded loss being approximately 1m³/s in one vicinity⁵.

Flooding

- 9.65 The Environment Agency Flood Mapping shown within Drawing No. 9/3 indicates that Ardley Landfill Site is almost entirely within Flood Zone 1, classified as having an annual probability of fluvial flooding of less than 0.1%. The Flood Mapping indicates that a small area within the south east of Ardley Landfill Site falls within Flood Zones 2 and 3, classified as having an annual probability of more than 0.1% and 1% of flooding⁸ respectively.
- 9.66 The proposed EfW and associated infrastructure fall wholly within Flood Zone 1. Planning Policy Statement 25 – Development and Flood Risk, indicates that Flood Zone 1 is compatible for all land uses. No significant changes to the topography within Flood Zones 2 and 3 are proposed which are not already consented under previous planning permissions.
- 9.67 The proposed development features no significant changes to the currently consented restoration topography along the eastern boundary of the site within approximately 20m of Gagle Brook. The previously consented masterplan features raising of levels along the eastern part of the site to 102mAOD and construction of a pond 40m west of Gagle Brook, these features are replicated within the newly revised masterplan submitted as part of this planning application.
- 9.68 The Environment Agency has confirmed they do not hold any records of historic flooding at or adjacent to the site¹³.

Assessment of Potential Impacts

- 9.69 A detailed description of the proposed development and operations is provided in Section 3. For the purposes of this section, a review of the development proposals which may impact the baseline geology, hydrology and hydrogeology of the site is provided below:
- Amendments to the existing landfill restoration plan including a reduction in the total landfill footprint, in order to site the EfW plant and infrastructure.

¹⁶ SECOR, 1998 Remediation Studies Report, Ref 4B/036/005

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- Construction of an EfW plant and associated infrastructure, bottom ash recycling facility, offices, visitors centre and hardstanding areas.
- Extension of the Household Waste Recycling Centre.
- Infilling of the current pond in the south east of the site.
- Creation of several ponds and water features on site.

9.70 This section identifies the potential impacts of the proposed development on the geological, hydrogeological and hydrological environments. It also assesses the likelihood of occurrence of each identified impact. The results of this assessment are summarised in Table 9-12. The magnitude of the impact has been assessed as described in Table 9-2.

**Table 9-12
Summary of Unmitigated Potential Impacts**

Potential Impact	Spatial and Temporal Impact	Probability of Occurrence	Magnitude of Impact	Significance of Impact	Mitigation Required?
Geology					
Failure of over-tipped waste slopes	Local, Short Term	Negligible	Severe	Low	No
Groundwater Level and Flow					
Reduction in water levels due to loss of recharge	Local, Long Term	Medium	Mild	Low	No
Dewatering during construction affecting water resources	Local, Short Term	Medium	Moderate	Medium	Yes
Groundwater drainage during operation affecting water resources	Local, Long Term	High	High	High	Yes
Creation of a vertical pathway between aquifers during construction of waste pits and piling and during operation	Local, Short and Long Term	Medium	Moderate	Medium	Yes
Creation of barriers to groundwater flow influencing groundwater levels	Local, Long Term	Low	Mild	Low	No
Groundwater Quality					
Leakage of fuels etc to groundwater	Local, Short and Long Term	Medium	Severe	High	Yes
Generation of leachate from temporary storage of waste and the bottom ash recycling facility	Local, Short and Long Term	High	Moderate	High	Yes
Mobilisation of pollutants from contaminated soils	Local, Short Term	Low	Mild	Low	No
Surface Water Quality					
Spillage of fuels and oils	Local, Short Term	Medium	Severe	High	Yes
Sediment from earthworks	Local, Short Term	High	Moderate	High	Yes
Generation of leachate from temporary storage of waste and the bottom ash recycling facility	Local and Regional, Long Term	High	Severe	High	Yes

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Mobilisation of pollutants from contaminated soils	Local, Short Term	Low	Mild	Low	No
Discharge of contaminated groundwater to Gagle Brook	Local, Long Term	Medium	Moderate	Medium	Yes
Flood Risk					
Risk of fluvial flooding to the development	Local, Long Term	Negligible	Severe	Near Zero	No
Risk of overland flow flooding the development	Local, Long Term	High	Moderate	High	Yes
Risk of groundwater flooding the EfW	Local, Long-Term	High	Severe	High	Yes
Risk of runoff flows exceeding drainage capacity	Local, Long-Term	Low	Moderate	Low	No
Risk of EfW flooding due to pump failure	Local, Long-Term	Medium	Severe	High	Yes
Risk of structural failure of south east pond causing flooding of EfW and downstream environment	Local and Regional, Long-Term	Low	Severe	Medium	Yes
Increased runoff causing increased downstream flood risk	Regional and Long Term	Low	Severe	Medium	Yes

Geology

9.71 The development will involve an amendment to the profile of the landfill and the potential for instability of new slopes has been considered during the design process to ensure the proposed slopes are stable. The likelihood of slope failure is therefore assessed as 'negligible', although if it occurred the magnitude of the consequences are potentially 'severe'. As the potential impact has been considered in the design, the overall significance of slope failure is rated as 'low' and does not require further mitigation.

Groundwater Level and Flow

9.72 The development of the site by the construction of impermeable buildings, weighbridges and covering parts of the site with hardstanding has the potential to reduce the amount of recharge to groundwater potentially affecting groundwater levels and impacting groundwater flows to the Gagle Brook.

9.73 The probability of this occurring, without mitigation, is considered to be 'medium' and the magnitude of impact 'mild', given the relatively small area affected in relation to the outcrop area of the aquifer and limited baseflow in Gagle Brook. The overall risk is therefore assessed as 'low' and does not require mitigation. However, despite this, surface water run-off from the development will be discharged to a lined pond in the south-east of the development which will discharge to the Gagle Brook thus reducing even the predicted 'low' significance to 'near zero'.

9.74 The construction of the EfW will involve deep excavations down to 87.5mAOD, through the Upper and Middle Flaggy Limestone and probably into the Lower Flaggy Limestones. This is below the water table in all three

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aquifers and will penetrate the marl layers which partially confine groundwater in the Middle and Lower Flaggy aquifers. Dewatering and control of the confined hydraulic heads in the aquifers will be needed during the construction phase of the project. This could potentially affect the groundwater resources in the area. The significance of this impact is rated as 'Medium' as the aquifer is not extensively used near to the site.

- 9.75 The installation of groundwater drains will intercept natural groundwater flow during the operational phase of the development and could affect flows in the Gagle Brook. The significance of this impact is rated as 'High'.
- 9.76 Excavations to a level of 87.5mAOD, the installation of piled foundations and the presence of confined groundwater levels in the Lower and Middle Flaggy aquifers means that there is a risk of vertical flow between the aquifer units beneath the site. This could occur during the construction and operation of the facility. The significance of this impact is rated as 'Medium' as there is already likely to be flow between the aquifers given their proximity and the nature of the aquicludes separating them.
- 9.77 The development includes the construction of waste bunkers below ground to receive the pre-sorted wastes. There is the potential for the deep waste bunker to provide a barrier to groundwater. The bunker area, however, comprises a small proportion of the total area of the aquifer and drains will be installed around the bunker to ensure groundwater can flow around it. It is therefore considered that the overall significance of an impact would be 'low' and no mitigation measures are necessary.

Groundwater and Surface Water Quality

- 9.78 During the development and operation of the site, there is a risk of contaminated runoff being generated from the following potential sources, which could affect surface and or groundwater quality:
- accidental spillage of fuels and lubricants, required over the short term by construction plant and over the longer term, from operation of the facility and from the vehicles moving around the site.
 - increase in suspended solids during the construction phase resulting from the proposed earthworks;
 - contaminated run-off from the temporary storage of bottom ash; and
 - contaminated run-off from the temporary storage of waste.
- 9.79 It is considered that, without mitigation, the probability of occurrence of spillage of fuels, lubricants and other potentially contaminative liquids during construction phase would be 'medium' owing to the limited area of the site and number of vehicles that would be using the site. The site overlies a Major Aquifer and the contaminants concerned are List 1 substances, therefore the magnitude of impact is rated as 'severe'. Therefore the overall risk during construction without mitigation is assessed to be 'high'. Mitigation measures are therefore required to reduce impacts to an acceptable level.
- 9.80 It is considered that, without mitigation in the form of appropriately considered management, the probability of occurrence of sediment erosion causing high sediment loading to Gagle Brook during all earthworks at the

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site is considered to be 'high' and the magnitude of impacts is 'moderate'. This gives an overall 'high' risk of impact and hence mitigation is required.

- 9.81 During the operation of the bottom ash treatment plant and bottom ash storage areas, there is the potential for the leaching of contaminated water high in metals to cause contamination of either the surrounding surface water features or the underlying aquifer. The probability of this occurring is considered to be 'high' and the magnitude of the impact 'moderate' given the likely nature of the bottom ash. This gives an overall 'high' risk of impact and hence mitigation is required.
- 9.82 Without mitigation, it is considered that the storage of waste prior to processing could result in an impact on surface water and groundwater quality if leachate is allowed to form and escape to ground. The probability of this occurring is considered to be 'high' and the magnitude of the impact 'moderate' given the nature of the wastes. This gives an overall 'high' risk of impact and hence mitigation is required.
- 9.83 Previous and current site uses indicate the potential for contaminated soils to be present which may be disturbed during preparatory earthworks leading to the mobilisation of pollutants and contamination of surface water or groundwater. However, the area where earthworks will be undertaken has not been landfilled or used to store waste materials. There is no evidence of soil contamination at the site and the probability and magnitude of any impact is rated as 'Low' and 'Mild' respectively, giving an overall impact significance of 'Low'. Mitigation is not therefore required.
- 9.84 Groundwater at the site is locally contaminated, including elevated concentrations of ammoniacal nitrogen and mecoprop. Groundwater drainage around the facility may intercept contaminated groundwater and its discharge could affect the quality of the Gagle Brook. The significance of this impact is rated as 'Medium'.

Flood Risk

- 9.85 A Flood Risk Assessment and Site Drainage Plan have been prepared for the site and are presented in Appendix 9/4. Table 9-13 summarises the risks of flooding.

**Table 9-13
Potential Risk to EfW Posed by Flooding Sources**

Potential Source	Potential Flood Risk at Application Site?	Justification
Fluvial flooding	No	The proposed EfW and associated infrastructure are situated within Flood Zone 1. Parts of the Ardley site are indicated to be within Flood Zones 2 or 3 but no significant changes to the currently consented restoration topography are proposed along the eastern boundary of the site.
Tidal flooding	No	Ground levels at the site are typically over 100mAOD and the site is over 150km from

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		the coast.
Groundwater flooding	Yes	The local groundwater levels are seasonally higher than the proposed ground levels across the EfW platform.
Surface water flooding	Yes	Surface gradients slope towards the EfW.
Flooding from artificial drainage systems	Yes	Surface water at and groundwater drainage within the EfW platform the site will be managed in accordance with a site drainage scheme designed to accommodate flows from up to the 1% (1:100 year) annual probability event.
Flooding due to infrastructure failure	Yes	Drainage of the EfW platform is reliant on pumping, and pump failure may cause flooding. A breach of the bunds of the south east pond poses a risk of flooding to the EfW downstream environment.

- 9.86 The FRA concludes that the EfW is not at risk of flooding from Gagle Brook and the risk of fluvial flooding inundating the development is considered 'Negligible' and the magnitude of any impact is considered 'Severe' giving an overall impact significance of 'Near Zero'.
- 9.87 The EfW and associated infrastructure is surrounded to the north and east by the sloped banks of the landfill. The increased runoff rate across these slopes associated with capping of the landfill means that these slopes will readily generate runoff which if not mitigated by drainage design would lead to surface water ponding or minor flows across the site of the EfW. The probability of runoff flooding the development is considered to be 'High' although given the relatively low volumes of water generated from these slopes the magnitude of impacts is likely to be 'Moderate', giving an overall impact significance of 'High'. Mitigation measures will be required to reduce these risks.
- 9.88 The EfW will be situated partially below local maximum groundwater levels and if no mitigation in the form of drainage were included within the design, the risks of groundwater flooding the EfW are 'High' and the magnitude is 'Severe'. An appropriately considered groundwater drainage scheme will be included in the development design.
- 9.89 The EfW may be at risk from events which exceed the design capacity of the site's drainage system. These events would have a 'Low' probability of occurrence but would have a 'Moderate' impact magnitude, giving an overall 'Low' impact significance.
- 9.90 The drainage scheme is reliant upon pumping, any pump failure will cause flooding of the EfW. The risks of infrastructure failure causing flooding of the EfW are considered to be 'Medium' probability and would have a 'Severe' magnitude of impact, giving an overall 'High' impact significance. These risks will be mitigated by an appropriately designed drainage scheme.
- 9.91 The drainage scheme features a large capacity attenuation pond in the south east of the site, adjacent to the EfW. Structural failure of the pond would result in flooding of the EfW and may result in flooding in the downstream environment. The probability of structural failure of the pond is considered to

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be 'Low' but the magnitude of impact would be 'Severe', giving an overall 'Medium' significance of impact. These impacts will require mitigation.

- 9.92 When compared with the pre-development condition of the site, the proposed development and associated amendments to landscaping may increase in the rate and volume of surface water runoff, which if not mitigated will increase the risk of flooding in the downstream environment. These impacts would, if not mitigated by appropriate surface water management, have a 'low' probability of occurring but could have a 'severe' magnitude of impact on the downstream catchment. Therefore the overall risk is considered to be 'medium'. Mitigation measures will be required to reduce these risks.

Proposed Mitigation

- 9.93 The assessment has identified that mitigation is required to address the following potential impacts:

- Groundwater Level and Flow
- Groundwater and Surface Water Quality
- Flood Risk

Details of the proposed mitigation given below.

Groundwater Level and Flow

- 9.94 Recharge intercepted by the construction of impermeable buildings, weighbridges and covering parts of the site with hardstanding will be discharged to the surface water attenuation lagoons in the south east of the site and discharged to the Gaggle Brook. This will mitigate the impact of any loss of groundwater recharge which would have discharged to the brook.
- 9.95 Impacts on hydrogeological flow regime by dewatering during the excavation of the waste bunker will be mitigated by re-infiltration of the groundwater into the limestones at the site and/or discharge to the Gaggle Brook after settlement. This would ensure that minimal water is lost from the aquifers on site and would reduce the significance of any impacts to 'Low'. Dewatering for engineering purposes is currently exempt from the water abstraction licensing regime. This exemption is due to be removed in April 2009 and hence an abstraction licence will be required for dewatering. The potential impacts and mitigation of dewatering will be addressed further when a licence application is made.
- 9.96 Groundwater intercepted by the drains around the EfW facility will be pumped to the surface water attenuation lagoons in the south east of the site and discharged to the Gaggle Brook thus mitigating any impact on flows in the brook.
- 9.97 The potential for creating a vertical pathway between the aquifers during construction will be mitigated by the proposed bunker construction method. It is proposed that the bunker walls will be emplaced in-situ into a bentonite-filled trench. The bentonite will create a hydraulic seal across the clay aquiclude and prevent flow between the two aquifers, thus reducing the significance of any impact to 'low'.

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- 9.98 The potential for the introduction of vertical pathways between the aquifer units due to installation of piled foundations will be mitigated by either driving the piles or using bentonite or steel casing to minimise the potential for flow between the units. These measures will reduce the significance of the impact to 'Low'. The construction will also be designed to ensure no long term pathway is created between the aquifers.

Groundwater and Surface Water Quality

- 9.99 In order to minimise the potential for accidental spills of potentially contaminating material during the construction phase of the project, the relevant Pollution Prevention Guidelines listed in Section 9.7 will be adhered to, to ensure construction works are undertaken in an environmentally responsible manner. Any environmentally hazardous material used during the operational phase of the site will be kept in dedicated stores and storage tanks will have appropriate secondary bunding. It is concluded that site management in accordance with the relevant Pollution Prevention Guidelines reduce the risk of surface water and groundwater quality impacts from the development being reduced from 'High' to 'Low'.
- 9.100 The potential for leachate generation and discharge to groundwater or surface water from the waste reception and bottom ash recycling facility will be minimised by the design of the facility. The waste would be delivered to a dedicated handling area using bulk transfer and street refuse collection vehicles (RCV's). All vehicles delivering residual waste will be weighed when entering the site and proceed to a vehicle delivery and tipping hall where they would back up and discharge the waste directly into a pit or storage hopper. This will minimise the potential for the generation and discharge of leachate. It is concluded that the site design inherently reduces the risk of surface water and groundwater quality impacts arising from leachate generation at the development being reduced from 'High' to 'Low'.
- 9.101 The landfill will be progressed in a phased manner and prior to progressing the next stage of earthworks a range of appropriately designed surface water management measures will be implemented including:
- Erosion control measures – these aim to prevent runoff from flowing across exposed ground and becoming polluted with suspended solids.
 - Sediment control measures – these aim to slow runoff and allow for settlement of sediment as close to the source as possible.
 - Site Measures – these aim to provide end of pipe treatment for polluted water, for example reed beds or settlement ponds
- 9.102 Further details of the recommended surface water treatment measures are detailed within the Appendix 9/4. It is concluded that implementation of appropriate surface water management measures as outlined within the FRA will reduce the risk of surface water quality impacts from the development being reduced from 'High' to 'Low'.
- 9.103 The potential for the discharge of contaminated groundwater drainage from the operational facility into the Gagle Brook will be mitigated by dilution with clean surface water in the lagoons and by the treatment of contaminants

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within the lagoon itself. The groundwater will also be discharged via a sprinkler system into the ponds allowing the water to be aerated, further enhancing contaminant removal. A modification of the current discharge consent will have to be made and further assessment of the water quality and its treatment in the lagoon will be made at that time.

Flood Risk

- 9.104 A surface water and groundwater drainage scheme has been designed for the development, as detailed in Appendix 9/4, in order to mitigate the risk of:
- The development being flooded by groundwater or surface water.
 - The development increasing the flood risk in the downstream environment by an increased runoff rate from the site.
 - Flooding of the EfW development and downstream environment caused by infrastructure failure.
- 9.105 A network of groundwater and surface water drains will protect the EfW from flooding by groundwater and surface water therefore reducing this risk to 'Low'.
- 9.106 Appendix 9/4 presents an outline drainage design featuring four hydraulically linked ponds, which attenuate peak runoff flows and allow for storage reducing peak flows generated by the entire site to greenfield rates. The scheme takes into account a potential 30% increase in future rainfall intensity attributable to climate change. The drainage scheme therefore mitigates any increased flood risk to the downstream environment caused by runoff from the site, reducing the risk of this impact to 'Low'.
- 9.107 The EfW platform will be drained by a network of french drains acting to suppress groundwater to a level of 99.5mAOD, groundwater from this area will enter the drains and is conveyed to a pond west of the EfW. The pond will be equipped with an automated pump which will discharge into the south east pond. An emergency outfall direct to Gagle Brook will drain the EfW platform in the event of pump failure.
- 9.108 The south east pond introduces a risk of flooding to the EfW and downstream environment. These risks are mitigated by appropriate structural design of the pond and a set of measures are recommended to deal with any residual risks including a water level based flood warning system, an evacuation plan and flood resilience building measures.
- 9.109 The above features mitigate the risks of flooding to the EfW and downstream environment caused by infrastructure failure, reducing these risks from 'high' to 'low'.

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Assessment of Residual Impacts

9.110 It is considered that there are no significant residual impacts associated with the development on the geological, hydrogeological and hydrological regime after the incorporation of mitigation measures detailed above. A summary of the residual impacts is provided in Table 9-14.

**Table 9-14
Summary of Residual Impacts**

Potential Impact	Spatial and Temporal Impact	Probability of Occurrence	Magnitude of Impact	Significance of Impact	Mitigation Required?	Residual Impacts
Geology						
Slope failure	Local, Short term	Negligible	Severe	Low	No	Low
Groundwater Level and Flow						
Reduction in water levels due loss of recharge	Local, Long Term	Medium	Mild	Low	No	Low
Dewatering during construction affecting water resources	Local, Short Term	Medium	Moderate	Medium	Yes	Low
Groundwater drainage during operation affecting water resources	Local, Long Term	High	High	High	Yes	Low
Creation of a vertical pathway between aquifers during construction of waste pits and piling and site operation	Local, short and Long Term	Medium	Moderate	Medium	Yes	Low
Barrier to flow increasing water levels	Local, Long Term	Low	Mild	Low	No	Low
Groundwater Quality						
Leakage of fuels etc to groundwater	Local, Short and Long Term	Medium	Severe	High	Yes	Low
Generation of leachate from temporary storage of waste and the bottom ash recycling facility	Local, Short and Long Term	High	Moderate	High	Yes	Low
Mobilisation of pollutants from contaminated soils	Local, Short Term	Low	Mild	Low	No	Low
Surface Water Quality						
Spillage of fuels and oils	Local, Short Term	Medium	Severe	High	Yes	Low
Sediment from earthworks	Local, Short Term	High	Moderate	High	Yes	Low

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Generation of leachate from temporary storage of waste and the bottom ash recycling facility	Local and Regional, Long Term	High	Severe	High	Yes	Low
Mobilisation of pollutants from contaminated soils	Local, Short Term	Low	Mild	Low	No	Low
Discharge of contaminated groundwater to Gaggle Brook	Local, Long Term	Medium	Moderate	Medium	Yes	Low
Flood Risk						
Risk of fluvial flooding to the development	Local, Long Term	Negligible	Severe	Near Zero	No	Near Zero
Risk of overland flow flooding the development	Local, Long Term	High	Moderate	High	Yes	Low
Risk of groundwater flooding the EfW	Local, Long-Term	High	Severe	High	Yes	Low
Risk of runoff flows exceeding drainage capacity	Local, Long-Term	Low	Moderate	Low	No	Low
Risk of EfW flooding due to pump failure	Local, Long-Term	Medium	Severe	Medium	Yes	Low
Risk of structural failure of south east pond causing flooding of EfW and downstream environment	Local and Regional, Long-Term	Low	Severe	Medium	Yes	Low
Increased runoff causing increased downstream flood risk	Regional and Long Term	Low	Severe	Medium	Yes	Low

Summary and Conclusions

- 9.111 The potential impacts of the proposed development upon the baseline hydrogeological and hydrological environments have been identified and assessed, and where appropriate, mitigation measures have been accommodated into the design of the development.
- 9.112 All aspects of the construction and operation of the site would be in accordance with best practice guidance.

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- 9.113 A flood risk assessment has been undertaken for the development. The FRA concluded that the EfW scheme is at risk of flooding from surface water and groundwater both of which will be managed in accordance with the site drainage scheme thereby mitigating the risks associated by surface water and groundwater flooding. Runoff from the site is conveyed to a series of attenuation and infiltration ponds providing sufficient volume for on-site attenuation of flows back to the greenfield rates and the design accommodates for a potential 30% increase in rainfall intensity in accordance with PPS25 guidance. In the absence of any field data the designs are based on assumed values for permeability and infiltration rates. Prior to detailed design, further field testing should be undertaken and therefore the final design of the scheme may differ slightly to the details presented herewith. The EfW platform will be drained by a network of french drains acting to suppress groundwater to a level of 99mAOD, runoff from this area will enter the drains and is conveyed to a pond west of the EfW. The pond will be equipped with an automated pump which pump flows up into the south east pond. An emergency outfall to Gagle Brook will drain the EfW platform in the event of pump failure. The south east pond introduces a risk of flooding to the EfW and downstream environment. These risks are mitigated by appropriate structural design of the pond and a set of measures are recommended to deal with any residual risks including and water level based flood warning system, an evacuation plan and flood resilience building measures.
- 9.114 Overall, it is concluded that, with respect to geology, groundwater and surface water, there would be no significant residual impacts of the development with the proposed mitigation measures in place.
- 9.115 Additional information submitted to the Environment Agency during the consultations carried out on the previous planning application has been included as Appendices 9/5 and 9/5 in Volume 4 of this submission.