Coed Darcy
Hydrogeological Risk Assessment
Crymlyn Tip
St. Modwen Developments Ltd

June 2013

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1. INTRODUCTION

1.1. Report Context

Atkins have been commissioned by St. Modwen Developments Ltd (SMD) to produce an Environmental Setting and Installation Design (ESID) and related Hydrogeological Risk Assessment, Landfill Gas Risk Assessment and Stability Risk Assessment, in general compliance with an environmental permit (EPR/AP3990LR) held by SMD for the Crymlyn Tip on the Coed Darcy site, Llandarcy, Port Talbot. This report details the Hydrogeological Risk Assessment (HRA) for the Crymlyn Tip and is based on supporting information on the site collected by URS between 1998 and 2001 and Atkins between 2008 and 2010.

In 1977, a waste disposal licence (WDL) was granted for the Crymlyn Tip site which permitted the deposit of refinery wastes from the neighbouring Llandarcy Refinery. The permitted waste materials include both inert and potentially hazardous materials.

This report has been prepared in general accordance with the Environment Agency's "Hydrogeological Risk Assessment" template.

This report should be read in conjunction with the ESID Report which accompanies this HRA. An outline of the proposed installation and historical operations undertaken at this site is contained in Section 1 and 2 of the ESID Report. Activities currently undertaken on and around the site relate solely to improvement of the condition of the land and any discharges from the land. The site has not accepted waste since 1999 and has been non-operational since July 2001.

There are no known historical areas of landfill or former waste management licences adjacent to the site. The site is underlain by a Secondary A aquifer (Pennant Sandstone) but is not located within a Source Protection Zone (SPZ).

1.2. Conceptual Hydrogeological Site Model

1.2.1. Sources

The main source materials for consideration in this report comprise the refinery wastes landfilled to the eastern section of the permitted site, between 1977 and 1999. The Waste Disposal Licence (WDL), under the Control of Pollution Act 1974, permitted the deposit of refinery wastes including demolition materials, asbestos, boiler cleanings, oily sludge, bitumen, waxes and pyrophoric materials. Source materials are considered to be these deposited wastes only, sources of contamination from Llandarcy Refinery, including LNAPL, will not be considered as it does not result from landfill activity at Crymlyn Tip.

Source materials have only been deposited to the eastern section of the permitted site, as identified in Drawing ESID2 of the ESID document.

1.2.2. Pathways

Examination of publically available information and historical reports identify that;

- Superficial deposits on site comprise of Peat and Till;
- The superficial deposits make up the natural unsaturated zone, while made ground forms the remainder of the unsaturated zone;
- The unsaturated zone ranges from 0.5m to 3m in thickness;
- The saturated zone comprises Till and the Pennant Sandstone;
- The principal pathway is expected to be through infiltration of water through the landfill, and into groundwater;
- Flow within the saturated zone will be principally to the west, towards the unfilled half of the permitted area, and Crymlyn Bog.

No liner is present beneath the site; however the presence of a compacted peat, detailed in Section 2.4, is understood to provide a natural barrier of low permeability. This peat layer is likely to reduce the migration of contaminants to the groundwater receptor.

1.2.3. Receptors

The key receptor with respect to the landfill is considered to be Crymlyn Bog, which is a designated Site of Special Scientific Interest (SSSI), Special Area of Conservation (SAC), Ramsar Site and a National Nature Reserve (NNR). Other receptors include the groundwater aquifers beneath the site, which comprise the shallow aquifer in the made ground, and waste, and the deep aquifer in the till, and surface water receptors, comprising unnamed drains identified to the north, south, east and west of the permitted site. It is anticipated that each of the water bodies within and around the permitted site will be in hydraulic continuity with Crymlyn Bog, and as such the Bog is considered the key receptor. The locations and distances from the permitted site, of these receptors, are identified in Table 1–1 below.

For the purpose of this risk assessment the deep groundwater aquifer beneath the site will be considered first and foremost, as it is considered to be both a receptor and a contaminant pathway.

Table 1–1 List of receptors and their relative distance from the permitted site boundary, and landfilled area

Receptor	Designations	Distance from Permitted site	Distance from Landfilled area
Crymlyn Bog	SSSI, SAC, Ramsar Site, NNR	At western site boundary	200m to the west
Shallow groundwater	None	Beneath the site	Beneath the site
Deep Groundwater	Secondary A	Beneath the site	Beneath the site
Unnamed land drain	None	Along site boundaries	30m to the north and east, 50m to the south, 300m to the west

There are two discharge compliance points (W3 and W2) adjacent to the permit area, which are designed to monitor discharges from the containment area into the Crymlyn Bog. These are located to the northern and western boundaries of the permitted area.

Contaminant concentrations, as identified by groundwater and leachate monitoring will be compared with suitable Environmental Acceptance Levels (EALs) to identify any contamination of the above receptors. For the purpose of this report, it is proposed that the EALs used reflect the surface water environmental quality standard (EQS), The River Basin Districts Typology, Standards and Groundwater Threshold Values (Water Framework Directive) (England and Wales) Directions 2010. As no value has been assigned for ethylbenzene under this direction, this report shall consider the value set under the non-statutory EQS for the Aquatic Environment.

Table 1–2 List of COCs and their associated EAL

Contaminants	Environmental Acceptance Levels (EAL)
TPH	-
Benzene	10µg/l
Ethylbenzene	50µg/l*
Naphthalene	2.4µg/l
Benzo(a)pyrene	0.05µg/l
GRO (C4 – C12)	-
m&p Xylene	30µg/l
MTBE	-
O-Xylene	30µg/l

Contaminants	Environmental Acceptance Levels (EAL)
Toluene	50µg/l
BTEX	-

* Proposed Aquatic Environmental Quality Standards

It should be noted that EQS's are not available for some of the contaminants, and as such the assessment will consider their trending concentrations on and around site.

2. HYDROGEOLOGICAL RISK ASSESSMENT

2.1. The Nature of the Hydrogeological Risk Assessment

A hydrogeological risk assessment is required to assess the impact to Controlled Water receptors from landfilling activities at Crymlyn Tip, Llandarcy. The principal objectives of the hydrogeological risk assessment are as follows:

- Indentify contaminants of concern (COCs) to be carried forward in the hydrogeological risk assessment based on the materials deposited in the landfill, and anticipated background concentrations within the subsurface related to the Llandarcy refinery;
- Based on the proposed CSM (Section 1.2) determine the fate and transport of the COCs within the subsurface and establish if a risk exists to surface water receptors from the placement of the landfill material; and
- Determine whether the presence of landfill material has affected controlled water receptors, or is likely to do so.

Groundwater monitoring was undertaken by Atkins between 2008 and 2010 to determine both the quality of water, water levels around the site and the direction of groundwater flow. The monitoring was undertaken nine years after the final deposition of landfill material, and as such results represent the quality of groundwater following infiltration of rainwater and potential migration of leachate to groundwater. As such the quality data provides an understanding of how groundwater is being affected by the presence of the landfill.

Monitoring results indicate that a qualitative risk assessment is a suitable assessment to identify any risk to controlled water posed by the landfill, and that quantitative risk assessment is not required.

Monitoring results, as discussed in the ESID, identify contaminant trends both upstream, downstream and to the south of the site, which is not within the dominant groundwater flow direction. These trends suggest that the landfill does not pose a risk to controlled waters, which will be discussed in Section 2.6.

Due to the nature of historical activities on site, it is essential to differentiate between background contamination and that which has arisen from landfill activities. For this reason it is necessary to assess groundwater quality from a number of boreholes off-site that are not affected by greater flow from the landfilled area, as well as those within the permit boundary. By comparing the concentrations and types of contaminant in boreholes within the groundwater regime of the site, and outside of it, it will be possible to separate the contaminant origins.

As discussed in the ESID document, Section 3.5.2, groundwater flows to the west, and it is anticipated that any contamination as a result of the landfill will be identified in boreholes within the landfill and downgradient of the landfill. These boreholes include MSMW035, MSMW156 and MSMW155, which are within the landfill area, the permitted area that has not been filled, and to the west of the permitted area respectively. Boreholes to the east and south of the landfill, including MSMW034, MSMW025, MSMW163, MSMW177 and MSMW183, will serve as indicators of background contamination. A plan showing the locations of groundwater boreholes can be found in the accompanying ESID, Drawing ESID11.

2.2. The Proposed Assessment Scenarios

Llandarcy Refinery obtained a permit to landfill at the Crymlyn tip in 1977 and the site was operational until 1999. The landfill was permitted to accept refinery waste materials which included demolition materials, asbestos, boiler cleanings, oily sludge, bitumen, waxes and pyrophoric materials. Although no liner was placed beneath the landfill material, an underlying peat layer is considered to form a natural geological barrier.

For the purpose of this assessment it is assumed that a pathway between the landfill and groundwater exists, and that leachate can migrate to the receptor. It is assumed that the landfilled material is leachate generating, and may cause a risk to controlled waters. As such a prudent risk assessment can be carried out, considering the worst case scenario on site.

It is also considered that groundwater acts as both a receptor, and a pathway, for potential contaminants, and as such if the groundwater is not considered at risk then the other surface water receptors and the Crymlyn Bog will not be considered at risk of contamination from landfilling activity at Crymlyn Tip.

2.2.1. Lifecycle Phases

Landfill materials were deposited at Crymlyn Tip between 1977 and 1999. During this time it is understood by Atkins that only wastes relating to the Llandarcy Refinery were deposited.

For the purpose of this assessment the site will be assessed following completion of the landfill activities, and so only the post-operation phase will be considered. It is anticipated that this will provide a suitable risk assessment, as any potential contamination from the landfill should have already occurred.

2.3. The Priority Contaminants to be Considered

As landfilling has been completed at the Crymlyn Tip the contaminants of concern (COCs) for consideration will be selected based on the types of materials expected at the landfill.

Permitted landfilled materials include refinery wastes from Llandarcy Refinery, comprising demolition materials, asbestos, boiler cleanings, oily sludge, bitumen, waxes and pyrophoric materials. It is anticipated that the key COCs will relate to the deposition of oily sludges, bitumen and waxes. Based on this information, the following COCs have been carried forward in the hydrogeological risk assessment;

- TPH
- Benzene,
- Ethylbenzene,
- Naphthalene,
- Benzo(a)pyrene,
- GRO (C4 – C12),
- m&p Xylene,
- MTBE,
- O-Xylene,
- Toluene, and
- BTEX.

The above COCs have been selected as they are typically associated with the breakdown of hydrocarbons,. The presence of these contaminants in groundwater and leachate samples from MSMW035, MSMW155 and MSMW156 may indicate landfill material as a source, however due to historical activities around the permitted site, these may be present as background contaminants.

It is not anticipated that heavy metals or other contaminants will be an issue at the site as landfill materials are expected to be comprised of inert building materials and refinery wastes only.

The COCs will be compared with their relevant Environmental Acceptance Levels (EALs) for surface water to identify any elevated concentration present on site, as outlined in Section 1.2.3.

2.4. Review of Technical Precautions

Landfill material was deposited on naturally occurring peat found on the permitted site. As peat is highly compressible, it was understood that the weight of the landfill would create a natural geological barrier beneath the waste mass. This peat layer would then form a barrier of low permeability, and prevent the migration of contaminants into the underlying groundwater. No manmade liner has been installed beneath the waste.

The landfill does not have an engineered cap, but has a small thickness of soil placed on the surface. It is understood that no liner is in place above the waste material.

2.5. Numerical Modelling

Numerical modelling has not been carried out for the Crymlyn Tip, as it deemed unnecessary due to the availability of sufficient water quality monitoring data taken prior to completion of the landfilling activity.

2.6. Emissions to Groundwater

Groundwater quality, and leachate quality data, taken between 2008 and 2010, were evaluated for occurrences of COCs, as discussed in Section 2.1. The findings of which are outlined in Sections 2.6.1 and 2.6.2.

2.6.1. TPH

At present there is no standard value for which TPH are screened against. For the purpose of this report, TPHs have been screened against the old drinking water standards value of 10µg/l.

Concentrations of TPH of greater than 10µg/l are noted outside of the permit boundary, with the largest number of elevated results to the south of the permit boundary.

Landfilled Area
TPH was not identified within leachate monitoring results (MSMW035) throughout the monitoring period.

Permitted Area, Not Landfilled
Concentrations of over 10µg/l were noted for TPH C10 -C12, TPH C12 – C16, TPH C21 – C40 and C6 – C40 at borehole MSMW156.

Outside Permitted Site
Elevated TPH concentrations, between 32µg/l and 3610µg/l were noted up gradient and downgradient of the site in both boreholes MSMW034 and MSMW155.

Elevated concentrations were noted in boreholes to the south of the site of up to 4310 µg/l.

Concentrations of greater than 10µg/l of all TPHs are noted in all monitoring wells outside of the permitted area throughout the monitoring period. This suggests that elevated TPH concentrations are the result of background contamination in the groundwater.

Table 2–1 outlines the TPH concentrations identified during groundwater analysis conducted by Atkins between 2008 and 2010. For the purpose of this report, this table looks at the maximum concentration noted at each location over the monitoring period to represent the worst possible case scenario. The table shows the results of leachate monitoring in MSMW035 and groundwater monitoring for all other wells.

Table 2–1 Groundwater Quality Analysis - TPH

Sample Location	Borehole ID	TPH >C6-C8 6 split	TPH >C8-C10 6 split	TPH >C10-C12 6 split	TPH >C12-C16 6 split	TPH >C16-C21 6 split	TPH >C21-C40 6 split	TPH >C6-C40 6 split	TPH GRO
Units		**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**
EAL		-	-	-	-	-	-	-	-
Landfilled Area (Leachate)	MSMW035	<10	<10	<10	<20	<20	<50	<50	-
Permitted area, not filled	MSMW156	<10	<10	13	168	169	581	918	-
Upgradient of Permit Boundary	MSMW034	143	1620	616	830	400	<50	3610	1580
Down gradient of Permit Boundary	MSMW155	<10	<10	32	176	187	230	625	-
South of Permit Boundary	MSMW025	531	258	879	635	77	<50	2380	-
	MSMW163	<90	<90	<90	<180	<180	<450	<450	-
	MSMW177	1190	462	1840	931	36	<50	4310	-
	MSMW183	1240	179	141	41	<20	<50	1530	-

Elevations of all TPHs were noted in all monitoring wells outside of the permitted area throughout the monitoring, but no TPH was detected within the landfill area, and concentrations in MSMW156 were generally up to ten times lower, than those identified in the upgradient borehole MSM034. This suggests that elevated TPH concentrations are the result of background contamination in the groundwater, and not related to the presence of landfill waste.

Trend analysis was under taken for TPH, and charts showing the results can be found in Appendix 2 of the ESID document. For the most part, TPHs show decreasing concentrations across all monitoring wells, with time, however TPH > C21 – C40 6 split shows increasing concentration with time. Insufficient data is available to interpret these trends at present.

2.6.2. Benzene, Naphthalene, Ethylbenzene, GRO (C4 – C12), m&p Xylene, MTBE, o Xylene, Toluene, BTEX

Benzene, Naphthalene, Ethlybenzene, GRO, m&p Xylene, MTBE, o-Xylene, Toluene and BTEX have been compared with their relative EALs as discussed in Section 1.2.3.

Landfilled Area

Concentrations of the above contaminants were not identified within the leachate monitoring data (MSMW035) throughout the monitoring period.

Permitted Area, Not Landfilled

Concentrations of the above contaminants were not noted within the groundwater monitoring data within the permitted area throughout the monitoring period.

Outside Permitted Site

Concentrations of the above contaminants were not noted within the monitoring data, downgradient of the landfill (MSMW155) within the permitted area throughout the monitoring period.

Concentrations of GRO (C4 – C12) were identified in all offsite boreholes monitored ranging from 12µg/l in MSMW163 to 4,100µg/l in MSMW183. No EQS is available for GRO.

Benzene was identified outside of the permitted area, with concentrations ranging from 14µg/l in MSMW034 to 350µg/l in MSMW183. Exceedences of the EQS were noted upgradient of the site at boreholeMSMW034, and to the south of the site boundary, MSMW025 and MSMW183.

Table 2–2 outlines the TPH concentrations identified during groundwater analysis conducted by Atkins between 2008 and 2010. For the purpose of this report, this table looks at the maximum concentration noted at each location over the monitoring period to model the worst possible case scenario.

Table 2–2 Groundwater Quality Analysis

Sample Location	Borehole ID	Benzene	Naphthalene	Ethyl benzene	GRO (C4-C12)	m & p Xylene
Units		**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**
EAL		10	2.4	50	-	30
Landfill (Leachate)	MSMW035	0	<3.5	0	0	0
Permitted area not filled	MSMW156	0	-	0	0	0
Upgradient of Landfill	MSMW034	**14**	<4	0	2240	0
Down gradient of Permit Boundary	MSMW155	0	-	0	0	0
South of Permit Boundary	MSMW025	**32**	<3.5	0	2400	0
	MSMW163	0	-	0	482	0
	MSMW177	0	-	0	3900	0
	MSMW183	**350**	<4	0	4100	14

Note – figures in bold denote exceedences of the Surface water EAL

Concentrations of MTBE, o-Xylene, and Toluene were not detected within the permitted site, or downgradient, while low concentrations were noted upgradient and to the south of the site. A concentration of 217µg/l was in borehole MSMW183, to the south of the site.

Table 2–3 Groundwater Quality Analysis

Sample Location	Borehole ID	MTBE	o Xylene	Toluene	BTEX, Total
Units		**µg/l**	**µg/l**	**µg/l**	**µg/l**
EAL		**-**	**30**	**50**	**-**
Landfill	MSMW035	0	0	0	0
Permitted area not filled	MSMW156	0	0	0	0
Upgradient of Landfill	MSMW034	25	14	0	28
Down gradient of Permit Boundary	MSMW155	0	0	0	0
South of Permit Boundary	MSMW025	0	0	3	0
	MSMW163	17	0	0	0
	MSMW177	0	0	0	0
	MSMW183	0	0	16	217

Considering the monitoring data above, it is proposed that concentrations of Benzene, Naphthalene, Ethylbenzene, GRO (C4 – C12), M&p Xylene, MTBE, o Xylene, Toluene, BTEX noted during the monitoring period are the result of historical contamination, and not resulting from the leaching of contaminants from the landfill.

Trend analysis was undertaken for Benzene and GRO (C4 – C12), the COCs with the highest concentrations identified during monitoring. Charts showing the results can be found in Appendix 2 of the ESID document. Result showed no discernible trends, as concentrations are sporadic. Insufficient data is available to interpret these trends at present.

2.6.3. Conclusions

Groundwater monitoring data demonstrates that elevations of the COCs identified are not due to the presence of landfill material. For the most part, elevations and exceedences are sporadic, and a linkage cannot be made between the groundwater and potential landfill source. Further to this concentrations of contaminants were generally found to be high in the boreholes outside of the permitted site boundary, particularly those to the south. This suggests that any contamination noted in the groundwater is the result of the Llandarcy Refinery.

2.7. Hazardous substances

It is anticipated that the compressed peat layer underlying the landfill material will act as a barrier of low permeability, minimising migration of possible landfill leachate, containing hazardous substances, into groundwater.

Free product was not identified during monitoring of MSMW035, MSMW156, MSMW155, MSMW034, MSMW025, MSMW163, MSMW177 and MSMW183. However, the collection of free product, resulting from the Llandarcy Refinery, is ongoing in the area as part of the overall Coed Darcy Development, and as such it is expected that free product is present within the permitted site. It is not anticipated that free product is a result of landfilling activities, and as such has been omitted from this assessment.

2.7.1. Non-hazardous pollutants

It is anticipated that the compressed peat layer underlying the landfill material will act as a barrier of low permeability, minimising migration of possible landfill leachate, containing non-hazardous pollutants, into groundwater.

2.7.2. Surface Water Management

Details of the surface water management system in place within the permitted boundary can be found in the ESID report, Section 2.5.

2.8. Hydrogeological Completion Criteria

As a result of the above qualitative assessment it is considered that the landfill site will not pose a risk to controlled waters as the COCs, as outlined above, do not appear to be present within the groundwater as a result of landfill activity. Contaminants identified are considered to be the result of background concentrations as elevations and exceedences of guideline values occur both with the permitted site, and to the south of the permitted site.

It is considered that there is no unacceptable risk of pollution from the landfill at present, or for the future. Any contaminants noted within groundwater are anticipated to be the result of historical pollution from the Llandarcy refinery, and not the associated Crymlyn Tip.

3. REQUISITE SURVEILLANCE

3.1. The Risk Based Monitoring Scheme

Based on the findings of the risk assessment it is not considered necessary to continue monitoring the part of the permitted site that has not been landfilled. Groundwater quality and leachate quality analysis suggests that any contamination noted in the groundwater is the result of historical contamination and not the associated landfill.

It is proposed, however, that groundwater and leachate monitoring is continued annually within the landfill to ensure that no unexpected breaches of the relevant EALs occur as a result of the landfill, and to identify any significant changes in quality which could pose a risk to controlled waters.

Water quality should be sampled after a minimum 3 well volumes have been removed from each standpipe in order to provide a representative sample of aquifer water. Teflon, stainless steel bailers, disposable bailers or Waterra tubing can be used for purging and sampling each standpipe.

Each sample should be stored in an appropriate container as supplied by the testing laboratory and transported in an appropriate fashion at a suitable temperature such that samples undergo the minimum of change between sampling and analysis in the laboratory.

3.1.1. Leachate Monitoring

Leachate monitoring is recommended in boreholes MSM152s and MSMW238, as the boreholes are installed within the waste mass and should represent up and down gradient samples. Monitoring results from the sampling of these wells should provide information on the concentration of COCs within the waste mass.

Table 3–1 Proposed Groundwater Monitoring Programme

Sample Type	Borehole ID	Proposed Analysis	Frequency
Leachate Quality	MSMW152s, MSMW238	TPH Benzene Ethylbenzene Naphthalene Benzo(a)pyrene GRO (C4 – C12) m&p Xylene MTBE O-Xylene Toluene BTEX	Monthly, for 12 months.
		Groundwater Level	

3.1.2. Groundwater Monitoring

Groundwater monitoring is recommended in boreholes MSMW036, MSMW156, MSMW157, MSMW172, CARW003 and CARW029, as this will provide quality data from both up and down gradient of the landfilled area. MSMW036, MSMW156, MSMW157 and MSMW172 are all installed in the till, while CARW003 and CARW029 are installed in made ground.

Table 3–2 Proposed Groundwater Monitoring Programme

Sample Type	Borehole ID	Proposed Analysis	Frequency
Groundwater Quality	Up gradient wells MSMW036, MSMW172, CARW003, Down gradient wells MSMW157, MSMW156, CARW029	TPH Benzene Ethylbenzene Naphthalene Benzo(a)pyrene GRO (C4 – C12) m&p Xylene MTBE O-Xylene Toluene BTEX	Monthly, for 12 months.
		Groundwater Level	

3.1.3. Surface Water Monitoring

No surface water monitoring is proposed as it is not expected that contaminants from the landfill will migrate to the surface water receptors. It is expected that any contamination of surface water receptors will be the result of historical contamination and not the landfill.

4. CONCLUSIONS

4.1. Compliance with the Landfill Directive

The hydrogeological risk assessment suggests that the Crymlyn Tip does not pose a risk to controlled waters, and as such complies with the Landfill Directive. Groundwater monitoring results taken between 2008 and 2010 suggest that the concentrations of contaminants of concern identified are not due to the presence of landfill material, but instead relate to historical contamination from the Llandarcy Refinery.

Control and trigger levels for groundwater quality have not be derived as sufficient data is not available. It is recommended that further groundwater monitoring is undertaken across the landfilled section of the permitted site for 12 months to provide sufficient data.

4.2. Compliance with the Environmental Permitting Regulations, 2010, Schedule 22

The above risk assessment proposes that there is minimal risk of a discharge occurring of hazardous or non-hazardous pollutants into groundwater as a result of the Crymlyn Tip, as no discernible concentrations of COCs relating to the Tip were identified during monitoring.

It is recommended that further groundwater monitoring is undertaken across the landfilled section of the site to insure there are no significant changes to groundwater quality. It is considered unnecessary to continue monitoring of the Permitted Area that has not been filled in relation to Crymlyn Tip.

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