Anaergia
Breaking Barriers to Sustainability

Title: Containment Assessment Report
Plant: Bio Dynamic UK Limited, Nottingham
Date Submitted: 31.08.2022
Revision: 2





Containment Assessment

at

Bio Dynamic UK Limited

Anaerobic Digestion Facility,

Unit 1, Private Road No. 4, Colwick Industrial Estate, Nottingham NG12 2JT

TABLE OF CONTENTS

TABLE OF FIGURES

LIST OF ACRONYMS

Acronym	Definition
AD	Anaerobic Digestion
BMP	Bio-Methane Potential
BOD	Biochemical Oxygen Demand
BOD_5	5 Day Biochemical Oxygen Demand
CH_4	Methane
CHP	Combined Heat and Power
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
COD	Chemical Oxygen Demand
dB	Decibels
DBFOM	Design Build Finance Operate Maintain
DBO	Design Build Operate
DBOO	Design Build Own Operate
DBOOM	Design, Build, Own, Operate, Maintain
FIT	Feed-In-Tariffs
FOG	Fats, Oils and Grease
FSP	Filter Screw Press
GRF	Glass Reinforced Fibre
GJ/h	Gigajoule per hour
GUP	Gas Upgrading Plant
H_2	Hydrogen
H_2S	Hydrogen Sulphide
HPU	Hydraulic Power Unit
HRT	Hydraulic Retention Time
IPPC	Integrated Pollution Prevention and Control Directive
kV	Kilovolts
kW	Kilowatt
kWel	Kilowatt Electrical
kWh	Kilowatt Hour
kWth	Kilowatt Thermal
mg/L	Milligram per Litre
MSW	Municipal Solid Waste
MW	Mega Watt
MWel	Mega Watt Electrical

Acronym	Definition
MWth	Mega Watt Thermal
t	Tonne (metric ton)
t/h	Tonnes per hour
t/d	Tonnes per day
t/a	Tonnes per annum
N	Nitrogen
Nm^3	Normal Cubic Meters
Nm^3/h	Normal Cubic Meters per hour
Nm^3/d	Normal Cubic Meters per day
NOx	Nitrogen Oxides NO and NO_2
O&M	Operation and Maintenance
OLR	Organic Loading Rate
P	Phosphorus
P&ID	Process and Instrumentation Drawing
PLC	Programmable Logic Controller
PO	Purchase Order
POW	Pure Organic Waste
PPE	Personal Protective Equipment
ppm	Parts per Million
PSA	Pressure Swing Absorption
PP	Polypropylene
SO_2	Sulfur Dioxide
SO_X	Sulfur Oxide
SSO	Source Separated Organics
tbd	To be defined
TDS	Total Dissolved Solids
TN	Total Nitrogen
TP	Total Phosphorus
TS	Total Solids
TSS	Total Suspended Solids
VOC	Volatile Organic Compound
VS	Volatile Solids
VSS	Volatile Suspended Solids
WWTP	Waste Water Treatment Plant
% w/w	Mass percent
Vol.%	Volume percent
η	Efficiency

1 PREAMBLE

This report has been prepared by Sam Smith, UK Projects Director for Anaergia Limited.

Anaergia Limited is a wholly owned subsidiary of Anaergia Incorporated, a company headquartered in Canada but which operates worldwide, with offices on 4 continents, in the field of organic waste recovery and has designed and built more than 1,500 organic waste and anaerobic digestion plants globally over a period of nearly 3 decades in the industry. Anaergia has constructed 13 anaerobic digestion plants in the UK to date – including design, installation and commissioning aspects – and has a growing business in both servicing and operating plants in the UK.

Sam Smith holds a Bachelor's Degree in Civil Engineering, has worked for Anaergia Limited for more than 7 years and has worked in the field of organic waste and anaerobic digestion for 15 years.

2 INTRODUCTION

The purpose of this report is to provide an assessment of the primary, secondary and/or tertiary containment measures in place at the Bio Dynamic UK Limited anaerobic digestion plant in Colwick Industrial Estate, Nottingham, NG4 2JT against best available technology/techniques ("**BAT**").

A programme of significant technology and infrastructure upgrade works has been carried out at the Bio Dynamic Nottingham facility starting in early 2020 and with the upgraded plant in operation as at the date of this report as per the layout provided as **Appendix A**.

This assessment report uses the following assessment logic:

a. Assess the current primary containment provisions on the site against BAT *(see Section 3 of this report)*

b. Determine the Classification of Secondary & Tertiary Containment System required on the Bio Dynamic Nottingham facility, using the risk assessment approach set out in CIRIA 736 (*see Section 4 of this report)*

c. Clarify the status of the secondary and/or tertiary containment currently in place at the Bio Dynamic Nottingham facility (*see Section 5 of this report).*

d. Assess the suitability of the current secondary and/or tertiary containment against BAT (*see Section 6 of this report).*

3 BAT ASSESSMENT OF CURRENT PRIMARY CONTAINMENT

The reference for BAT for primary containment on a food waste anaerobic digestion plant such as Bio Dynamic Nottingham is not immediately clear. CIRIA document C535 "Above-ground proprietary prefabricated oil storage tank systems" published in 2002 may seem to be an obvious reference point but this almost exclusively addresses the petrochemical industry, which is quite different in nature to a food waste anaerobic digestion plant. Notwithstanding this, the primary containment at Bio Dynamic Nottingham is expected to be confirmed as compliant with BAT guidance for the following reasons:

3.1 ASSESSMENT OF PRIMARY CONTAINMENT

As detailed in **Figure ii** the vast majority of the Inventory is contained in three major process tanks, designated Digester 1, Digester 2 & Post-Digester. These three major tanks are pre-cast, post-tensioned concrete vessels constructed by A-Consult (see **Appendix B** for design details). A-Consult are a reputable and experience supplier of tanks within the market, both in anaerobic digestion and more widely, and concrete tanks are more robust, durable and have a longer design life than most steel tank systems.

During the recent upgrade works, all three major process tanks were emptied, cleaned and then thoroughly inspected by A-Consult, the reports from these inspections being provided as **Appendices C,D & E** to this report. A number of improvement actions were identified by A-Consult and these actions were all completed as confirmed in the signed inspection records provided as **Appendix F** to this report.

3.2 ASSESSMENT OF PRIMARY CONTAINMENT OPERATIONAL CONTROLS

Appendix G to this report is a process and instrumentation diagram ("P&ID") of Digester 1, but is indicative of the process control philosophy and measures for all primary containment vessels, the key features being:

- Material transfers in and out of the primary containment vessels are by controlled pumping only (i.e. they are not hydraulically linked)
- The process design incorporates an Operating Level and Maximum Level capacity of the primary containment vessels, both of which are sensibly below the brim-full levels of the tanks
- The Operating Level of the vessels is constantly monitored and controlled according to a permanent level instrument (designated LT41102 for Digester 1)

- The Maximum Level of the vessels is monitored by a separate, independent level sensor (designated LSH41103 for Digester 1) that shuts down any material transfers in and out of the vessel if activated.

3.3 PRIMARY CONTAINMENT INSPECTION & MAINTENANCE

The primary containment vessels will be periodically inspected and maintained in accordance with the written scheme of examination set out by the manufacturer, A-Consult, in its technical manuals for the vessels – included as **Appendices H & J** to this report – and in particular Section 6 of these manuals.

4 CLASSIFICATION OF SECONDARY CONTAINMENT REQUIRED

The reference for BAT in the area of secondary/tertiary containment has been selected as CIRIA document C736 "Containment systems for the prevention of pollution" published in 2014 ("**CIRIA 736**") and this document shall be referred to throughout this report.

Chapter 2 of CIRIA 736 sets out a risk assessment methodology to support a three-tier risk-based classification system for secondary and tertiary containment. This classification system recommends different standards of construction, or levels of performance, in accordance with each of the three levels of risk. In short, the results of the assessment are a classification of the containment system standard required appropriate to the site-specific risk.

The risk assessment process is outlined in the flow chart provided as **Figure i** below and the specific assessment for the Bio Dynamic Nottingham facility is set out in the following sub-sections.

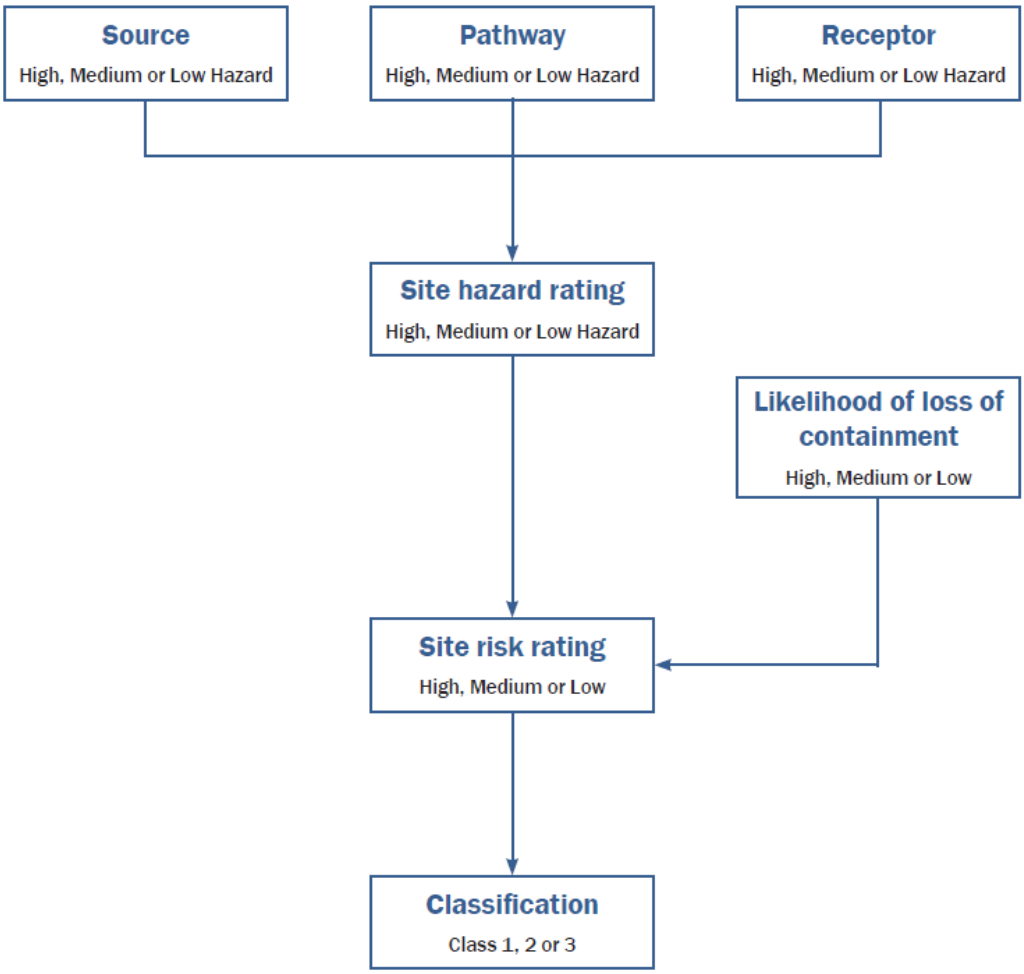


Figure i – CIRIA 736 Figure 2.5 'Risk Assessment Framework'

4.1 SITE HAZARD RATING

CIRIA 736 directs that an overall Site Hazard Rating should be assessed based on three factors; Source, Pathway and Receptor. Assessment of each of these factors for the Bio Dynamic Nottingham facility are set out in Section 3.1.1 to 3.1.3 below and lead to the following assessment of the overall Site Hazard Rating:

BIO DYNAMIC NOTTINGHAM SITE HAZARD RATING = Medium-Medium-Medium = "Medium"

4.1.1 SOURCE

As set out in CIRIA 736 "Source" refers to the following:

a. The inventory
b. The rainwater or surface water runoff contaminated by the inventory
c. Firefighting agents that are harmful to the environment in their own right and/or are contaminated by the inventory
d. Firefighting and cooling water contaminated by the inventory

Taking each of these elements in turn:

Inventory

The primary inventory of the Bio Dynamics Nottingham site is the de-packaged, diluted and pasteurised 'diluted waste slurry' derived from the waste materials the facility is licenced to accept and process under Environmental Permit reference **EPR/DP3935ER**.

The primary inventory consists of 'diluted waste slurry' that has a water content of at least 80% and is held in tanks as set out in **Figure ii** below. The diluted waste slurry is initially anaerobic digestion process elevates the temperature of the material to a range of 35-45 degrees Celsius and a substantial proportion of the 'active' organic content of the material is digested and converted into biogas that is removed and converted into utilities elsewhere on the facility.

The permit restricts the wastes to a range of segregated pre- and post-consumer food wastes, which materials have a relatively low toxicity and, particularly given the level of dilution in the form they are stored in and the digestion process further reducing the 'active' organic content, present a low hazard to potential environmental receptors if released.

Tank Reference	Tank Contents	Tank Brim-full Volume (m^3)
Digester 1	Diluted Waste Slurry	3,695
Digester 2	Diluted Waste Slurry	3,695
Post-Digester	Diluted Waste Slurry	6,842
Liquid Reception Tank	Diluted Waste Slurry	380
Depackaged Slurry Tank	Diluted Waste Slurry	180
Pasteuriser 1	Diluted Waste Slurry	50
Pasteuriser 2	Diluted Waste Slurry	50
Buffer Tank 2	Diluted Waste Slurry	180
	Total Primary Inventory Volume	**15,072**

Figure ii – Bio Dynamic Nottingham Primary Inventory Volume & Locations

A secondary inventory exists in the form of the following two elements:

1. Waste Pre-Processing Buffer Storage: A number of smaller vessels are located with the main building on the Bio Dynamics Nottingham facility to hold either waste delivered to the site in liquid form or a product of interim stages of the waste de-packaging and dilution processes. These smaller vessels are not hydraulically linked and are within the footprint of the building which, due to having a continuous perimeter upstands, is capable of containing any spillage from these smaller vessel.
2. Chemical Storage: Small quantities of chemicals, including dilute acids, diesel and liquid propane, are stored on the Bio Dynamics Nottingham facility but each is provided with it own separate, local secondary containment.

On the basis of the above, the secondary inventory is therefore excluded from the considerations of this assessment with the focus being on the primary inventory.

Rainwater

All the primary inventory is stored externally on the Bio Dynamic Nottingham facility and therefore any consideration of secondary/tertiary containment must take account for rainwater as required.

Firefighting Agents & Water

As detailed above, the material is at least 90% water and does not contain substantively flammable/combustible and therefore any incident in which the inventory material is released will only

serve to control a fire and therefore firefighting agents and water are not relevant considerations for the Bio Dynamic Nottingham facility.

So considering the primary inventory and rainwater provisions at the Bio Dynamic Nottingham Facility: The nature of the stored material presents a low hazard to potential environment receptors, but there is a large quantity of the material present on the facility (i.e. the potential quantity that could be discharged is high). CIRIA 736 also notes that EPR establishments would normally be expected to be given a site hazard rating of high/medium. On this basis:

BIO DYNAMIC NOTTINGHAM "SOURCE" HAZARD RATING = "MEDIUM"

4.1.2 PATHWAY

CIRIA 736 sets out a wide range of factors that could contribute or influence this hazard element, however in considering the specific location of the Bio Dynamic Nottingham facility a simpler and more direct assessment can be made on the basis of the following two points:

- The site is within 50 metres of the banks of the River Trent
- There are no natural channels or artificial channels/drainage connections between the site and the River Trent

Therefore, the pathway risk cannot be 'low' given the proximity of a major watercourse, however without direct channels any spilled material from the site must be transferred to the river via groundwater, meaning the transfer of material will be slow. On consideration of these points and logic:

BIO DYNAMIC NOTTINGHAM "PATHWAY" HAZARD RATING = "MEDIUM"

4.1.3 RECEPTOR

Again, as with Pathway, CIRIA 736 sets out a wide range of factors that could impact this hazard element, however the specifics of the Bio Dynamic Nottingham facility again present a simpler and more direct assessment as follows:

- The primary Receptor for the site is the River Trent
- CIRIA 736 notes that 'locally designated' surface water bodies are likely to be rated as 'Medium' hazard

BIO DYNAMIC NOTTINGHAM "RECEPTOR" HAZARD RATING = "MEDIUM"

4.2 SITE RISK RATING

Having assessed the Site Hazard Rating as 'Medium' (see Section 3.1) the next step set out in CIRIA 736 is to determine the Site Risk Rating which, as set out in **Figure i**, is a combination of the Site Hazard Rating and a rating of likelihood of loss of containment.

CIRIA 736 provides a general guide to determining the risk of loss of containment factor as set out in **Figure iii**.

Risk of loss of containment	Annual probability of loss of containment per site
High	Greater than 1% (1 in 100)
Medium	Between 1% (1 in 100) and 0.001% (1 in 1 million)
Low	Less than 0.001% (1 in 1 million)

Figure iii – CIRIA 736 Table 2.3 'Frequency of loss of containment'

To determine the risk of loss of containment factor for Bio Dynamics Nottingham the standard of the facility following the currently ongoing upgrade works must be considered, which includes the following features:

- Concrete tanks (highly durable and robust)
- Stainless steel pipework used for all inventory material transfers
- 'Fail shut' valves installed at all key locations in the process
- High degree of process automation, with instrumentation and critical alarms on all key process parameters

Given the above the features, the upgraded plant is considered to have a "Medium" risk of loss of containment.

The overall Site Risk Rating is therefore:

BIO DYNAMIC NOTTINGHAM SITE RISK RATING = Medium-Medium = "Moderate"

4.3 CONTAINMENT CLASSIFICATION SYSTEM TYPE

In accordance with the guidance set out in CIRIA 736 for a facility with a "Moderate" site risk rating:

BIO DYNAMIC NOTTINGHAM CONTAINMENT CLASSIFICATION TYPE = "Class 2"

5 STATUS OF CURRENT SECONDARY CONTAINMENT

As set out in the general layout drawing provided as **Appendix A**, The Bio Dynamic Nottingham facility has in place a secondary containment bund, formed in earth but lined with HDPE, around the three main primary inventory tanks, but following recent upgrade works there is also an area around the smaller primary inventory tanks surrounded by a 2m high reinforced concrete wall and solid concrete flooring, that is now linked to the lined bund.

5.1 CURRENT SECONDARY CONTAINMENT VOLUME

As per the data from a topographic survey of the as-built, upgraded plant carried out in June 2022 – provided as **Appendix J** – the volume of the secondary bund at Bio Dynamic Nottingham is confirmed as follows:

- Lowest average level of bund around three main tanks = +19.50m
- Top of bund datum = +21.74m
- Total Base Area of 2,900m^2 (lower bund area around 3 main tanks) + 1545m^2 (remaining bund area) = 4,445m^2
- Lower bund area around 3 main tanks providing bund height of +2.24m x 2,900m^2 = 6,496m^3
- Upper bund area providing average height of +1.15m x 1545m^2 = 1,777m^3

Current Secondary Containment Bund Volume = **8,273m^3**

5.2 CURRENT SECONDARY CONTAINMENT CONSTRUCTION

Having completed the extensive upgrade works to the Bio Dynamic Nottingham plant, the secondary containment construction is confirmed as the following:

- Shape and size as detailed in Section 5.1 above
- Constructed from compacted layers of suitable material with a welded HDPE liner throughout the bund, with the exception of the new reception tank/pasteuriser area where full concrete surfacing has been provided (see below). The HDPE liner was exposed, inspected and repaired as required during the upgrade works
- Any vehicle access areas, or high pedestrian traffic routes within the bund area have additionally been provided with concrete hard-surfacing
- The new reception tank/pasteuriser area has been installed with a perimeter reinforced concrete bund wall 2m high and full concrete flooring linking into the HDPE liner of the main bund.

- A permanent drainage and pumping system for the removal of rainwater from the bund is now in place (with rainwater being transferred for use as dilution in the plant process)
- Inspection chambers have been installed at regular intervals around the 3 main primary containment vessels to allow samples of water within the secondary containment bund to be collected and tested for evidence of process material leakage into the bund.

5.3 OTHER CURRENT FEATURES RELEVANT TO SECONDARY CONTAINMENT

The following features must be included in any consideration of the secondary containment provision at the Bio Dynamic Nottingham facility:

- Tanks are not hydraulically linked: Material transfers between tanks are by pump through normally/fail closed valves
- Inventory is not flammable
- Tanks are robust concrete construction
- Rainwater can only be removed from the bund by pump (no gravity drain connections)
- There are no utility or service penetrations of the bund's HDPE liner

6 BAT ASSESSMENT OF CURRENT SECONDARY CONTAINMENT

The following section assesses the current secondary containment provision(s) at the Bio Dynamic Nottingham facility as set out in Section 4 against the BAT requirement for a 'Class 2' containment classification system type as determined in Section 3. For clarity, if it is considered that the current containment provisions fall short of the BAT requirement then a Remedial Action will be detailed, but where no Remedial Action is identified it is considered that the current containment provisions meet the BAT requirement.

6.1 ASSESSMENT OF SECONDARY CONTAINMENT SYSTEM CAPACITY

Containment system capacity is addressed in Chapter 4 of CIRIA 736 and consists of four elements as follows:

a. The total volume of inventory that could be released during a credible incident
b. The maximum rainfall that would be likely to accumulate within the containment before, during and/or after an incident
c. Firefighting agents (water and/or foam), including cooling water
d. Freeboard and/or dynamic effects

Taking each of these elements in turn:

Volume of Inventory

Considering nature and volume of the primary inventory material at the Bio Dynamic Nottingham facility against the various legislative approaches set out in CIRIA 736 it is reasonable to deploy the "110%/25%" rule for the site, namely that the recommended capacity of the containment bund is the greater of:

- 110% of the capacity of the largest tank within the bund; and
- 25% of the total capacity of the tanks within the bund (except if they are hydraulically linked)

With reference to **Figure ii** for Bio Dynamic Nottingham these capacities are:

- 110% of largest vessel (Digester 3/Post-Digester) = 7,526m^3
- 25% of all vessels (they are not hydraulically linked) = 3,768m^3

Therefore, the recommended capacity of the secondary containment bund is at least **7,526m^3**, so the existing current secondary containment bund volume per Section 4.1 is sufficient.

Rainwater:

CIRIA 736 recommends that provision be made in containment volume for the total volume of accumulated rainfall in response to a 10 per cent (1 in 10 year return period) annual exceedance probability event for (with figures in italics specific to the Bio Dynamics Nottingham facility as per **Figure v**):

- 24-hour period preceding an incident: *32mm*
- Duration of the incident: *For a large volume incident this will be very quick and certainly no longer than a 24-hour period, so 32mm*
- An eight-day period following an incident or other time period as dictated by site specific assessment: *65mm*

So, a total rainwater depth of 129mm over the bund base area of 4,445m^2 (see Section 4.1) = **573m^3 of rainwater capacity provision is required**. Added to the inventory provision above this means the recommended capacity of the secondary containment bund is at least **8,099m^3**, so the existing current secondary containment bund volume per Section 4 is sufficient.

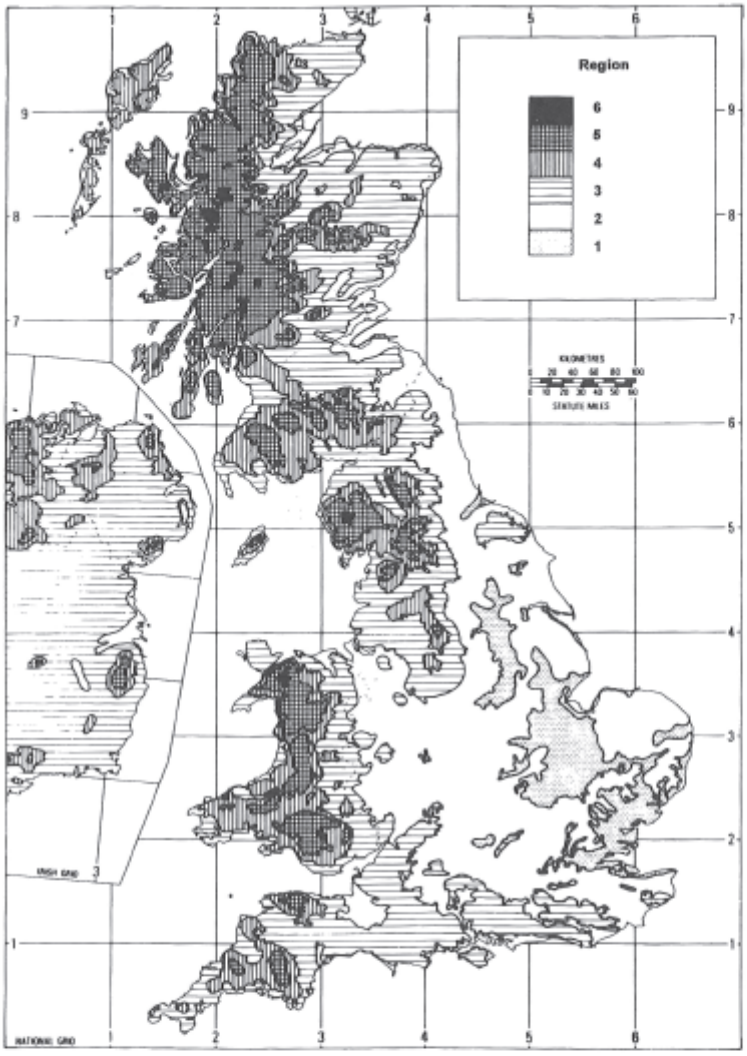
Firefighting water & firefighting agents:

As noted elsewhere in this assessment, the primary inventory on the Bio Dynamic Nottingham site is not flammable/combustible and, in fact, any release of material during an incident would help to control any fire rather than to exacerbate one. As such, provisions for firefighting water and agents is not directly relevant to containment considerations on this site. Notwithstanding this, however, it should be noted that the freeboard provision defined by the '110%/25%' rule, as set out above will be in excess of the minimum 100mm freeboard allowance that CIRIA 736 recommends for firefighting agents.

Freeboard for Dynamic Effects

Freeboard is the increased heigh allowed in the design of structures to account for uncertainty, which includes rainwater and firefighting agents (see above) but CIRIA 736 also recommends provision for the '*surge effects of the catastrophic failure of the primary storage vessel.*'

It is noted, however, that the capacity of the Bio Dynamics Nottingham containment bund has been primarily determined by the '110%/25%' rule as set out above, which already makes significant provision for freeboard and, as such, it is considered sufficient to accept this provision.



Region	Standard annual average rainfall (mm)	Rainfall depth (mm) 10-year return period	
		24-hr duration	8-day duration
1	<600	29	54
2	600–800	32	65
3	800–1200	41	95
4	1200–1600	52	120
5	1600–3200	88	231
6	3200	106	288

Notes

It should be stressed that Figure 4.2 should only be used to derive a first estimate for considering containment volumes. This is for two reasons:

1 The figure is based on *Flood studies report* (Institute of Hydrology, 1975) data produced up to 1988.

2 Climate change effects since the publication of HR Wallingford (1988) will have resulted in different annual rainfall figures.

Detailed design should therefore be based on the output of the FEH rainfall.

Figure 4.2 Average rainfall depths (from HR Wallingford, 1986)

Figure iv - CIRIA 736 Figure 4.2 'Average Rainfall Depths'

6.2 ASSESSMENT OF SECONDARY CONTAINMENT SYSTEM CONSTRUCTION

Chapter 8 of CIRIA 736 provides recommendations and guidance on '*earth banked containment basins (lagoons), earth bunds and earth floors'* and recommends the type of construction for "Class 2" earth bunds to be as set out in **Figure v**.

With reference to Section 5, the design of the Bio Dynamic Nottingham secondary containment bund therefore complies with BAT recommendations as set out in CIRIA 736.

As as noted in Section 5.2, as part of the recent upgrade works on the plant the continuity and integrity of the HDPE liner has been confirmed and further improvement measures – e.g. concrete surfacing to vehicle/high-traffic areas – have been added.

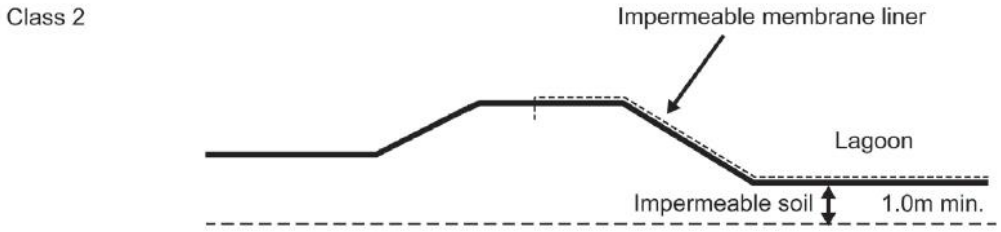


Figure v - CIRIA 736 Figure 8.4 'Classification of Lagoons'

6.3 SECONDARY CONTAINMENT SYSTEM INSPECTION & MAINTENANCE

Inspection of the secondary containment system at the Bio Dynamic Nottingham plant will form part of the normal operating procedures and will consist of the following:

- Visual inspections of the secondary containment system by operations personnel once per month
- A cumulative water sample to be taken from inspection chambers (see Section 4.2) and tested by a suitably accredited lab for the presence of process contamination once per year
- Visual inspections of the secondary containment by a competent person once per year

7 CONCLUSIONS

The conclusion of this containment assessment is that the Bio Dynamics Nottingham is compliant with BAT guidance for both primary and secondary containment.

8 LIST OF APPENDICES

The following documents are appended with, and form an inseparable part of, this document:

APPENDIX A	125 A04 01 General Layout, Bio Dynamic Nottingham Rev 03
APPENDIX B	AQ 430407-60-1001-2 Iss 2, Digester 1 Tank Design
APPENDIX C	A-Consult Inspection Report, Digester 1 210521
APPENDIX D	A-Consult Inspection Report, Digester 2 070521
APPENDIX E	A-Consult Inspection Report, Digester 3 071221
APPENDIX F	Digester Tank Inspection Records
APPENDIX G	125 A01 01 P&ID Digester 1
APPENDIX H	430407 A-Consult User Manual (Digesters 1 & 2)
APPENDIX I	430508 A-Consult User Manual (Post-Digester)
APPENDIX J	A0 22F070/001 Topographic Survey, Bio Dynamic Nottingham Jun-22