NRW Discharge Consent Application

Afon Seiont, Caernarfon

Proposals and Calculations to Support the Application

November 2019

Project Information	
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Approval Record	
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Document History		
Revision	**Date**	**Comment**
01	19/08/2019	Draft issue
02	21/08/2019	Text amendments
03	22/08/2019	Sediment pond relocated
04	13/09/2019	Text section and appendix relating to suspended solids added
05	06/11/2019	Modified text in relation to Finishing Lagoon

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Introduction

This report has been prepared in support of a proposed surface water discharge consent application associated with Seiont Quarry, Caernarfon, LL55 2YL. The site is located at National Grid Reference: 249037, 361545. The site comprises a construction compound and a quarry void with associated access roads. The construction compound serves the ongoing Caernarfon and Bontnewydd bypass construction.

The base of the quarry void has three lagoons, which have been pumped down ready for remodelling/re-engineering. The proposal is to incrementally fill the quarry void with non-hazardous cut material (mainly till) from the construction of the bypass road. A Discharge Consent application is required for disposing of surface water runoff from the quarry void to the Afon Seiont, a designated 'main river'. The discharge from the quarry void will be restricted and provisions are to be made for sediment removal from the runoff.

A site plan identifying the proposed surface water management features is included in Appendix A.

This report provides information to support the Discharge Consent application. In accordance with the document provided by NRW entitled 'Design and Layout of Treatment Systems for Solids-Contaminated Site Drainage' document (included as Appendix C for completeness). This document recommends the following information should be provided (where applicable) to support the Discharge Consent application:

- Quantify area of site to be drained to treatment area (in m^2);
- Time of concentration (for peak flow)
- Volume and design basis of attenuation pond
- Lagoon dimensions, configuration and design
- Outlet pipe diameters from both attenuation pond and from settlement lagoon(s)
- Name and type of polyelectrolyte, if used
- Particle size/settlement rate assumed, and basis
- Rainfall data
- Site plan, clearly identifying:
    - Area draining to the treatment facility
    - Location of attenuation pond
    - Location & configuration of settlement lagoon(s)
    - Sampling point, where representative sample of the discharge may be safely obtained
    - Discharge point to watercourse
    - Watercourse (which the discharge will be made)

This report provides calculations and details to support the Consent Application for the infilling works and concludes with responses to each of the points above.

The final reinstatement plan is also included in appendix A for completeness.

Catchment Assessment

The map presented below as Figure 1 has been generated using LiDAR and GIS / watershed analysis. The quarry void sub-catchments identified include the quarried area, identified as catchments 1, 2, and 3, and two higher level smaller catchments, identified as catchments 4 and 5.

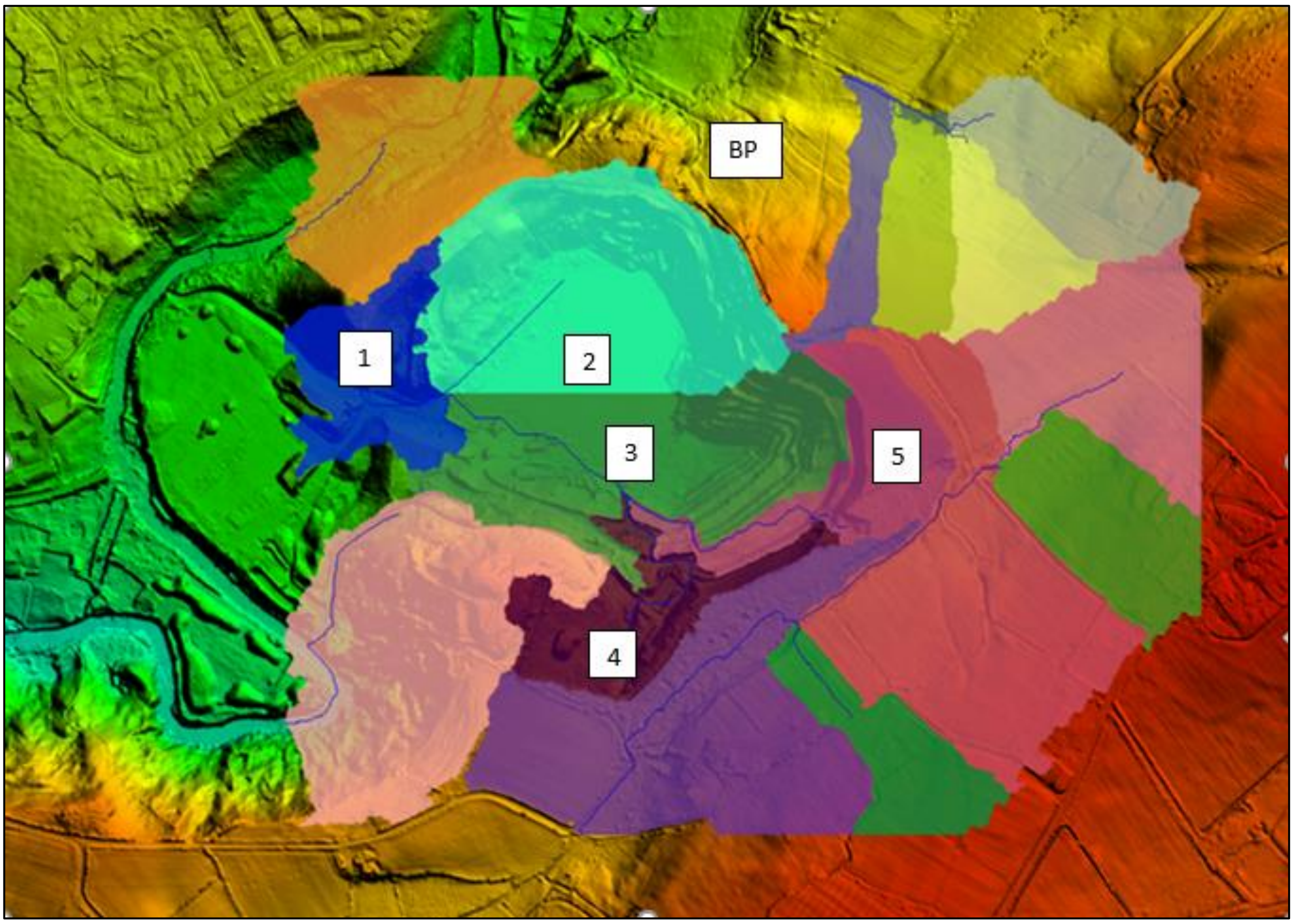


Figure 1 – Seiont Quarry Sub-Catchments

The borrow pit area (shown as BP in Figure 1), has been considered. While this could add to the quarry sub-catchment area, it is reasonable to assume that water flowing from this source will be controlled by a cut-off drain or continue to drain northwards, away from the quarry. The BP area is therefore not included within the catchment area considered in this report.

The total catchment area considered to drain to the quarry void and hence to be drained to treatment area is 11.1 ha………… 111000 m2

General arrangement schematic

An overview diagram is presented in figure 2 below to outline the approach discussed in subsequent pages.

Storm runoff from the catchment into the quarry void will firstly be 'buffered' within an attenuation pond at the base of the quarry void. A pumped discharge will deliver flow (at low rate) to a sediment lagoon, also within the confines of the quarry, but near the top of the void. Further pumping will then deliver settled water to the finishing lagoon where it will infiltrate through the base and soakaway into the water table and hence the nearby Afon Seiont. A sampling point will be provided at the overflow, if used.

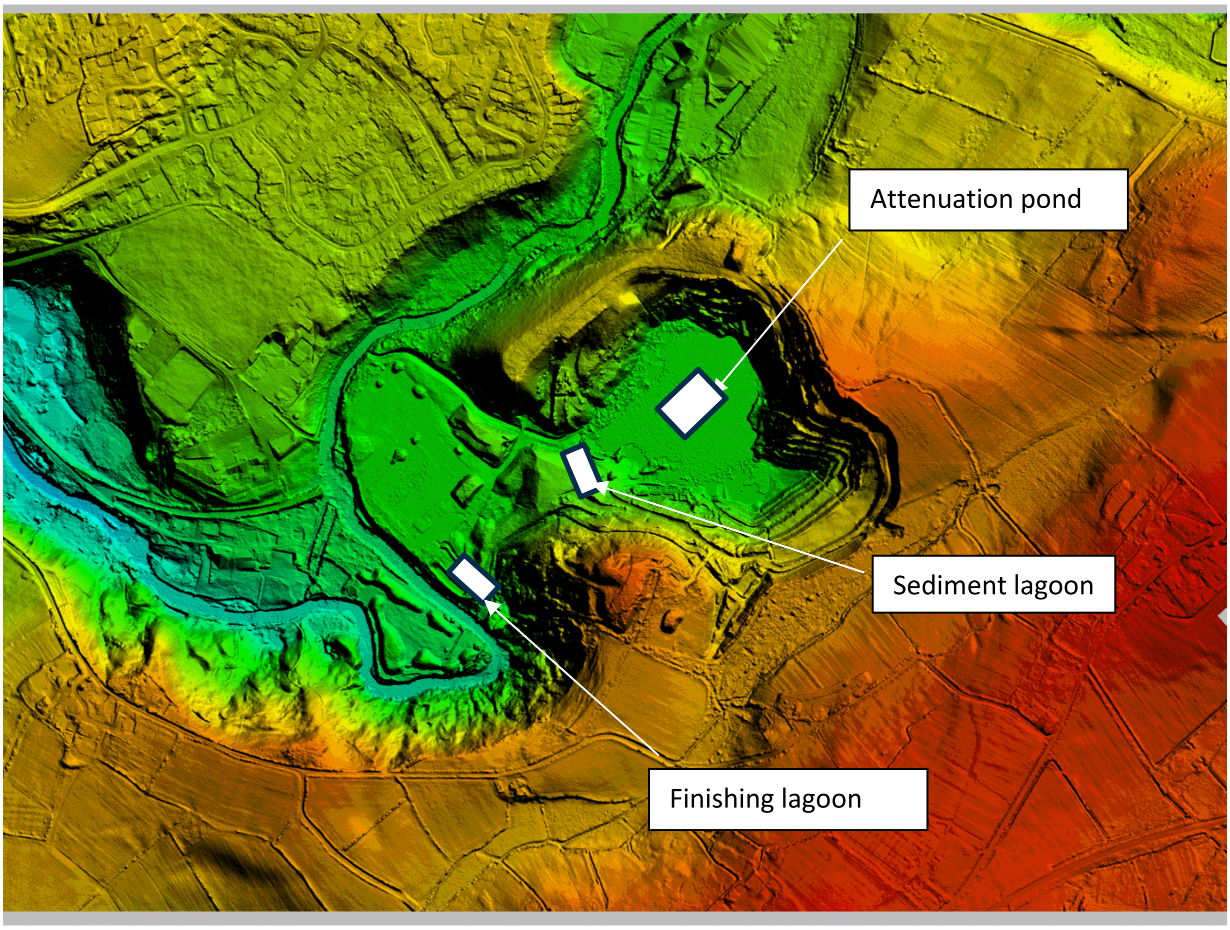


Figure 2 – Surface water management key features

Attenuation pond –the existing ponds will be used initially and then a new pond will be created at a higher level as the quarry infilling progresses……. with pumping to →
Sediment lagoon – located on the edge of the quarry hole and remaining fixed during the filling operation (until final reinstatement) to remove fine clay…. with pumping to →
Finishing lagoon - reusing the existing pond (from former quarry operation) will act as soakaway (Cleaned out routinely to maintain infiltration and retained as part of final reinstatement)

Attenuation Pond Sizing

Consideration was firstly given to flood volumes for typical storm durations as recommended in the guidance document. The table below compares storm flow rates and volumes for ReFH2 using a scaled proxy catchment and the modified rational method for the return periods from 1 to 10-years. The rational method has higher peak flows for short return period events. However, these are convective events of very limited coverage, and ReFH2 is generally the preferred rainfall model. While these assessments provide useful context, neither methodology provides guidance on an appropriate storage volume.

Return period and duration	Rainfall peak (mm/hr)	Rainfall total (mm)	Peak flow ReFH2 l/s	Volume ReFH2 m^3	Rational method Peak flow l/s*
1-yr D- 75min	3.34	7.76	130	940	264
1-yr D- 375min	2.02	19.3	190	2740	88
2-yr D-75min	3.93	8.86	150	1080	340
2-yr D-375min	2.18	20.87	200	2900	107
5-yr D-75min	5.7	12.85	210	1510	438
5-yr D-375min	2.89	27.67	270	3890	133
10-yr D-75min	7.19	16.2	270	1940	528
10-yr D-375min	3.46	33.11	320	4610	158

*Calculated on durations 60min and 360min

MicroDrainage assessment was therefore undertaken for attenuation pond sizing. BFIHOST (a measure of soil/rock infiltration) was recalculated using a value of 0.15 over the siltstone quarry area and a value of 0.6 for areas outside the quarry steep zone, from a small proxy catchment to the south-west. A final rounded BFIHOST value of 0.2 was used in MicroDrainage and ReFH2 calculations. Two MicroDrainage runs were undertaken one on the basis of the whole catchment area 111000m2 and the other for 80% area assuming some permeability.

The FEH 2013 rainfall model was used with climate change was taken to be zero, as the site is short term. Design parameters included: Area 110000 / 88800; BFIHOST 0.2; maximum outfall rate 4 l/s; return period 10-years; duration 6-hours. Results are included in Appendix D. with some 3,707m^3 being required for totally impermeable catchment and 2,959m^3 assuming 20% infiltration. The latter appears appropriate here. A uniform depth is unnecessary. As there will always be sufficient freeboard in the quarry during filling operations, a storm overflow will not be required. During an extreme event, any ongoing filling operations would cease.

The requirement for the attenuation pond is a volume of 3000m^3

The existing holes in the base of the quarry will be used initially, as the survey data shows they have a capacity in excess of 3000m3. As the quarry is filled in the attenuation pond will need to be repositioned. The new pond should be formed before the existing are filled in.

Pumping is necessary and controlling the pump rate is the simplest and most assured control methodology. A pumped outlet limited to 4 l/s is proposed for the attenuation pond.

Sediment Lagoon Sizing

The existing infiltration lagoon alongside the Afon Seiont is assessed to be some 400m^2. Materials entering the quarry are expected to contain glacial till and although very variable in clay content, these could quickly blind the base of the infiltration lagoon. The area is too small an area for sedimentation of clay (till). Therefore, and additional pond is proposed, between the attenuation pond and the final infiltration lagoon.

The particle distribution of the glacial till is unknown at present, but a sedimentation rate of 4 x 10^{-6} m/s is considered to be a reasonable (safe) basis for design, for clay (till).

The annual rainfall (SAAR), derived from the Flood Estimation Handbook (FEH) catchment descriptors, is 1149mm. Statistical analysis using local rainfall data appears unwarranted here. Experience suggests a wet year may be up to 50% higher in rainfall and this factoring is used to provide a ‘safe-side’ estimate. Evaporation from the quarry area has been taken to be approximately 500mm per year, based on CHESS (CEH) guidance.

Using the above values and a catchment area of 11.1 ha, suggests a typical wet year mean inflow to the quarry will be around 4 litres/sec [calculated as (rainfall x 1.5 x area) minus evaporation)/ 1-year(seconds].

On the basis that an attenuation pond is to be provided within the quarry (to buffer storm flows) the value of 4 l/s (0.004m^3/sec) can be used as the inflow rate into the sediment lagoon. This suggests a sediment lagoon sizing of approximately 1,000m^2 [A=Q/S …….0.004 / 4 x 10^{-6}]

The lagoon depth has not been calculated, but 1000mm Is recommended in the guidance document and would appear appropriate here as a balance between settlement depth and safety considerations. The sediment lagoon will be located at high level but still within the confines of the quarry, as shown on the annotated site plan included in Appendix A.

The requirement for the sediment pond is an area of 1000m^2 with a nominal depth of 1 metre.

It is proposed that the sediment lagoon would be a simple, rectangular configuration of 1000m^2 total area ,. The provisional shape is. 40m x 25m x 1 m deep shape. Dimensions may differ, but the lagoon geometry should be rectangular and not exceed a length/width ratio of 5.

As there is a finishing lagoon stage, an inlet weir is unnecessary. The outlet from the sediment lagoon will be pumped to the finishing lagoon. A simple broad-crested outlet weir or some other means will therefore be incorporated to limit the amount of silt being sent to the finishing lagoon. Inlet and outlet of the sediment lagoon will be separated as far as practical.

The pumped flow to the finishing lagoon will be a maximum of 4 l/sec.

Finishing Lagoon

The existing lagoon alongside the Afon Seiont has a potential capacity of some 400m^2(derived from Lidar). This is as a large enough area for silt sedimentation but is too small for significant amounts of clay sedimentation. The proposal is therefore to use this for finishing and on the basis the water received from the sediment lagoon will be relatively clean already, it is likely that water will infiltrate through the base into the river providing excellent water quality.

The existing inlet pipe will be blocked off and the associated gap in the bank will be filled in to maximise containment and a 150mm high level outlet pipe (invert 1.5m above finishing lagoon floor level), with suitable embankment erosion protection, will be added as a high level overflow to the Afon Seiont

To eliminate the possibility of any uncontrolled sediment concentrations entering the Afon Seiont, through the high level overflow pipe, the following will be included in the site management plan:

During periods of high river levels (i.e. greater than 11.15m AOD), or during normal river levels, if rapidly rising finishing lagoon levels are observed during daily inspections, all pumping to the finishing lagoon will cease; unless on-site operators are present to implement the agreed monitoring plan for controlled discharge.

Site testing on the lagoon has shown a high infiltration rate, with the lagoon having been part filled (given present low bank constraints) with some 300 m^3 of water and observed to drain away over a period of 8 hours giving a soakaway rate of around 10 litres per sec. Allowing for some blinding of the base, prior to routine cleaning, an infiltration rate of 7 l/s is to be used as a basis for design. However, the limiting rate, 4l/s, is controlled by the flow through the sediment lagoon.

In the best case, depending on the suspended solids concentration from the proposed sediment lagoon and the longevity of the site, the finishing lagoon may act as an infiltration basin for the whole period and effectively disconnect quarry site flows from the river. In the worst case of it silting-up early, it could be de-sludged to re-infiltrate.

Monitoring

A full monitoring programme is described below for completeness. This is not expected to be initiated as the finishing lagoon is intended to operate by infiltration. As such there will be **no direct discharges** to the Afon Seiont. Nevertheless, prior to start-up of the system a sampling point will be established at the overflow from the finishing lagoon, with safe access provided for sampling personnel.

Water levels in the finishing lagoon will be observed daily. Should levels begin to rise to be closer to the overflow level than the normal operating level, the following actions will be taken, as appropriate:

1. during times of flood flow in the Afon Seiont, (i.e. infiltration rate diminishes due to reduced hydraulic gradient), pumping rates from the attenuation pond will be restricted to maintain the status quo, until river levels subside.

2. plans will be put in place to clean out the base of the finishing lagoon (with materials arising disposed of as part of the quarry infill operation) to revitalise the soakage characteristics.

3. In the event that some overflow is proposed the Monitoring Plan below will be organised before any discharge to the river occurs

Monitoring Plan

In the event of high levels in the finishing pond a sample for laboratory testing of suspended solids will be taken for a baseline value along with an initial visual qualitative examination of water turbidity using a clear sample jar.

Should discharging to the Afon Seiont begin a further laboratory sample should be taken from the outfall. If the laboratory sample fails to meet the standards or in the meantime a sample is visually unsatisfactory pumping will be stopped immediately.

Provided the daily visual sampling gives no cause for concern a sample will be submitted for quantitative laboratory testing to confirm compliance with NRW standards each week The determination of suspended solids will be by the paper filtration method (full details in the appendix E).

This routine will continue on a daily basis with a visual sample being used as a go / no-go decision for pumping; with samples being taken for laboratory testing as confirmation.

Sampling will continue until:

a) river levels have subsided and the overflow ceases to operate
   or
b) action (2) is completed such that infiltration rates are reinstated
   or
c) if discharging to the Afon Seiont continues, laboratory sampling will fall to once per month with daily visual sampling , any laboratory test failure causing reversion to the original laboratory sampling rate of one per week with daily visual sampling.

Storm discharges

There will be no storm discharges to the river. Adequate volume in the quarry will be present on start-up and during filling operations to hold storm volumes exceeding rainfall return periods of 100-years. This is shown in the flow schematic as ‘quarry attenuation’.

Flow schematic

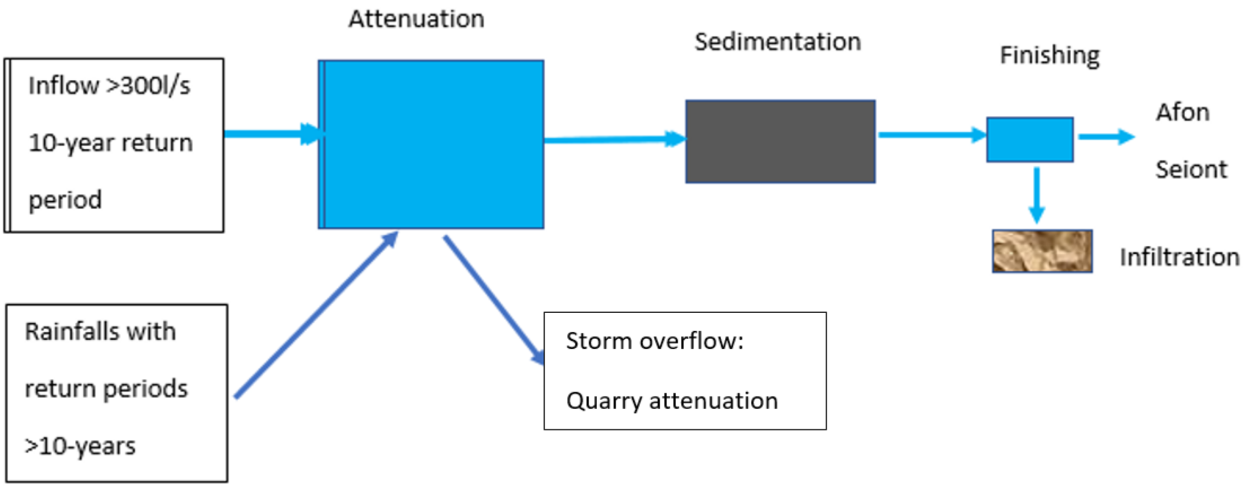


Figure 3 – Flow Schematic

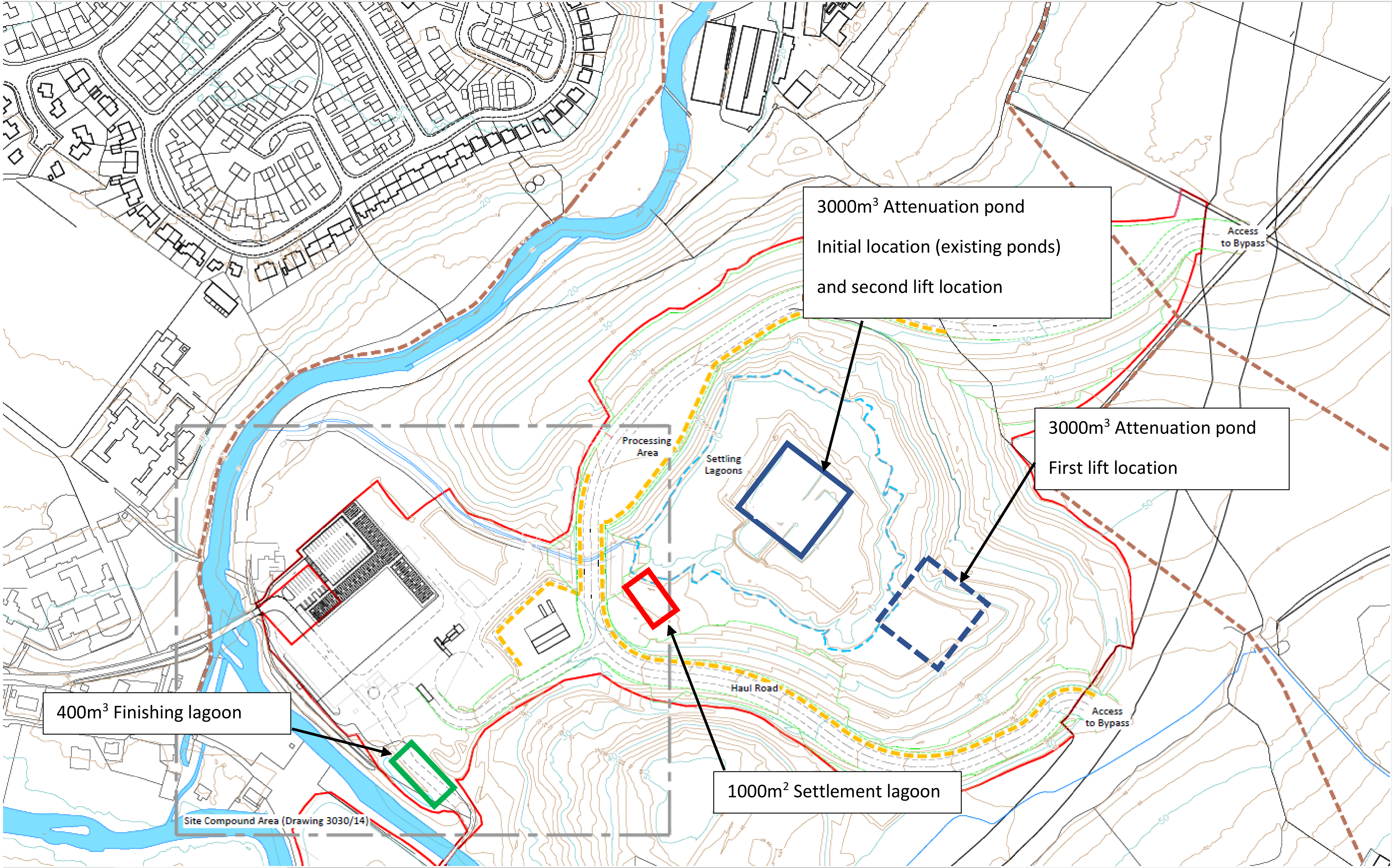
Conclusions

The following is a summary review using section 6 v (Consent applications) of the 'Design and layout of treatment systems for solids-contaminated site drainage':

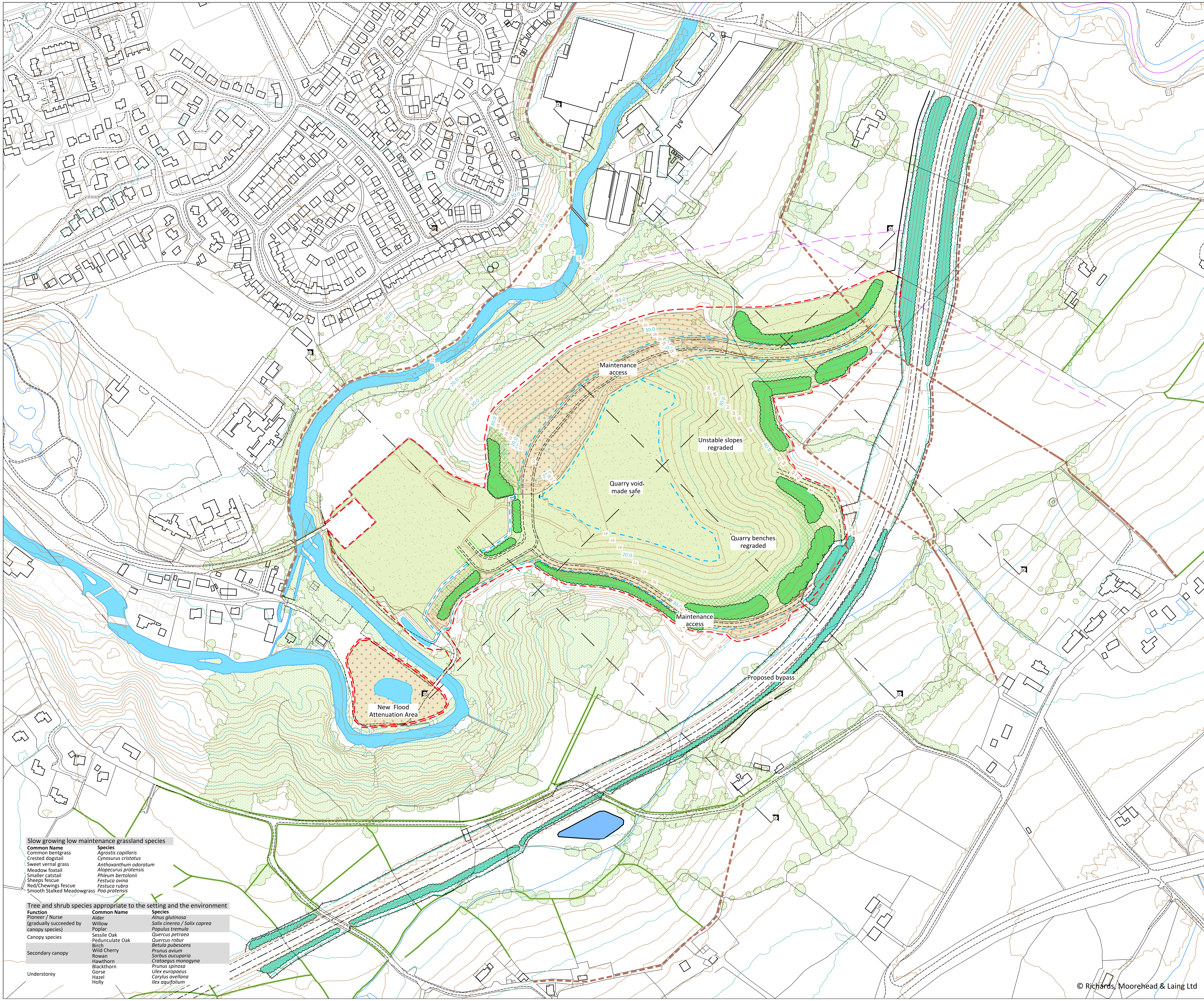
1. Quantify area of site to be drained to treatment area ………….. 111000 m²
2. Time of concentration (for peak flow)………….. N/A –Time to peak ($t_{p)}$ calculated within ReFH2
3. Volume and design basis of attenuation pond ……… 3,000 m^3 simple rectangular to suit operations
4. Lagoon dimensions, configuration and design … 40m x 25m x 1.0 m deep.
5. Outlet pipe diameters …..N/A pump rates will control transfer flows (4l/s max)
6. Name and type of polyelectrolyte, if used …….. Not used (3-stage treatment adopted)
7. Particle size/settlement rate assumed, and basis …. 4 x 10^{-6} m/s clay (till)
8. Rainfall data ……….FEH 2013 model

Provided the design concept described in this document are followed, the final effluent outflow to the Afon Seiont, will readily achieve the 10-30mg/l suspended solids mean.

Appendix A Site Plans



3000m³ Attenuation pond
Initial location (existing ponds)
and second lift location
3000m³ Attenuation pond
First lift location
Access to Bypass
Processing Area
Settling Lagoons
Haul Road
Access to Bypass
400m³ Finishing lagoon
1000m² Settlement lagoon
Site Compound Area (Drawing 3030/14)



Slow growing low maintenance grassland species

Common Name	Species
Common bentgrass	*Agrostis capillaris*
Crested dogstail	*Cynosurus cristatus*
Sweet vernal grass	*Anthoxanthum odoratum*
Meadow foxtail	*Alopecurus pratensis*
Smaller catstail	*Phleum bertolonii*
Sheeps fescue	*Festuca ovina*
Red/Chewings fescue	*Festuca rubra*
Smooth Stalked Meadowgrass	*Poa pratensis*

Tree and shrub species appropriate to the setting and the environment

Function	Common Name	Species
Pioneer / Nurse (gradually succeeded by canopy species)	Alder	*Alnus glutinosa*
	Willow	*Salix cinerea / Salix caprea*
	Poplar	*Populus tremula*
Canopy species	Sessile Oak	*Quercus petraea*
	Pedunculate Oak	*Quercus robur*
Secondary canopy	Birch	*Betula pubescens*
	Wild Cherry	*Prunus avium*
	Rowan	*Sorbus aucuparia*
	Hawthorn	*Crataegus monogyna*
Understorey	Blackthorn	*Prunus spinosa*
	Gorse	*Ulex europaeus*
	Hazel	*Corylus avellana*
	Holly	*Ilex aquifolium*

0 10 20 30 40 50 75 100 150 200 m

Eglurhad / Key:

- Planning Application Boundary
- Established Vegetation (existing)
- Proposed Woodland Planting
- Proposed Scattered Trees and Scrub Planting
- Grassland
  Area finished with topsoil and seeded with a low maintenance mixture
- Low Fertility Grassland
  Area finished with subsoil or left bare to allow natural colonization of herb and shrub species
- Waterbody / Pond
- Drainage Ditch
- Proposed Surface Contours (2.0 m interval)
- Public Right Of Way
- Proposed Bypass Hedgerow Planting
- Proposed Bypass Woodland Planting

PLANNING APPLICATION

Cywi. Rev.	Dyddiad Date	Disgrifiad Description	Gan By	Gwiriwyd Checked	Cymer. Appro.
05	Dec 2016	issued for planning	RhE	SMB	
04	Sep 2016	pre-application consultation	RhE	SMB	
03	05/06/2016	issued for information	RhE	SMB	
02	08/03/2016	issued for information	RhE	SMB	
01	25/02/2016	issued for comment	RhE	APCS	

Cleient / Client:

JONES BROS CIVIL ENGINEERING UK

Enw project / Project name:

ENGINEERING WORKS AND USE OF LAND RELATING TO THE CONSTRUCTION OF THE PROPOSED CAERNARFON AND BONTNEWYDD BYPASS AND EXISTING MINERALS PERMISSION

Teitl lluniad / Drawing title:

Restoration Plan

Darparwyd gan / Prepared by:

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Graddfa / Scale (A1): 1:2,000 @ A1

Dyddiad / Date: Feb 2016

Darlunwyd gan: Drawn by: RhE

Gwiriwyd gan: Checked by: APCS

Rhif lluniad / Drawing number: 3030 / 16

Cywiriad: Revision: 05

Appendix B Photographs

Finishing Lagoon

Quarry Void

Appendix C Guidance document

DESIGN AND LAYOUT OF TREATMENT SYSTEMS FOR SOLIDS-CONTAMINATED SITE DRAINAGE

Typical treatment for solids-contaminated site drainage is via a settlement lagoon system. The design of lagoon systems is crucial in achieving a high quality discharge in order to protect the receiving watercourse.

From experience it has been demonstrated that a well designed and correctly operated lagoon system can achieve 10-30 mg/l suspended solids, on average, in the final effluent.

Theoretically, if the settlement rate is adequate (eg. for coal shale usually 1×10^{-5} m/s) then **all** solids should be settled out in the lagoon. However, in reality factors such as 'sheer' (the stress exerted by the outflowing liquid on the settled solids which opposes the gravitational force acting to pull the settled solids downward) significantly affect the performance of the lagoon and cause suspended solids to discharge, hence 10-30 mg/l being typical.

1 Configuration

Various layouts are possible although the most effective basic design is:

Input→ Attenuation Pond → 2 (or more) settlement lagoons <u>in parallel</u>

Settlement lagoons in *series* do not offer the same degree of settlement as those arranged in parallel. This is due to flow re-acceleration between each lagoon which generates sheer and turbulence and thereby impairs the settlement rate, particularly of the finer particles, which consequently results in poorer discharge quality. Lagoons arranged in *parallel* each receive only a proportion of the overall flow to the treatment system, thereby optimising attainment of quiescent conditions to promote settlement. Additionally, lagoons thus arranged facilitate individual lagoon de-sludging or maintenance, if required, without it being necessary to take the entire system off-line.

2 Attenuation Pond

The attenuation pond is merely a single (usually) storage pond provided to deal with the 'top end' of the flows generated in heavy rainfall events. They serve to ensure a maximum design flow to the settlement lagoon(s) is never exceded, facilitating their optimum performance and thus protecting consent compliance. All run-off is directed via the attenuation pond which should be designed to pass forward regulated flows into the final settlement lagoons for treatment. ***Attenuation ponds do <u>not</u> provide treatment - they merely store run-off***. Essential features are as follows:

i) The outflow pipe from the attenuation pond into the settlement lagoons should be located towards the <u>*bottom*</u> of the pond.

ii) This outflow pipe should <u>*not*</u> be valved, as the design should be to allow free flow into the settlement lagoons.

(Where a valve is installed, contrary to the above advice, this must be throttled to the correct rate. Experience shows that site operators often close these valves when lagoon maintenance (eg. desludging) is required, which would be done in dry weather and re-opened at end of maintenance. However, occasionally site operators close down the valve to reduce flow to the lagoons, usually to aid settlement. This is poor practice and risks premature operation of the storm overflow discharge, if present. This would also be in breach of the consent, hence must be discouraged).

iii) The rate of flow passing forward into the settlement lagoons should be **delimited by the bore of the outflow pipe** from the attenuation pond. Failure to size this correctly will result in either too much flow passing forward into the lagoon and causing poor settlement or premature operation of storm overflow discharge (see iv). Pipe diameter together with head-over-pipe must be considered in the design specification. As a guide, flow through an orifice may be calculated as follows:

$$Q = 2.1 \times D^2 \times H^{0.5}$$

where **Q = lagoon outflow (m^3/s)**
D = orifice diameter (m)
H = static head (m)

This equation may be reconfigured to verify pipe diameter, thus:

$$D = \sqrt{[Q / (2.1 \times H^{0.5})]}$$

iv) In most cases, the attenuation pond should be designed with a high level storm overflow, which will require separately consenting (See **s4**). However, at the risk of the consent applicant*, this may be waived in the following exceptional instances:

- If additional storage capacity exists on-site (eg. within opencast cut, where excess flows may be retained or indeed naturally gravitate);
- If flows to the attenuation pond are well managed, ie. largely or entirely pumped, rather than gravity fed;
- Where attenuation lagoons are ‘overdesigned’ in terms of storm return period catered for, relative to the lifetime of the required treatment – thereby minimising the likelihood of available storage proving insufficient during storm events. This may potentially be the case for short term (6-12 months) sites.

* Applicants must be aware that any unconsented storm overflow due to unforeseen storm events would constitute an illegal discharge.

3 Settlement Lagoons

Lagoons should be designed to incorporate:

i) A settlement lagoon design and sizing (in application of Stokes’s Law) based on a through-flow rate set to ensure that:

$$\frac{Q}{A} = \text{Settlement Rate (m/s)}$$

where **Q = lagoon outflow (m^3/s)**
A = lagoon surface area (m^2)

A settling rate of 1×10^{-5}m/s is the rate at which 95% of 4μm diameter coal shale particles have been shown to settle – which is typical for opencast sites. For other sites (eg. remediation work using soils) then the applicant should use a *site specific particle size / settling rate*, so as to ensure correct lagoon sizing. The more difficult the particle is to settle, (eg. clay), the greater the total lagoon surface area will need to be for a given through-flow rate, although it should be noted that smaller particles may not adhere closely to Stokes's Law.

If **polyelectrolyte** is used to assist settlement it should be added into the inlet to the settlement lagoons but not to the attenuation pond. The correct use of polyelectrolyte can enhance settlement rates significantly, often by a factor of 100 times. **See Annex 1 for further information on Polyelectrolyte.**

ii) Inlet design, ie. from the attenuation pond, should control the incoming velocity and spread the flow over the full width of the pond, (eg. multiple inlets, castellated weirs).

iii) In order to facilitate sedimentation and sludge storage the main body of lagoon should be a **length to width ratio of not exceeding 5 to 1 where possible.**

iv) The outlet should be designed to prevent short-circuiting – in other words it should ideally be located at the opposite end from the inlet, in order to maximise lagoon effectiveness. Appropriately located multiple pipe outlets into a collection channel or ideally a full-width outlet weir is best practice. Single point discharges are NOT efficient but are often acceptable on smaller or shorter-term sites.

v) Lagoons are not normally lined, however at some sites a clay membrane may be used in order to avoid seepage to adjacent vulnerable sites (eg. mine-workings).

vi) Usual design depth is 1m with 0.5m free board. This allows ease of desludging. Sludge should be stored away from watercourses, typically on opencast sites it is placed back in the cut.

4 Storm Overflows

Generally, unless significant voids are located on a site, where run-off naturally gravitates and requires pumped conveyance to treatment, (eg. some opencast sites with huge capacity within the cut), a storm overflow **must** be included in the design (see **s2**). It is impossible to design a lagoon system that will treat all rainfall events. Hence, it is reasonable to require a design that will treat up to a certain storm flow and thereafter spill to storm overflow when the receiving watercourse is itself in spate and can therefore accept the discharge without major impact.

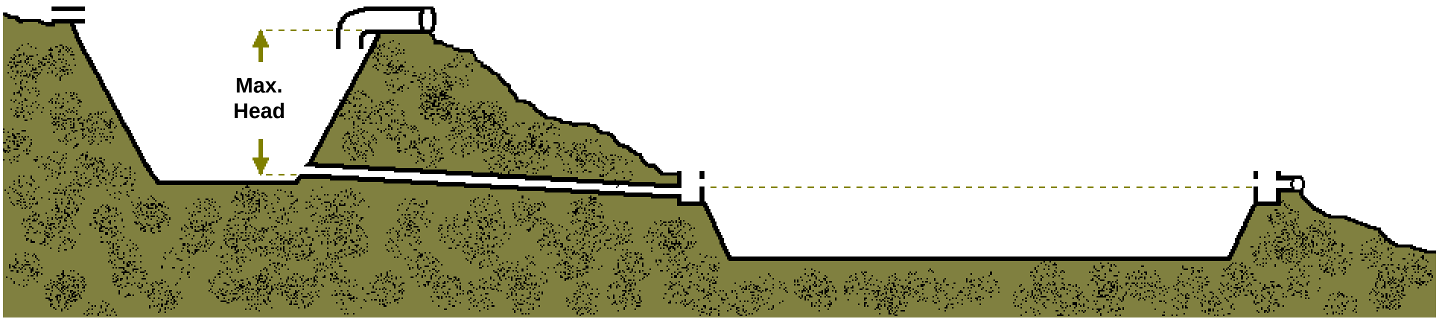
The storm overflow should be located within the attenuation pond, at a high level. Location of the overflow on the in-coming channel of the attenuation pond should be discouraged. This design can result in premature operation of the overflow during short surges in rainfall intensity.

The storm overflow should operate when the volume of water draining into the treatment system exceeds the design capacity. Hence overflow pipes should be large enough so as to avoid restriction of flows.

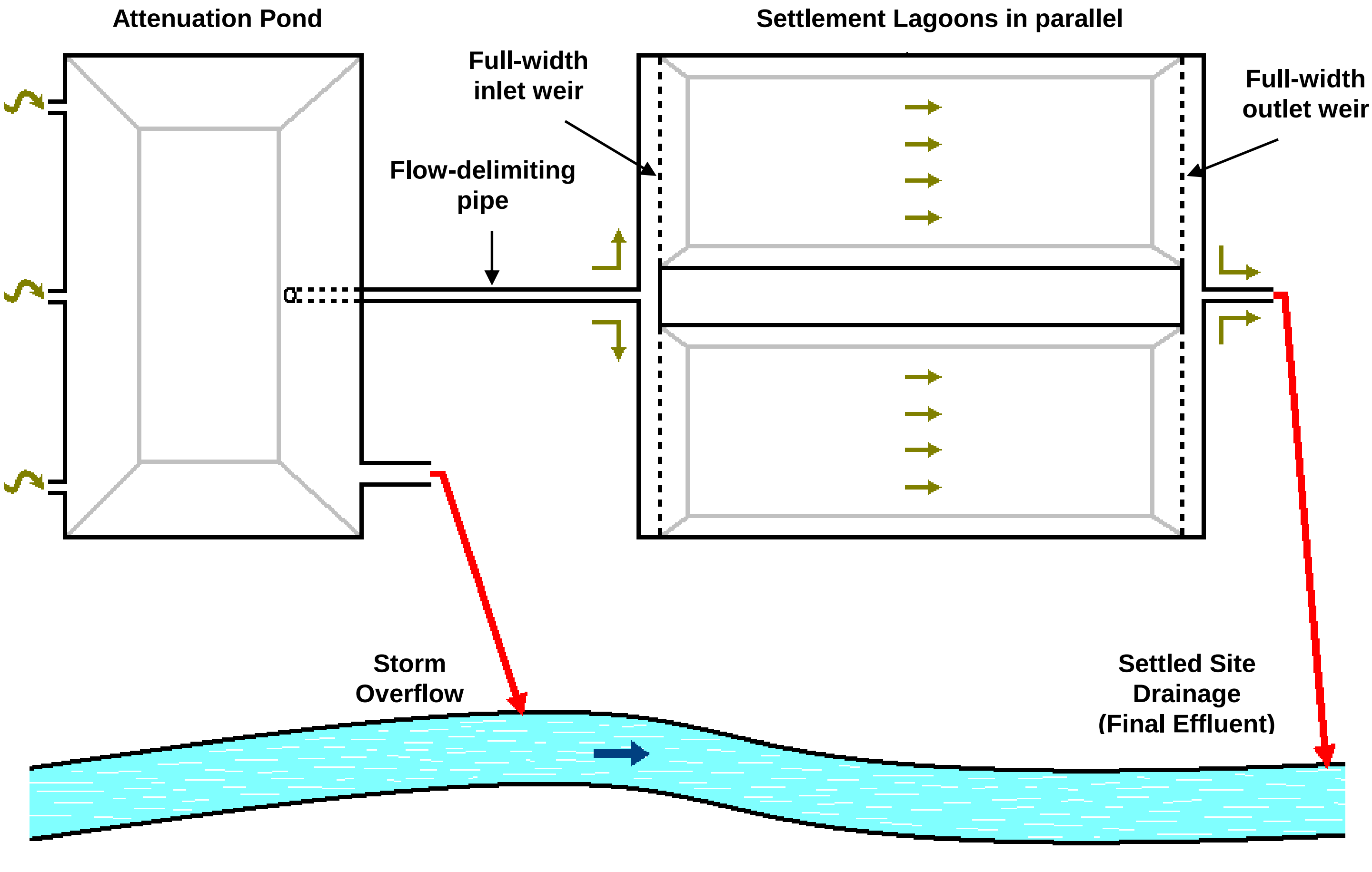
The quality of storm discharges from attenuation ponds varies according to the nature of the solids present in the site run-off, although levels around 400mg/l are considered to be typical.

The storm discharge must be separately consented as it receives a different level of treatment compared to the final settlement lagoon effluent, although it is **inappropriate for quality limits to be imposed** on the discharge as these are clearly beyond the control of the site operator.

Diagrammatic Representation of Recommended Lagoon Configuration



Elevation View



Plan View

5 Design Methods used by Applicants

i) For smaller sites (eg. mines, domestic refuse tips and small land reclamation sites), the space available and/or topography often dictates the design submitted. In such cases Agency will ensure the maximum lagoon size possible is used and evaluate impact of this design.

ii) For medium and some large sites, (eg. opencast) the Rational Method as given in '*Technical Management of Water in the Coal Mining Industry'* (published by the NCB – 1982) is often used. This is a well-proven design method and is acceptable to Agency. The method relies on the applicant choosing suitable rainfall data and evaluating the site, (eg. size of site, run-off coefficient, time of concentration).

In evaluation of submitted proposals, a most important factor is the use of appropriate rainfall data – both in terms of it being area-specific and that storm return periods (eg. 1-in-2 year rainfall event, 1-in-5yr, 1-in-10yr etc) appropriate to the proposed longevity of the site are considered. The method provides a design (attenuation and settlement system) which will cater for all storm events that occur for a given return period, ie. from 15-minute duration up to 72 hours. This means the storm discharge will not operate for any storm event for that return period, and as such, offers good protection up to that return period.

However a section of the guidance given in the NCB publication is not recommended by the Agency. This relates to use of a combined attenuation / final settlement pond design - ie. storage **within** the settlement pond – the storm overflow being located at a higher level than the final effluent discharge pipe. This type of design is discouraged as the quality of the effluent is poorer than that achieved by a conventional system. This is due the introduction of significant turbulence due to the extra storm flows, and the consequent loss of controlled quiescent flow conditions. Nevertheless, if there is no other option Agency may have to accept this design, although pessimism will be built in when evaluating the potential impact.

iii) For large sites, applicants generally have access to tools such as Flood Studies Models which can be used to predict flows and thereby size treatment systems. Such models, which the Agency will consider, are only applicable to large site catchments.

Such sites tend to work to highly protective designs usually based on a 1-in-20 or 1-in-25 year event return period, using well proven "off the shelf designs" which the companies have developed in-house, over time. These return periods are chosen to prevent flooding problems downstream, off-site, the treatment system hence providing attenuation of flows. They have subsequently become utilised as a design standard for water quality protection, but it should be noted that **there is no scientific basis for this.**

The reality is that these storm discharges rarely operate, indeed the shorter the life of the site the less likely they will operate. One potential disadvantage in using the 1-in-25 year event as a design "standard" is that with larger sites the land take for such designs is considerable and the ponds themselves can become massive. However the Reservoirs Act effectively limits this in that they must remain <25,000m^3 in volume.

For any of the above methods Agency will obtain rainfall data independently from the applicant in order to evaluate their submission.

6 Consent Applications

Applicants should be encouraged to:

i) design treatment systems as large as possible, given the constraints of the site;

ii) provide, if possible, 3 design options (if space allows) based on 1-in-2, 1-in-5, and 1-in-10 year storm event return periods, and provide an indication of the anticipated life of the site;

iii) comply with standard best practice design as detailed in s1, above;

iv) justify any decision not to include storm overflow from the attenuation lagoon;

v) supplement details supplied in the standard Agency application form with the following information:

- quantify area of site to be drained to treatment area (in m^2)

- time of concentration (for peak flow)

- volume and design basis of attenuation pond

- lagoon dimensions, configuration and design (inlet/outlet weirs etc)

- outlet pipe diameters from both attenuation pond **and** from settlement lagoon(s)

- name and type of polyelectrolyte, if used

- particle size/settlement rate assumed, and basis

- run-off coefficient assumed, and basis

- rainfall data

- site plan (also submitted electronically, if possible), clearly identifying the following -
    - area draining to the treatment facility
    - location of attenuation pond
    - location & configuration of settlement lagoon(s)
    - sampling point, where representative sample of the discharge may be safely obtained
    - discharge point to watercourse
    - watercourse (‘Controlled Waters’)

vi) ensure any tandem attenuation lagoon storm overflow consent application (if required) is submitted concurrently with the settled site drainage application and also contains all the above outlined information.

ANNEX 1 - POLYELECTROLYTES

Agency Policy

Polyacrylamide polyelectrolytes are increasingly being used in the Water Industry as secondary coagulants and in some cases as primary coagulants. Cationic polyelectrolytes are highly toxic to fish through a surface active effect which causes gill damage. Acute toxicity occurs at concentrations as low as 300µg/l, lower than the practical chemical analytical detection limit of approximately 1mg/l.

Anionic and non-ionic polyacrylamide polyelectrolytes are significantly less toxic (in the range 50-100mg/l) but approximately the same detection limit as cationic forms.

Anionic and non-ionic polyelectrolytes are therefore environmentally preferable, particularly in areas where water hardness and pH are low. This is because polyelectrolyte activity will persist longer under such conditions and it is necessary to be able to measure concentrations in the effluent for consent compliance to be demonstrated.

Information on Use of Polyelectrolyte to assist settlement in the Minerals Industry.
(Provided by Allied Colloids Ltd.)

Original natural polymer was starch. Today they are synthetic polymers divided into 3 types and can be in liquid or solid block form:

Anionic	-ve charge	molecular weight 18-20M	Non toxic
Non-anionic	0 charge	molecular weight <18M	Non toxic
Cationic	+ve charge	High molecular weight	Toxic to fish

The longer the polymer chain, the higher the molecular weight and the more charge can be attached to the chain during its manufacturing process. This process for attaching specific amounts of charge and charge type is trade secret and involves the use of various catalysts. The charge is variable and typically a low charge would be 10-15%.

The higher the molecular weight the more expensive the polyelectrolyte.

All work on the Vanderwaal Principal, that is the electrostatic charge placed on the polymer attracts any oppositely charged particles in the effluent. The attracted particles form into flocs which are heavy and given sufficient time will settle. The typical settlement rate aimed for by the industry is 100mm/minute. Hence for a positively charged clay-laden effluent the addition of anionic polymer (-ive charge) will cause flocculation and the effluent should achieve an almost neutral charge. Too much polymer and the effluent will become -ively charged causing any like charge particles to repel. This typically results in a non-settling floc. In such situations the oppositely charged polymer could be dosed to re-establish the regime.

Higher Molecular weight (or longer chain length) polymers do allow for more particles to attach and hence the floc to become heavier. However it is not necessarily good practice to use high molecular weight / high charge polymers as these can easily lead to overdosing, ie. there could remain a residual polymer charge, or unreacted polymer. A safer option is to use high molecular weight / low charge polymers.

Sites have their own particular characteristics which determine the most appropriate polymer product for use. This is done taking into account the percentage of solids in the effluent, and the particle size distribution. It is essentially a trial-and-error process, testing different flocs and different dosages in samples of the effluent. The dosage is further influenced by the size of lagoon available.

Manufacturers of polymer recommend addition of polymer in the incoming channel of the final effluent lagoon. It should be upstream of a point of agitation where the polymer can be thoroughly mixed in the effluent. Following addition, the effluent should be rapidly transferred to lagoon to prevent settlement of particles, slow-flowing channels are not desirable as these lead to build up of solids and enhance the possibilities of unreacted floc being washed through.

Polyelectrolyes are inactivated by acidic pH. A pH of 5.5 will reduce polyelectrolyte performance by approximately 50%. In these cases pH correction before polymer addition is essential.

Twin dosing of the effluent can enhance performance of either liquid or solid polymers. In this case the required dosage is split 50% being added at the upper end of the dosing channel and the remainder being added further down the channel.
Control of liquid dosage should be based on turbidity and flow rate. Allied Colloids have an Alcotech which they lease out for measuring this. Control of solid polymer (blocks) is predominantly influenced by flow rate over the blocks which presents a surface area of polymer to the effluent. The larger the surface area the more polymer is available to the effluent.

Laboratory tests for cationic floc are available however there is no test for anionic floc. However the industry use a test based on comparison with china clay settlement characteristics to evaluate presence or absence of unreacted anionic floc. This test compares the well-established settlement rate of a sample of china clay suspended to china clay suspension containing some effluent.

Appendix D Microdrainage modelling - storage assessment

Summary of Results for 10 year Return Period

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	9.100	0.100	1.2	798.3	O K
30 min Summer	9.136	0.136	1.5	1090.4	O K
60 min Summer	9.180	0.180	1.7	1441.3	O K
120 min Summer	9.230	0.230	1.9	1836.3	O K
180 min Summer	9.263	0.263	2.1	2107.7	O K
240 min Summer	9.290	0.290	2.2	2318.8	O K
360 min Summer	9.330	0.330	2.4	2640.5	O K
480 min Summer	9.361	0.361	2.5	2886.3	O K
600 min Summer	9.386	0.386	2.6	3086.4	O K
720 min Summer	9.407	0.407	2.6	3255.8	O K
960 min Summer	9.441	0.441	2.8	3531.9	O K
1440 min Summer	9.492	0.492	2.9	3938.5	O K
2160 min Summer	9.553	0.553	3.1	4427.9	O K
2880 min Summer	9.604	0.604	3.2	4828.3	O K
4320 min Summer	9.682	0.682	3.4	5457.6	O K
5760 min Summer	9.744	0.744	3.6	5948.9	Flood Risk
7200 min Summer	9.792	0.792	3.7	6332.5	Flood Risk
8640 min Summer	9.833	0.833	3.8	6661.7	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	48.000	0.0	99.9	24
30 min Summer	32.800	0.0	120.4	39
60 min Summer	21.700	0.0	275.6	70
120 min Summer	13.850	0.0	314.5	130
180 min Summer	10.616	0.0	337.4	190
240 min Summer	8.775	0.0	353.1	250
360 min Summer	6.683	0.0	373.6	368
480 min Summer	5.496	0.0	386.0	488
600 min Summer	4.716	0.0	393.9	608
720 min Summer	4.158	0.0	398.8	728
960 min Summer	3.403	0.0	402.8	968
1440 min Summer	2.558	0.0	396.9	1448
2160 min Summer	1.948	0.0	883.4	2168
2880 min Summer	1.617	0.0	881.1	2884
4320 min Summer	1.253	0.0	841.0	4324
5760 min Summer	1.051	0.0	1948.3	5760
7200 min Summer	0.918	0.0	1927.8	7200
8640 min Summer	0.824	0.0	1884.1	8640

Summary of Results for 10 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Summer	9.869	0.869	3.9	6955.0	Flood Risk
15 min Winter	9.112	0.112	1.3	894.1	O K
30 min Winter	9.153	0.153	1.6	1221.4	O K
60 min Winter	9.202	0.202	1.8	1614.4	O K
120 min Winter	9.257	0.257	2.1	2057.1	O K
180 min Winter	9.295	0.295	2.2	2361.3	O K
240 min Winter	9.325	0.325	2.3	2598.1	O K
360 min Winter	9.370	0.370	2.5	2959.0	O K
480 min Winter	9.404	0.404	2.6	3235.0	O K
600 min Winter	9.432	0.432	2.7	3459.8	O K
720 min Winter	9.456	0.456	2.8	3650.2	O K
960 min Winter	9.495	0.495	2.9	3961.0	O K
1440 min Winter	9.553	0.553	3.1	4420.0	O K
2160 min Winter	9.622	0.622	3.3	4974.2	O K
2880 min Winter	9.679	0.679	3.4	5429.2	O K
4320 min Winter	9.769	0.769	3.7	6149.0	Flood Risk
5760 min Winter	9.840	0.840	3.8	6717.1	Flood Risk
7200 min Winter	9.896	0.896	4.0	7165.3	Flood Risk
8640 min Winter	9.944	0.944	4.1	7555.5	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	0.755	0.0	1822.3	10080
15 min Winter	48.000	0.0	107.2	24
30 min Winter	32.800	0.0	128.7	39
60 min Winter	21.700	0.0	294.4	70
120 min Winter	13.850	0.0	335.5	128
180 min Winter	10.616	0.0	359.6	188
240 min Winter	8.775	0.0	376.3	246
360 min Winter	6.683	0.0	397.9	366
480 min Winter	5.496	0.0	411.1	484
600 min Winter	4.716	0.0	419.5	602
720 min Winter	4.158	0.0	424.8	722
960 min Winter	3.403	0.0	429.0	958
1440 min Winter	2.558	0.0	423.1	1432
2160 min Winter	1.948	0.0	941.5	2144
2880 min Winter	1.617	0.0	939.4	2852
4320 min Winter	1.253	0.0	897.4	4244
5760 min Winter	1.051	0.0	2079.6	5648
7200 min Winter	0.918	0.0	2057.8	7000
8640 min Winter	0.824	0.0	2011.7	8384

Summary of Results for 10 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Winter	9.988	0.988	4.2	7906.8	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Winter	0.755	0.0	1946.5	9776

Rainfall Details

Rainfall Model	FEH
Return Period (years)	10
FEH Rainfall Version	2013
Site Location	GB 248350 360800 SH 48350 60800
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+0

Time Area Diagram

Total Area (ha) 8.880

Time (mins) From:	To:	Area (ha)
0	9	8.880

Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

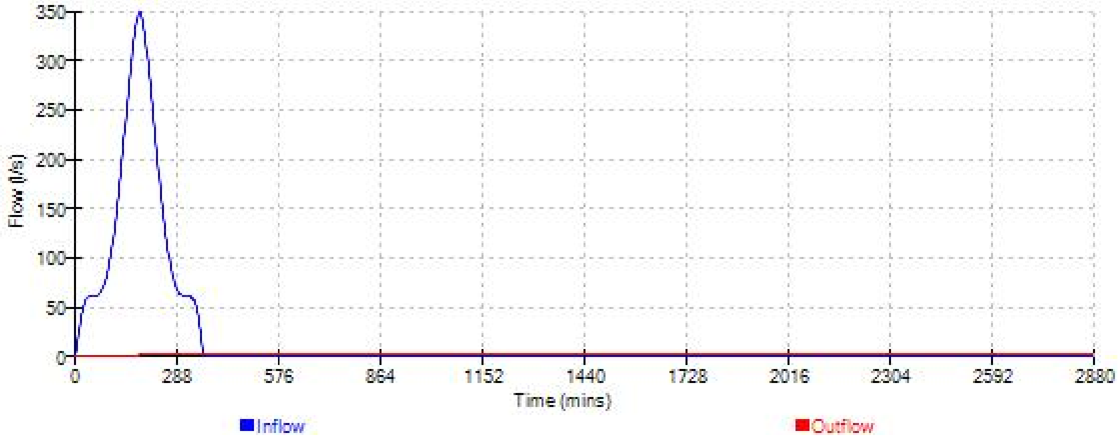
Invert Level (m) 9.000

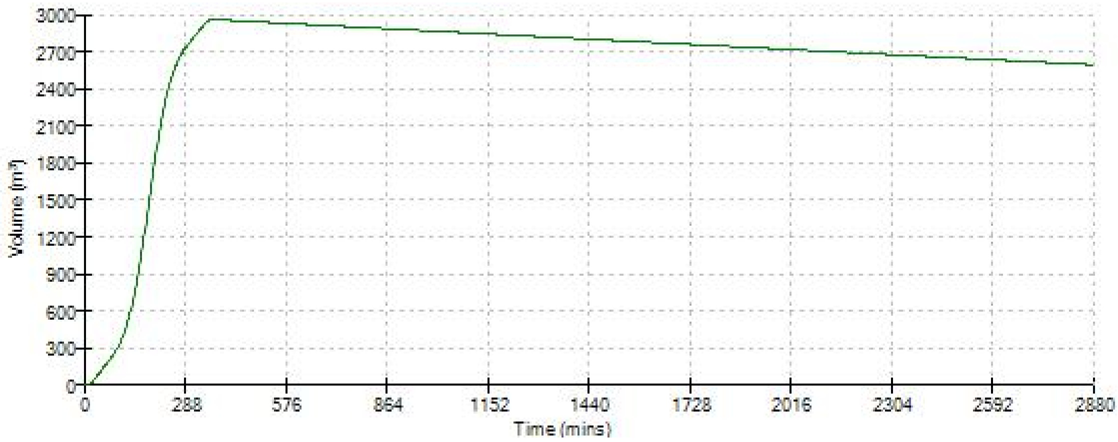
Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	8000.0	1.000	8000.0

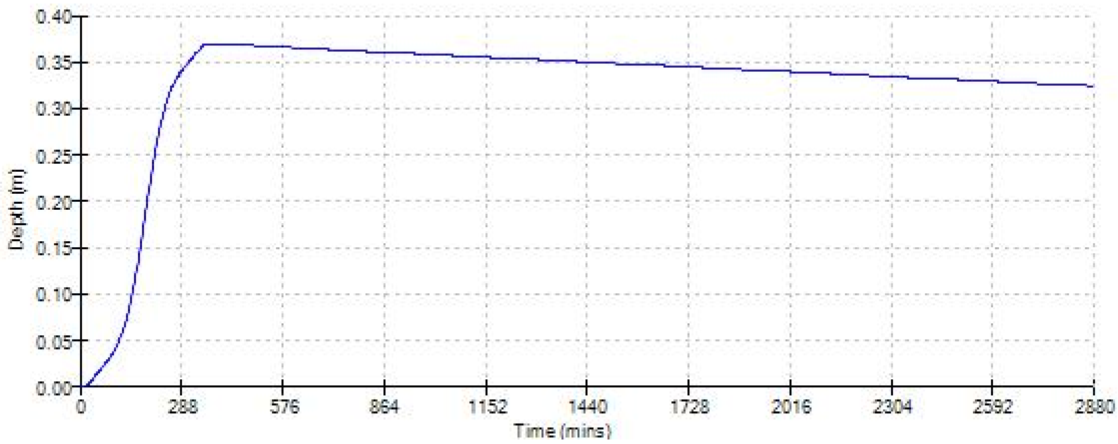
Orifice Outflow Control

Diameter (m) 0.045 Discharge Coefficient 0.600 Invert Level (m) 8.995

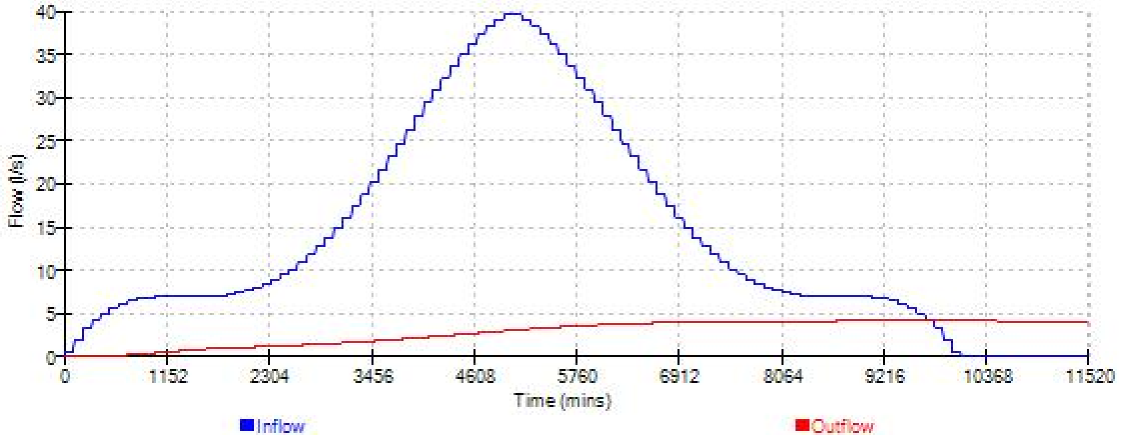
Event: 360 min Winter

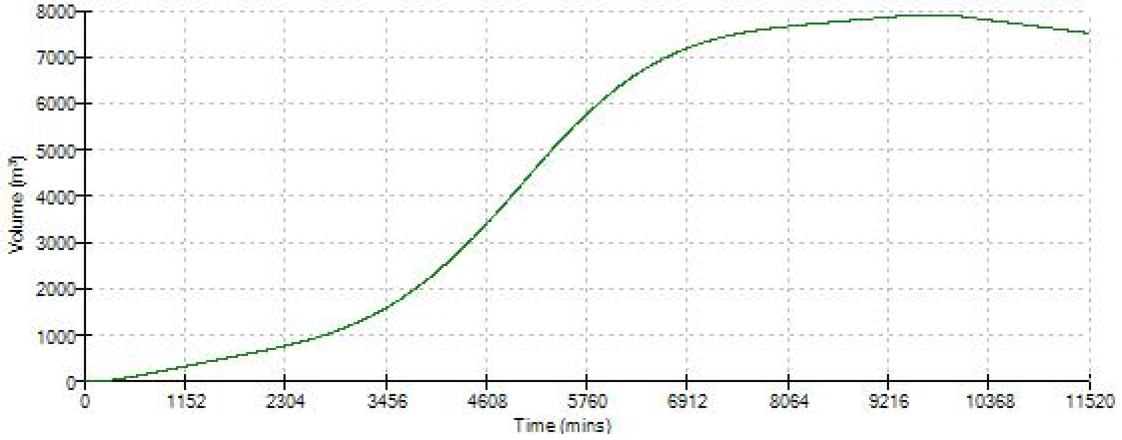


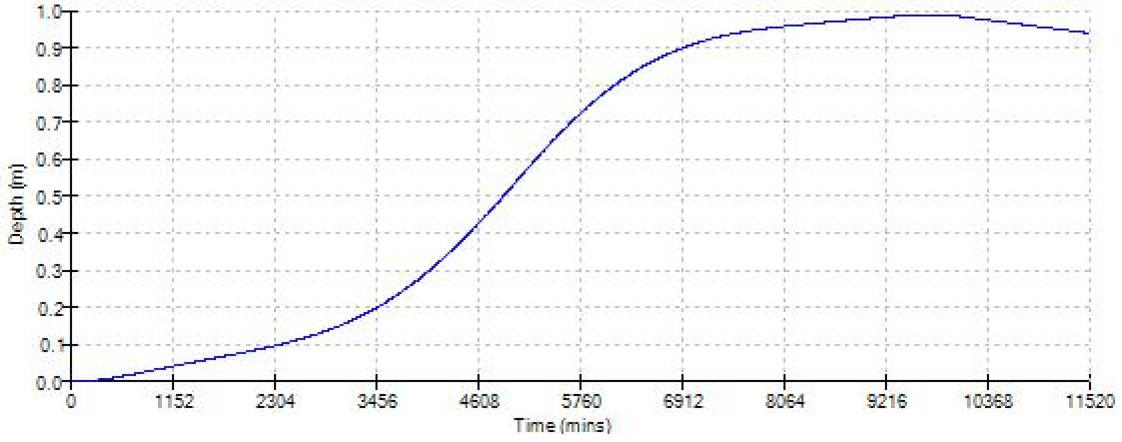




Event: 10080 min Winter







Summary of Results for 10 year Return Period

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	9.095	0.095	1.2	998.1	O K
30 min Summer	9.130	0.130	1.4	1363.5	O K
60 min Summer	9.172	0.172	1.7	1802.6	O K
120 min Summer	9.219	0.219	1.9	2297.7	O K
180 min Summer	9.251	0.251	2.0	2638.2	O K
240 min Summer	9.277	0.277	2.2	2903.6	O K
360 min Summer	9.315	0.315	2.3	3308.8	O K
480 min Summer	9.345	0.345	2.4	3619.4	O K
600 min Summer	9.369	0.369	2.5	3873.0	O K
720 min Summer	9.389	0.389	2.6	4088.3	O K
960 min Summer	9.423	0.423	2.7	4440.8	O K
1440 min Summer	9.473	0.473	2.9	4964.4	O K
2160 min Summer	9.533	0.533	3.0	5601.0	O K
2880 min Summer	9.584	0.584	3.2	6127.7	O K
4320 min Summer	9.664	0.664	3.4	6969.6	O K
5760 min Summer	9.728	0.728	3.6	7642.1	Flood Risk
7200 min Summer	9.779	0.779	3.7	8181.2	Flood Risk
8640 min Summer	9.824	0.824	3.8	8653.7	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	48.000	0.0	97.8	26
30 min Summer	32.800	0.0	117.8	41
60 min Summer	21.700	0.0	271.6	72
120 min Summer	13.850	0.0	309.6	132
180 min Summer	10.616	0.0	331.9	192
240 min Summer	8.775	0.0	347.2	252
360 min Summer	6.683	0.0	367.0	370
480 min Summer	5.496	0.0	379.0	490
600 min Summer	4.716	0.0	386.6	610
720 min Summer	4.158	0.0	391.3	730
960 min Summer	3.403	0.0	394.9	970
1440 min Summer	2.558	0.0	388.8	1450
2160 min Summer	1.948	0.0	871.1	2168
2880 min Summer	1.617	0.0	867.9	2888
4320 min Summer	1.253	0.0	826.9	4328
5760 min Summer	1.051	0.0	1936.9	5768
7200 min Summer	0.918	0.0	1913.3	7208
8640 min Summer	0.824	0.0	1867.7	8648

Summary of Results for 10 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Summer	9.865	0.865	3.9	9083.0	Flood Risk
15 min Winter	9.106	0.106	1.3	1117.9	O K
30 min Winter	9.145	0.145	1.5	1527.1	O K
60 min Winter	9.192	0.192	1.8	2019.1	O K
120 min Winter	9.245	0.245	2.0	2573.8	O K
180 min Winter	9.281	0.281	2.2	2955.5	O K
240 min Winter	9.310	0.310	2.3	3253.1	O K
360 min Winter	9.353	0.353	2.4	3707.5	O K
480 min Winter	9.386	0.386	2.6	4056.0	O K
600 min Winter	9.413	0.413	2.7	4340.7	O K
720 min Winter	9.436	0.436	2.7	4582.5	O K
960 min Winter	9.474	0.474	2.9	4978.7	O K
1440 min Winter	9.530	0.530	3.0	5568.5	O K
2160 min Winter	9.599	0.599	3.2	6287.2	O K
2880 min Winter	9.656	0.656	3.4	6883.5	O K
4320 min Winter	9.747	0.747	3.6	7840.5	Flood Risk
5760 min Winter	9.820	0.820	3.8	8609.8	Flood Risk
7200 min Winter	9.879	0.879	3.9	9231.8	Flood Risk
8640 min Winter	9.931	0.931	4.0	9780.3	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	0.755	0.0	1804.9	10080
15 min Winter	48.000	0.0	105.0	26
30 min Winter	32.800	0.0	125.9	41
60 min Winter	21.700	0.0	290.0	72
120 min Winter	13.850	0.0	330.1	130
180 min Winter	10.616	0.0	353.6	190
240 min Winter	8.775	0.0	369.8	248
360 min Winter	6.683	0.0	390.8	368
480 min Winter	5.496	0.0	403.6	486
600 min Winter	4.716	0.0	411.6	606
720 min Winter	4.158	0.0	416.7	724
960 min Winter	3.403	0.0	420.6	962
1440 min Winter	2.558	0.0	414.4	1436
2160 min Winter	1.948	0.0	928.0	2148
2880 min Winter	1.617	0.0	924.9	2856
4320 min Winter	1.253	0.0	882.2	4280
5760 min Winter	1.051	0.0	2065.4	5656
7200 min Winter	0.918	0.0	2040.6	7064
8640 min Winter	0.824	0.0	1992.6	8472

Summary of Results for 10 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Winter	9.979	0.979	4.1	10281.6	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Winter	0.755	0.0	1926.5	9792

Rainfall Details

Rainfall Model	FEH
Return Period (years)	10
FEH Rainfall Version	2013
Site Location	GB 248350 360800 SH 48350 60800
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+0

Time Area Diagram

Total Area (ha) 11.100

Time (mins) From:	To:	Area (ha)
0	11	11.100

Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

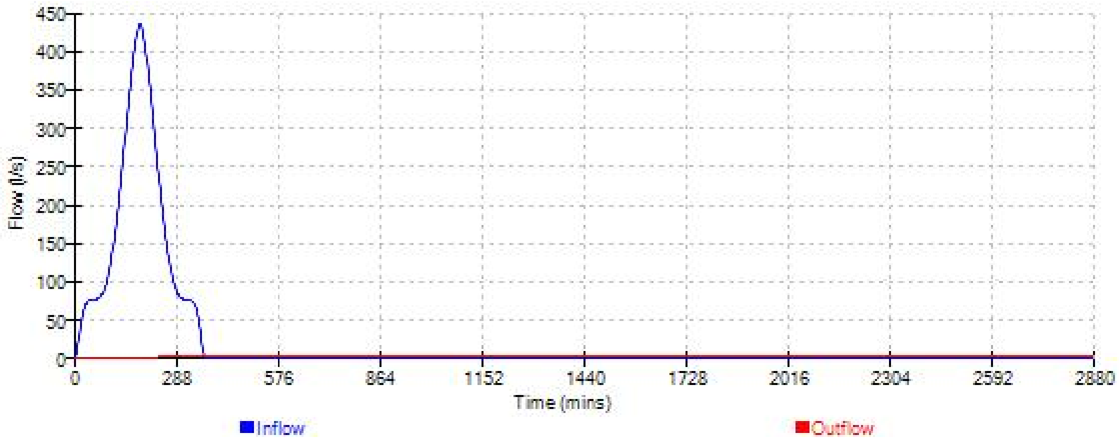
Invert Level (m) 9.000

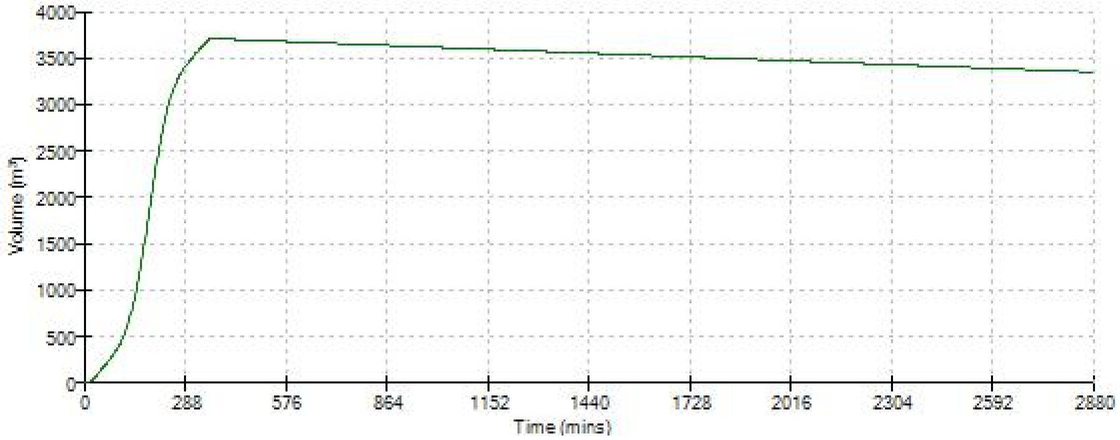
Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	10500.0	1.000	10500.0

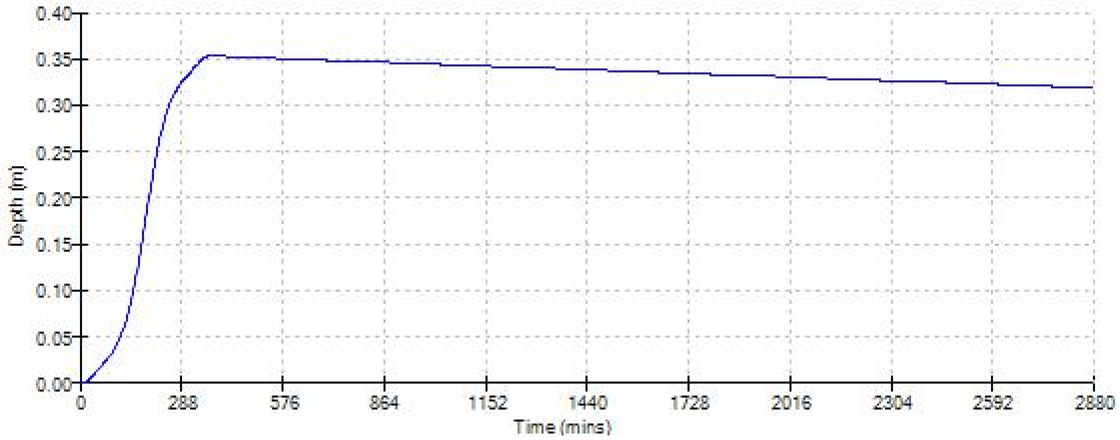
Orifice Outflow Control

Diameter (m) 0.045 Discharge Coefficient 0.600 Invert Level (m) 8.995

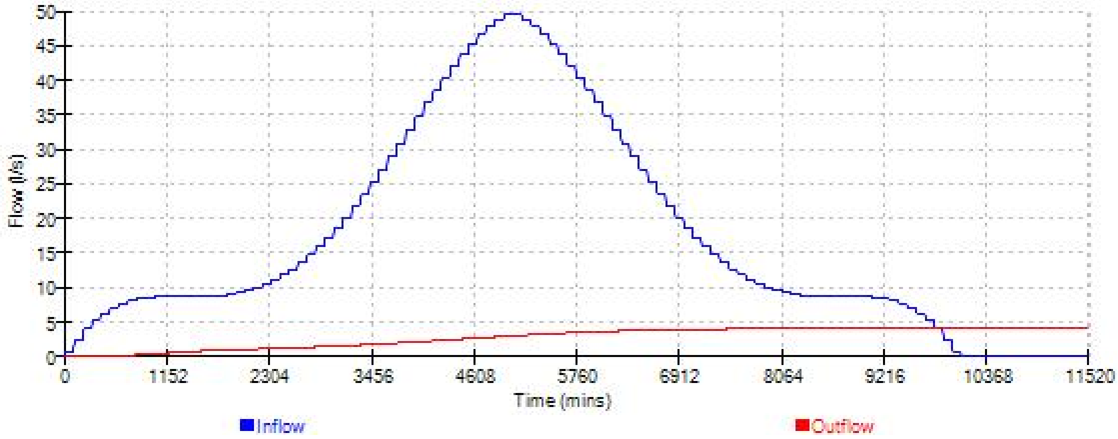
Event: 360 min Winter

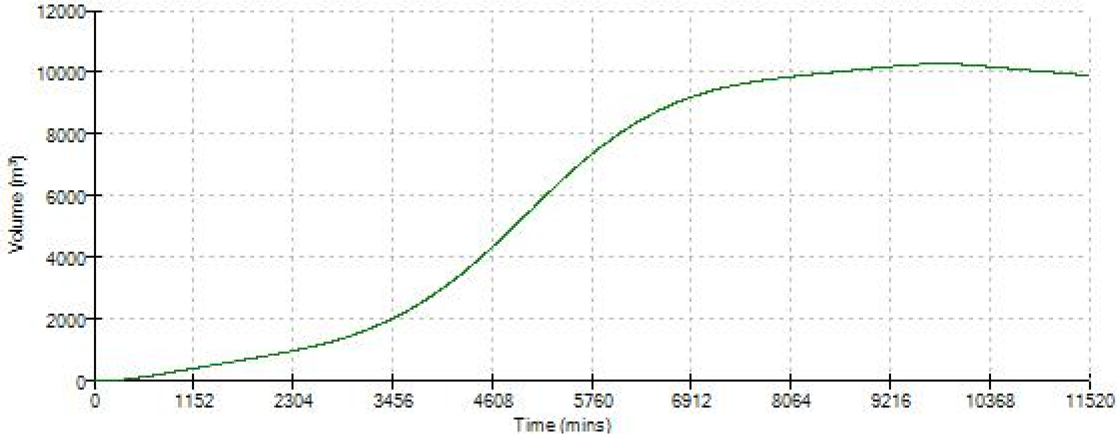


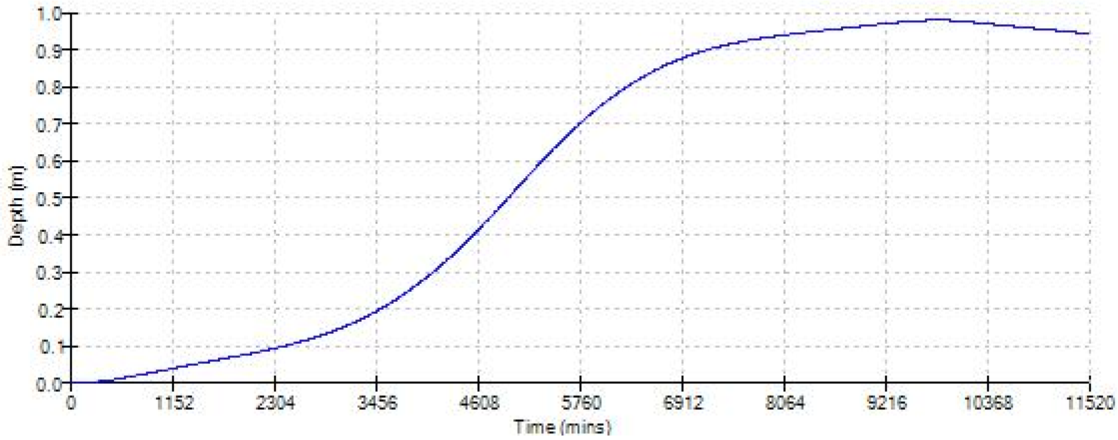




Event: 10080 min Winter







Appendix E Determination of suspended solids

ALS Environmental Hawarden
Units 7-8 Manor Road
Hawarden CH5 3US

Method Summary

Determination of Total, Non-Volatile and Volatile Suspended Solids in Aqueous Samples

Scope and Range

This method has accreditation to ISO 17025 for Total suspended solids, Volatile and Non-volatile suspended solids in ground water, surface water, landfill leachate, treated and untreated industrial water, sewage effluents and saline water.
Neutralised suspended solids and Non settleable solids are also ISO17025 accredited when prepped by PM210.
TSS is also accredited to MCERTS for Industrial effluent and treated and untreated sewage effluent.
Detection limit: TSS 2 mg/l for 200ml of sample, VSS 7mg/l for 200ml of sample
Working range: 2 – 2000 mg/l

Principle

Preparation
Samples are collected in 1 litre PET bottles and kept in fridge until required. Refer to SOP.5.8.J for holding times. Samples must be thoroughly homogenised before analysis.

Analysis

A recorded volume of homogenised sample is filtered through a pre-washed and weighed GF/C filter paper. The filter paper is dried in an oven at 105°C for 2 hours and then re-weighed on a 5 figure balance. The total suspended solid content of the sample is calculated from the difference in the two weights.
The filter paper and suspended solids are then placed into a muffle furnace at 500 °C.
This ignites the volatile (organic) matter. The solids remaining on the filter paper are therefore non-volatile (inorganic) matter and are calculated with reference to the original sample volume. The volatile matter is calculated from the TSS – NVS result
A blank and an AQC are performed with every batch.

Interferences

Very oily samples will be washed with industrial methylated spirits to minimise interferences.
Sample that contain large floating particles (e.g. leaves or twigs) or submerged agglomerates (e.g. stones) of non-homogeneous materials, which are not representative of the sample. These would be removed from the filter and a note placed on the file.