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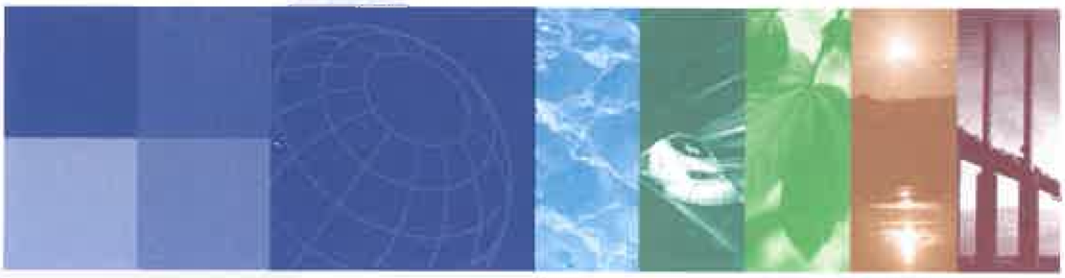
Scottish Enterprise Lanarkshire
Gartcosh Industrial Park
Bothlin Burn Report



May 2001

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SCOTTISH ENTERPRISE LANARKSHIRE

GARTCOSH INDUSTRIAL PARK

BOTHLIN BURN REPORT

Contents Amendment Record

Document Reference No: SB/GSSS/11

Section No.	Page No.	Number of Pages	Issue No	Rev No	Issue Date	Updated Sheets Marked	Signed
Whole Report			1	0	Jan 01		
Whole Report			2	1	May 01		

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Contents

1 Introduction

In December 2000 Halcrow Crouch wee instructed by Scottish Enterprise Lanarkshire to prepare a report on the Bothlin Burn Culvert, Gartcosh. The Brief from the Client was that the report should cover the following topics: -

- Background
- Design Information
- Survey & Inspection

2 Background

2.1 *Pre-Development Situation*

Ordnance Survey Mapping of 1910 indicated that the Bothlin Burn gently wound across the site and had an approximate channel length of 845m, measured from the railway line at Gartcosh station, to Woodneuk Avenue in the north. Early maps indicate the site comprised a broad valley and was liable to flooding. By 1954/55 the Ordnance Survey Mapping indicates that the burn adjacent to existing works had been diverted to the west of the site, discharging to a point some 530m downstream of the railway line.

Construction of Gartcosh Steel Rolling Mill in 1960/61 resulted in the infilling of Bothlin Burn valley and low lying ground to the north east of the site. As a result of this construction the Bothlin burn was culverted, location details of which are provided on Drawing GSSS-12.

2.2 *Design/Construction History*

The Culvert has been constructed in two phases, the original one in 1959/1960 and the extension in 1999.

The original Culvert was designed by Crouch & Hogg (now Halcrow Crouch). No record of who the contractor was is available. The extension was designed by Babtie and was constructed by R J MacLeod.

The original Culvert was constructed in in-situ reinforced concrete in an arch shape and is approximately 3.7m wide by 3.4m high by 542m long. The base of the culvert is 0.6m thick with the sides and crown being 0.38 thick. The Culvert is shown as falling 0.38m over its length.

There are 2 large pipes shown as discharging into the Culvert, one is 1.52m dia and the other is 1.07m dia. The possibility however of other smaller, unrecorded pipes, discharging into the Culver cannot be excluded.

The 1.52m dia pipe which discharges into the Culvert carried surface water drainage from the road, building and basement of the former British Steel Development. This pipe was backfilled with PFA grout over part of its length by SEL in November 1999 (see drawing No. GSSS-12). The pipe therefore now only drains a relatively small part of the road system, which runs around the former British Steel Mill.

The other large pipe is the 1050mm pipe, which runs across open ground to the North of the former British Steel Building. It would appear that this pipe drains the area around a former path, which constituted a Right of Way, which crossed the site in an East-West direction.

3 Design Information

3.1 *Hydrology of Bothlin Burn*

3.1.1 *Flood Risk and Return Period*

Flood risk involves both the statistical probability of an event occurring and the scale of the potential consequences. The degree of risk is calculated from historic data and expressed in terms of the expected frequency of a flood of a given magnitude e.g. the 10 year, 50 year or 100 year flood. The risk is expressed in terms of these "return periods". However this concept is often misunderstood and misinterpreted. The meaning is that there is a 10%, 2%, 1% chance respectively of such an event happening in any given year. Over a longer period, the probability is considerably greater. For example;

For the 50 year return period flood:

a) There is a 2% chance of it occurring in any year;

b) A 45% chance of at least one such flood in a 30 year period;

c) A 76% chance of at least one such flood in 70 years, the minimum life span of many developments.

For the 100 year return period flood:

a) there is a 1% chance of it occurring in any year;

b) a 26% chance of at least one such flood in a 30 year period;

c) A 51% chance of at least one such flood in 70 years.

It is also important to distinguish between the return period for rainfall, which is a function of both intensity and duration of precipitation, and the return period of river flood flows. The flood flow return period is not only a function of the rainfall pattern but also a multiplicity of factors that are collectively known as the catchment characteristics. The catchment characteristics include the catchment area, soil conditions, drainage channels serving the catchment, the slope of the channels and stream frequency within the catchment. The return periods for rainfall and flow are therefore not the same.

A point of concern in the flood derivation and further analysis from this is that it assumes that the climate (the long term weather patterns including statistically stable patterns of flood and drought) are static. These assumptions are now being queried and the changes in patterns are believed to be the combination of two possible effects:

(a) Long term climate change as a result of global warming. Climate models have predicted increases in the long-term average precipitation over the north west of Britain and this is supported by analysis of measured natural phenomena. This will increase the size of floods experienced but the magnitude of this change is unclear.

(b) Cyclical changes in precipitation patterns over Scotland with cycles of the order of 10 to 20 years.

The effects of climate change are only just becoming apparent with the nature and magnitude of these changes being disputed. This makes these effects impossible to incorporate into the statistics of a flood study but it is necessary to include uncertainties over this by using a conservatively high flood return period for design and by incorporating a freeboard in the design of flood defences.

The flood return period to be used for the design of any new works is a matter of balance between the capital cost of the works and the consequences of flooding of the land endangered. It is normally considered appropriate to use the 1 in 100 year return period flood in urban areas, however, ultimately it is for the local authority to decide what is an appropriate degree of protection.

3.1.2 *Hydrological Assessment*

The new methodology for flood flow estimation recently published by the Institute of Hydrology (Flood Estimation Handbook, December 1999) has been used.

The new publication represents the outcome of a 5-year research programme to develop and implement new generalised procedures for rainfall and flood frequency estimation in the UK, for both gauged and ungauged catchments. Significant improvements have been made compared with the previous methodology (Flood Study report, 1975), and in particular the statistical procedures for flood frequency estimation have been completely reviewed: -

- The FEH is based on a new index flow, Q_{MED} (1 in 2 year return period) instead of the index flow used in the FSR Q_{MAF} which was not associated with a return period.

- In the absence of flood peak data at ungauged catchments, Q_{MED} can be estimated from catchment characteristics based on digital data rather than derived manually from maps.

- Derivation of flood peak for a given return period is carried out by multiplying the index flow by a site specific ratio, rather than by a fixed regional ratio. This ratio is obtained by pooling of flood peak data from stations selected according to their catchment similarity.

- This new methodology is also based on an extended rainfall and river flow data set, which is accessible via the CD-ROM accompanying the handbook, and new software (WINFAP-FEH).

Using the FEH methodology Q_{MED} at the site was estimated at 5.12m³/s, utilising the actual catchment descriptors for the Gauging Station GS84023 located some 4km downstream of the site in conjunction with the median flow recorded from the data records for the period 1973 to 1998. The gauging station is operated by the Scottish Environmental Protection Agency (SEPA) and consists of a level gauge which is used in conjunction with flow meters which are installed in the Burn from time to time to gather the necessary data.

Results of this analysis are provided in Table 3-1 below:

Table 3-1 Flood flow assessment for the Bothlin Burn based on the Flood Estimation Handbook (FEH)

Return period (year)	Factor	Gauging Station (Area = 35km²)	Site (Area = 15.85km²)
		Peak Flow (m³/s)	Peak Flow (m³/s)
2	1	10.39	5.1
5	1.36	14.18	7.0
10	1.63	16.94	8.3
50	2.35	24.47	12.0
100	2.74	28.46	14.0
200	3.18	33.02	16.3

Note: Area = Catchment Area

3.2 *Hydraulic Design*

3.2.1 *Existing Arrangement*

The Bothlin Burn culvert has been constructed in two phases. The first section, constructed around 1960 is a reinforced concrete symmetrical arch, 3.74m wide and 3.43m high and approximately 560m long. The culvert extension constructed in 1999 is a 3.2m diameter (approx.) "Armco" culvert and is approximately 70m in length. The culvert inlet level drops approximately 0.46 over its original length of 560 ie a slope of 1 in 1250.

At the southern boundary of the site the Burn is culverted under the railway line. This Railtrack Culvert has a form of debris screen which is thought to involve a timber barrier which rises as the water level increases. A visual inspection of this debris screen suggests that some maintenance/remedial works is highly desirable.

A debris screen has been installed at the inlet to the culvert in two panels with a central pier bearing against the culvert headwall at the crown. A significant amount of debris has built up on the screen and is currently impeding flow through the culvert. The upper part of the screen has been removed, presumably to permit water to pass when the screen is not cleaned. With this arrangement it is likely that debris is being carried into the culvert during every flood, which will over time lead to increased silt deposition within the culvert.

Depths of fill over the culvert are in excess of 10m. Should the culvert inlet become blocked during a flood event there is no direct escape path for floodwaters. This would result in ponding of water upstream of the inlet ultimately to the 85m contour level, prior to floodwaters escaping over the site. Consequently water depths in excess of 5m would exist over extensive areas of low-lying land upstream of the inlet.

At the time of inspection a layer of silt was evident within the culvert and assumed to be of 300mm depth. For modelling purposes a silt depth of 600mm was also tested.

3.2.2 *Flooding History*

SEPA were approached in preparation of this report but could not provide any information regarding the flood risk of the area, however they did advise that localised flooding of a culvert further downstream of the Bothlin Burn (NS 692 713) occurred in 1994.

The widespread area of low lying land upstream of the Gartcosh site and railway embankment (marked on the catchment plan) has had a vulnerability to flooding which predates the Gartcosh development. It is marked "Liable to floods" on the 1910 OS map (as is the ground along the old route of the burn adjacent to the culvert that now lies under the fill platform). Because of the frequent occurrence of low-level flooding, there is an insignificant amount of existing development within this low-lying area. The area of potential flood risk marked on the catchment plan is defined approximately by the 80m contour.

3.2.3 *Model*

The software package ISIS was used to assess the capacity of the culvert. ISIS, jointly developed by Halcrow Crouch Ltd and HR Wallingford, represents culverts using routines based on the CIRIA Report 168, Culvert design guide.

Flooding scenarios for the Q100 and Q200 flood events were analysed. These scenarios took into account varying depths of silt within the culvert to assess the likely impact of increased sedimentation in the culvert.

Inlet conditions were modelled to represent complete blockage of the existing debris screen, as was visibly the case when inspected. Water was made to flow over the top of the screen prior to entering the culvert.

The results of this analysis are provided below:

TABLE 3.2 Hydraulic Assessment

Return Period	Peak Flow (m^3/s)	Maximum water level within culvert (m OD)			Culvert Soffit Level	Water level upstream of inlet (m OD)
		No silt layer	300mm silt layer	600mm silt layer		
100	14	75.58	75.62	75.82	76.67	77.57
200	16.25	75.75	75.79	76.03	76.67	77.75

Modelling of the worst case scenario (Q200 and 600mm silt depth) indicates that a free board of 600mm approximately remains, indicating that the culvert barrel has sufficient capacity to pass the 1 in 100 and 1 in 200 year flood events. This will only be possible however if the inlet does not become blocked with debris.

As discussed in Section 3.2.1 above, it is apparent that the area of the burn immediately upstream of the culvert and extending south of the railway line at Gartcosh station is at considerable risk of flooding should the culvert inlet become blocked, and prior to flood escaping over the site. Even partial blockage of the inlet, such that the flow is forced to spill over the top of the existing screen, will result in elevated water levels leading to deeper flooding upstream than would otherwise occur. It is likely that this condition already occurs during large flood events.

To reduce the risk of flooding it is essential that the design of the debris screen be reviewed with the view to improve its current design or replace it entirely. This will need to be undertaken in conjunction with an inlet maintenance programme that will recommend the inlet be cleaned at regular intervals to prevent build up of debris and blockage of the culvert inlet.

As current fill levels at the site exceed the 85m contour level flooding is not a constraint on redevelopment of the site.

It is expected that low dry weather flows have sufficiently low enough velocities to deposit silt within the culvert, impacting on the hydraulic capacity of the culvert barrel. Conversely larger flood events are expected to remobilise silt into the mainstream resulting in removal of partial quantities of silt from the culvert into the channel downstream.

3.3 Structural Design

No records of the original calculations are available in Halcrow Crouch's archives. However there are sufficient Record Drawings available to allow the structure to be assessed. A list of available Record drawings is given in Appendix B. The structure has been analysed based on the above drawings using a computer programme (SUPERSTRESS) and the following results obtained: -

- The Culvert can support a ground bearing floor slab (live load 10kN/m^2) at approximately the existing ground level along with an isolated pad foundation from say a building column with a bearing pressure of 100 kN/m^2.

- Vehicular traffic with HB axle loads at approximately existing ground levels.

In addition to the above the Culvert can also withstand an increase in the ground level of 1.0m along with the loading referred to above.

4 Survey & Inspection

4.1 Survey

The alignment of the Culvert was surveyed by Mason Land Surveys in August 2000. The location of the Culvert was related to the Topographical survey of the site also carried out by Mason Surveys. The location of the culvert is therefore accurately shown on the Mason drawings of the site.

4.2 Visual Inspection

In 1998 a brief visual inspection of the Culvert was carried out from a boat by Halcrow Crouch. This inspection did not look in detail at either the condition of the concrete or the silt in the bed of the Culvert. The basic conclusion of the inspection was that the Culvert was in reasonable condition for a structure, which is approximately 40 years old. Around 10 areas of spalling concrete were observed and it is recommended that these areas are repaired to preserve the structural integrity of the Culvert.

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Plan removed

Lanarkshire Development Agency

4.3 Photographs of the Bothlin Burn

Inlet Debris Screen

Typical Internal View

5 Maintenance

5.1 *Siltation of Culvert*

The culvert does not have a self-cleansing velocity during low flow conditions. During moderate to large flood events the flow achieves higher velocities with the potential to re-suspend silt particles within the culvert, but the extent to which this occurs will depend on the physical properties of the silt. This possibility may raise water quality concerns in the burn downstream.

If it can be assumed that the present depth of silt has accumulated over the whole life of the culvert, there would not appear to be a short-term problem of reduced culvert capacity if the silt is not removed. In the medium to long term, increasing silt levels will gradually reduce the available culvert capacity to the point where flood levels upstream would be adversely affected. However, at present it is the condition of the culvert inlet, rather than silting within the culvert barrel, that is of concern in respect of flood risk.

If the culvert is cleared of silt, it will certainly silt up again but this would appear to be a relatively slow process (again based on the assumption that the present levels have accumulated over the lifetime of the culvert).

The case for action to clean out the silt now is primarily based on the possible contamination concerns, rather than hydraulic capacity. Silt from the Culvert could be sampled and analysed for contaminants. The work would entail entering the Culvert in a small boat and scooping samples from the invert. Cost of such work would be around £10,000 assuming say 10 samples were taken. If cleaning is not now justified from the contamination standpoint, it will be necessary to monitor the silt levels in the culvert so that adequate warning is given of any developing capacity restriction. This might involve inspections at say five year intervals.

As noted, these comments are made on the basis that present silt levels have accumulated over the lifetime of the culvert (say 300mm over 30 years, or 10mm/yr). If the culvert has been cleaned out previously within this timescale, or existing depths of silt are significantly greater than 300mm, then the case for cleaning the culvert in the near future is enhanced on the grounds that the silt accumulation rate is greater and the onset of a hydraulic capacity concern is brought forward.

5.2 *Existing Debris Screen*

The existing debris screen should be cleared in the near future to minimise the risk of flooding.

The debris screen is clearly unsatisfactory (refer to Photograph) and should be replaced with one which can be safely maintained. It is anticipated that such a screen with an access platform for maintenance could be built for around £15,000 (excl. VAT) inclusive of design fees.

5.3 *Maintenance Access*

We are unaware of any recognised standards for maintenance access to a structure such as this Culvert. Access to the Culvert is not particularly good at the moment, with access only being achievable from the downstream end of the Culvert by means of a small boat. Access is also possible from a vertical shaft which is located at the change in direction of the Culvert although this is only affords access to the section of the Culvert immediately at the shaft. The cover to the vertical shaft consists of large steel plates which require to be removed by mechanical plant.

It is however probably not justifiable to incorporate enhanced access arrangements such as additional vertical shafts. The only reason to enter the Culvert is probably only necessary to inspect both the integrity of the concrete structure and silt levels at say 5 yearly intervals and this we suggest can be carried out from a small rowing boat. Personnel entering the Culvert would of course have to comply with the necessary Health and Safety Regulations.

5.4 *General Maintenance*

The following are the current maintenance requirements associated with the culvert:-

1. Replacement of Debris Screen – highly recommended

2. Testing of Silt – Optional

3. Repairs to Concrete – Optional

4. General inspection of Culvert recommended at 5 yearly intervals to review concrete structure and silt levels

5. Improvement to vertical access shaft cover - Optional

6 Issues for New Development

It is recommended that further work be undertaken to address the various issues associated with the requirements of the proposed new development.

The core issues are outline below and briefly discussed herein:

a) Feasibility of diverting the Burn around the site in an open channel

b) Maintenance and issues associated with retaining the culvert

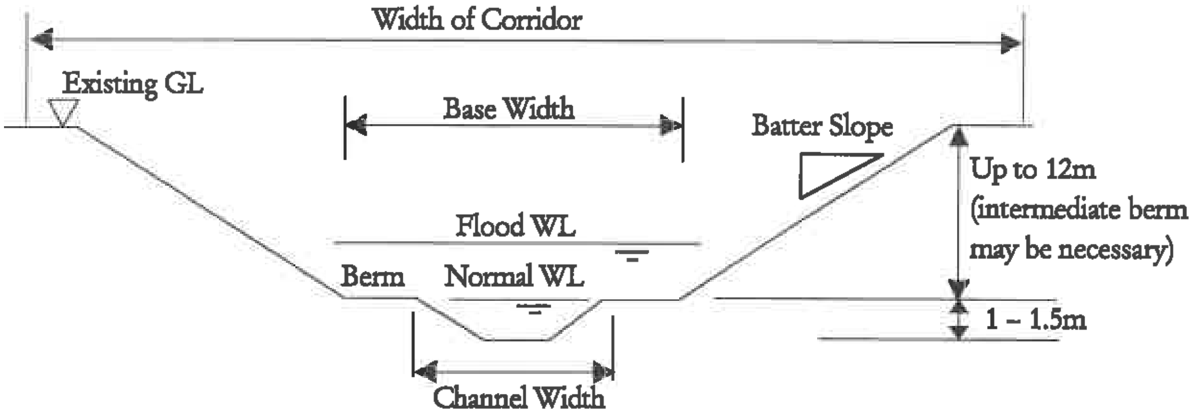
c) Feasibility of diverting the 1050mm dia. Pipe

d) Infilling of gap between the Bothlin Burn Culvert and the Railway Culvert

6.1 Feasibility of Burn Diversion

A possible route for diverting the burn around the site involves the construction of an open channel westward from the culvert inlet then northward along the western edge of the site, refer to Drawing No. GSSS-13 (Appendix A). The channel would rejoin the culvert upstream of the new motorway interchange. The large depth of excavation necessitates a wide construction corridor. A typical cross section of the diversion is shown below. The width of the corridor is dependent on the following:

- Engineering of channel slopes (berm construction, batter slopes)
- Width of the base of excavation
- Depth of excavation (parts in excess of 12m)
- Constraints imposed by relevant authorities (e.g. SEPA, Planning Authority etc) to limit detrimental impact to the environment during construction, if any, and to provide enhancement of the diversion where possible.



The various constraints imposed by both hydraulic design requirements and relevant authority guidelines will determine the impact of the corridor on the land available for redevelopment.

Should the burn be diverted investigation into decommissioning the existing culvert will be required. Options for it's decommission may be:

- Close upstream end of culvert, clean out contaminated silt and fill culvert with an inert material. Extent of possible grouting of the culvert will need to be investigated.
- Excavate, remove contaminated silt, demolish or remove culvert and backfill to prevent risk of culvert collapse and potential soil contamination risks during redevelopment of the site.

The cost of abandoning the Culvert and diverting the Burn would be extremely high and is outwith the scope of this Report. It is felt however that it is unlikely that the high costs could be justified by the benefits gained.

6.2 *Maintenance and Issues Associated with Retaining the Culvert*

6.2.1 *Capacity/flooding limitations that may affect redevelopment*

It is considered that the culvert has sufficient capacity to handle a Q200 flood event, provided the inlet remains free of debris. The existing debris screen is choked with debris and is currently impeding the flow into the culvert. Investigations into possible redesign or replacement of the culvert will be required.

There is a small risk that the inlet could become blocked with debris during a flood. Provision of access to the culvert during flood events in addition to maintenance of the culvert inlet during these events needs to be investigated and provided for in the proposed redevelopment.

Development of the site will not increase flooding in the area. Liability issues associated to flooding caused by partial or complete blockage of the culvert during a flood event would arise from widespread flooding of low lying areas south of the railway line at Gartcosh station.

6.2.2 *Contamination of burn associated with silt within the culvert*

Liability issues associated with contamination of the river due to re-suspension of silt particles, which maybe contaminated within the main stream, will need to be investigated. It is estimated that flow velocities sufficient to promote movement of silt particles and subsequent re-suspension into the main stream will occur during modest flood events.

6.2.3 *Structural limitations on redevelopment works adjacent to the culvert*

As stated in 3.3 the Culvert almost certainly has at least another 25 years of service before significant structural repairs are required.

Whilst the Culvert is structural capable of supporting loads from low to medium rise buildings it would however seem prudent not to construct permanent buildings directly over the top of the Culvert as it will prevent access for possible excavations to repair the Culvert at some unknown time in the future.

It would be sensible to arrange the layout of the Industrial Park so that areas of car parking or landscaping are located directly over the top of the Culvert and perhaps 5m either side of it.

Apart from future access considerations there is also the practical considerations that settlement of the backfill to the Culvert could take place under increased loading.

From a structural point a view there is no practical reason why the present ground level cannot be either lowered or increased by a maximum of 1.0m.

6.2.4 *Improvements to existing culvert*

As indicated in 3.2 improvements to the inlet debris screen are recommended to allow regular safe maintenance. The works should also include for an access road down to the inlet to allow removal of debris off site. The only access point to the Culvert apart from the downstream headwall is a vertical access shaft, which is located at the change of direction of the Culvert. This is also the point where the 1.52m surface water pipe enters the Culvert. There is no overriding reason for manual access at this point but it does exist and depending on the development proposals consideration should be given to improving safety (e.g. lockable covers, ladders etc).

6.2.5 *Anticipated Working Life of the Culvert*

As stated previously the culvert is now approximately 40 years old. No records of the design calculations are available but it is reasonable to assume that the original design life was 50 years.

The durability of concrete structures depend on a variety of factors, the main ones being as follows: -

- Exposure conditions
- Quality of the concrete
- Cover to the reinforcement

We are unaware of the chemical contamination within the backfill around the culvert, but given this uncertainty we believe the exposure environment of the Culvert can be described as moderate.

We have no information on the quality of the concrete but the surface finish to the internal face looks reasonably good and this might suggest that the quality of the concrete will be likewise.

Cover to the reinforcement is stated as being 50mm on the original construction drawings. The cover therefore complies with current standards.

Clearly it is impossible to give exact figures on the live expectancy of the Culvert but given the above factors we would anticipate that the Culvert structure is good for at least another 25 years assuming the repairs to the spalled concrete referred to above are carried out and the structure is inspected on a regular basis say every 5 years.

6.3 ***Feasibility of Diverting the 1050mm Dia Pipe***

As stated previously the 1050mm dia pipe seems to have drained a path which crossed the site and probably some field drainage. There are several manholes along the line of the pipe but these do not appear to comply with current legislation and one in particular is badly tilting. The level of the ground has been raised by several metres and it is possible that the need for the drain could now be redundant. The area is presently waterlogged which suggests that the drain is not effective. It is possible that new drainage installed at a higher level could be more effective and be located in a position more suitable to a future development. The effect on the groundwater regime in the area would require further investigation.

This investigation should identify the current groundwater regime and establish the geotechnical parameters required to design an adequate new drainage system. The work would involve excavating a series of trial pits across the area to be drained, in-situ soakaway tests and laboratory testing. Such an investigation is outwith the scope of this Report but is estimated to cost £12,000 (excl. of VAT) including all design, fieldwork and testing.

6.4 ***Infilling of Gap between Bothlin Burn Culvert and Culvert Under Railway***

There is a 50m long section at the south end of the Gartcosh site where the Bothlin Burn runs as an open watercourse, this is between the culvert under the railway line and the start of the Bothlin Burn Culvert. The area is dominated by high brick retaining walls and steep cuttings. Clearly there would be advantages from a development point of view in culverting this section of the Burn and infilling the area to match the surrounding site levels. There are no technical reasons why this cannot be done but clearly Statutory Approvals from the Planning Authority and SEPA would be required.

SEPA may have a concern about the deterioration in water quality which is usually associated with enclosing water but given the relative lengths involved we would not anticipate that this would be a major concern.

An added benefit in infilling the area is that as previously mentioned there are large existing retaining walls in the area and a bridge all of which will eventually need to be replaced. Culverting the Burn will make these structures superfluous to requirements.

The cost of constructing a new culvert and infilling the area would be considerable and is outwith the scope of this Report.

APPENDIX A
Drawings

Halcrow : Bothlin Burn Culvert Drawings

Catchment Plan

Possible Diversion Route GSSS-13

Site Drainage Plan and Bothlin Burn Culvert Sections GSSS-12