FLOOD RISK ASSESSMENT REPORT FOR THE LONGMAN LANDFILL SITE, INVERNESS

SITUATED BETWEEN THE STADIUM ROAD, MORAY FIRTH, RAIGMORE INTERCHANGE AND THE A9 (T) TRUNK ROAD – INVERNESS

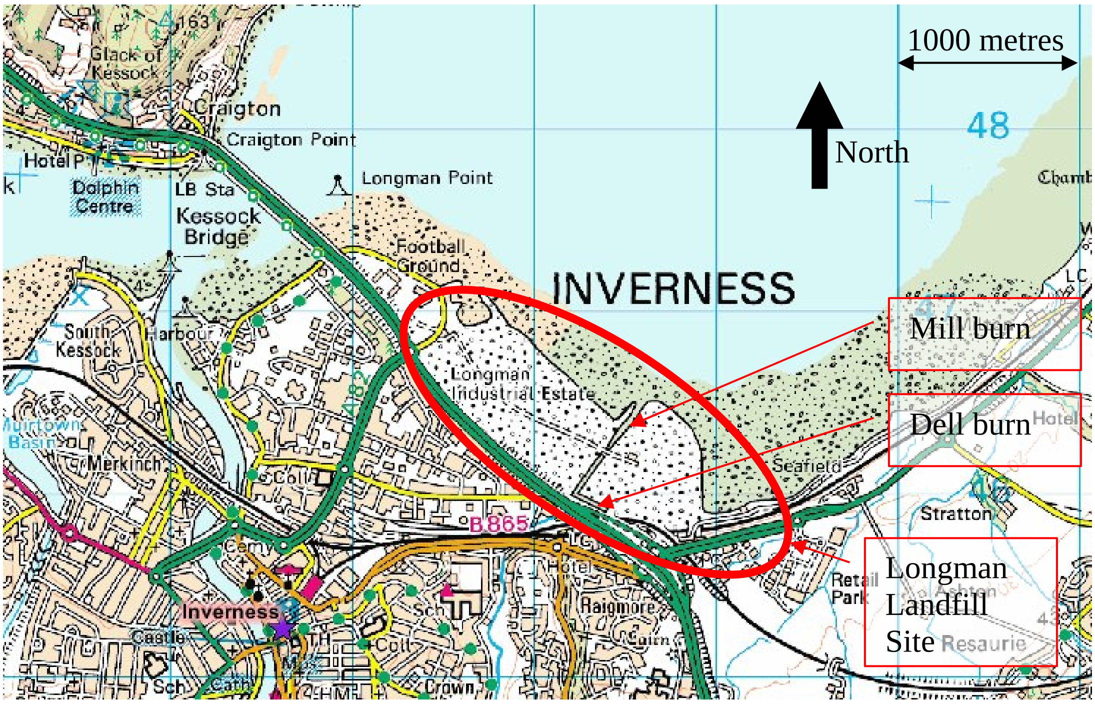
THE LONGMAN LANDFILL SITE

The site occupies the area of foreshore of the Moray Firth which has been landfilled. The landfill has effectively raised the ground levels which displaces the sea from an area of the foreshore.

The site is bounded by the Stadium Road to the north west, the A9 (T) dual carriageway Trunk Road on the south west and the Inverness to Aberdeen railway on the southern boundary. The seaward eastern boundary is the Moray Firth.

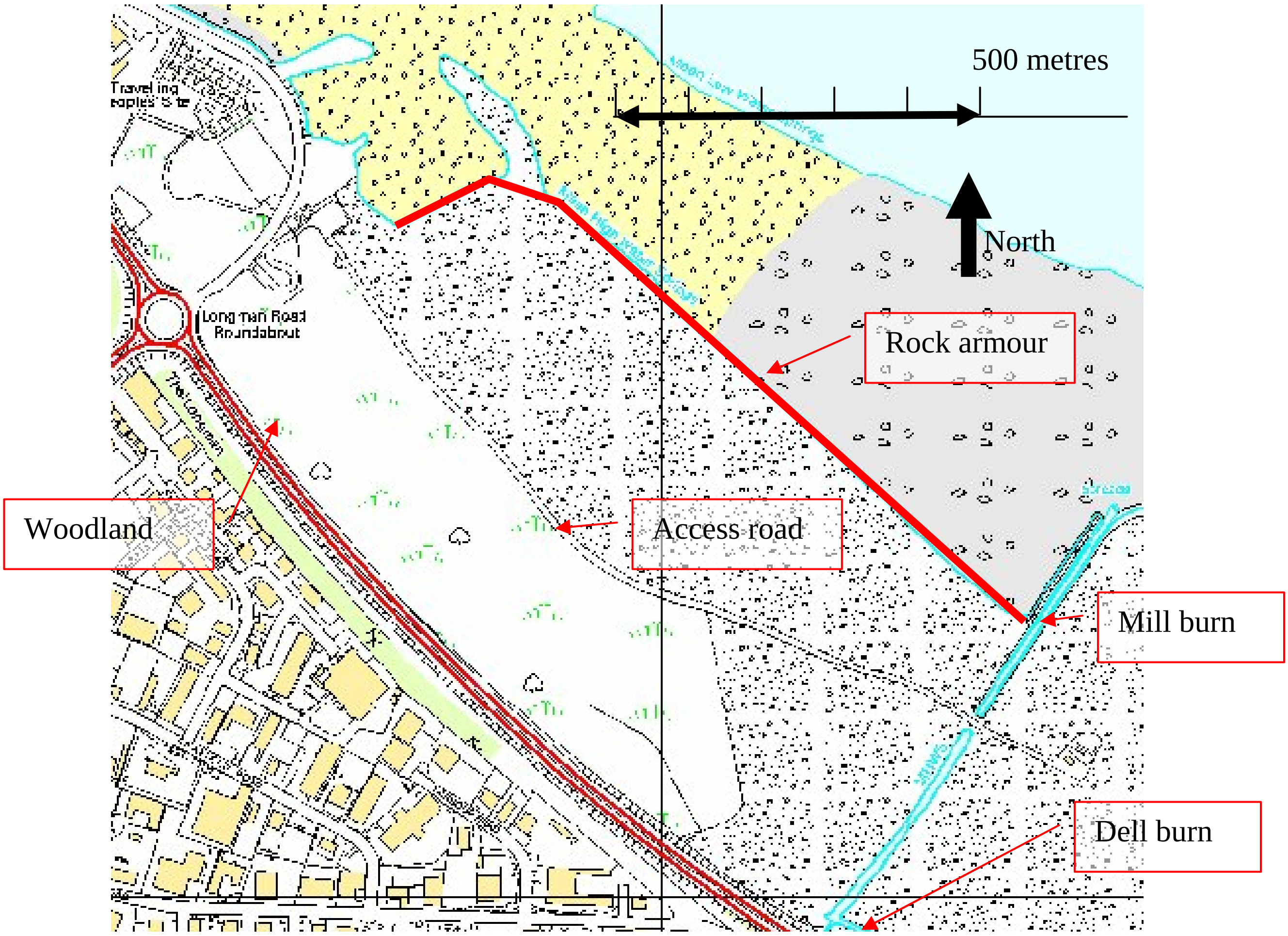
The raised landfill area is situated on the foreshore some of which was originally above Mean High Water Spring Tides (MHWST) and some of which was between MHWST and the current Mean Low Water Spring Tide (MLWST).

The whole of the site is to the landward side of the MLWST by a margin of approximately 100 to 200 metres.



LOCATION PLAN

The site is bisected by the Mill Burn which discharges into the Moray Firth. A small water course known as the Dell Burn flows into and joins the Mill Burn at the South East edge of the site.



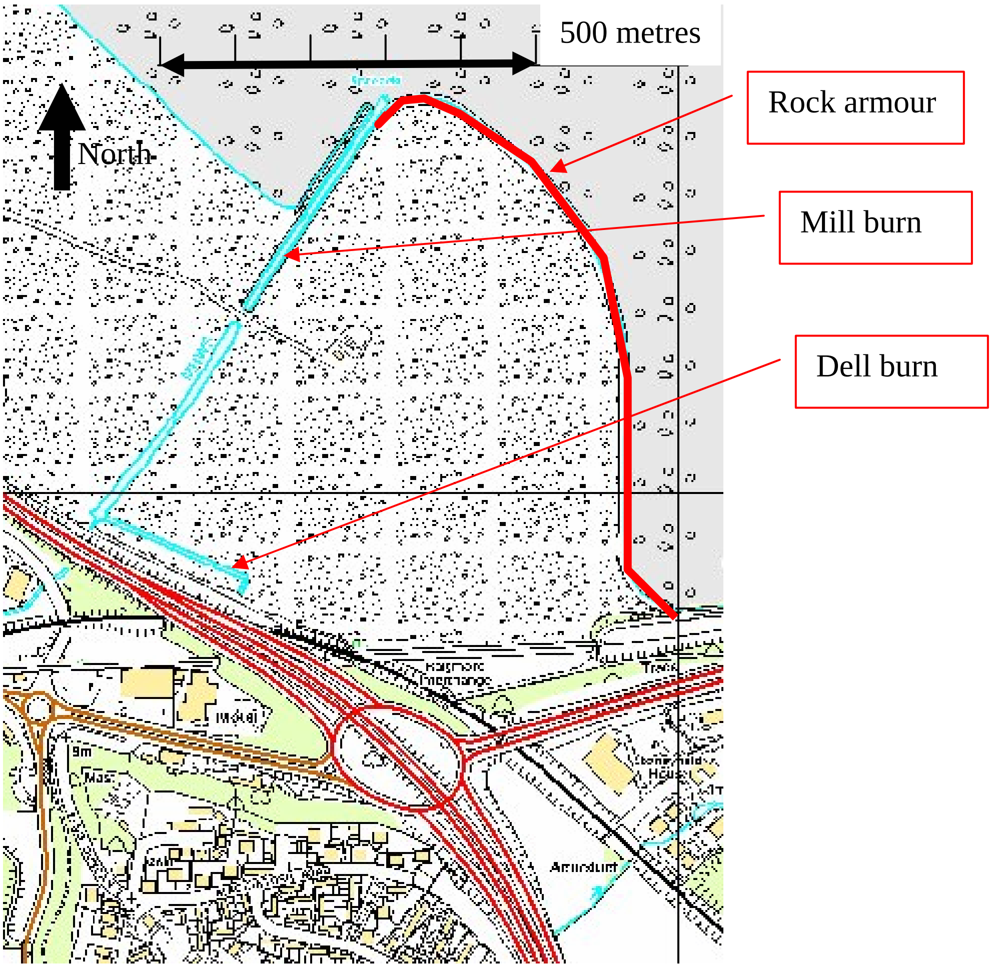
PLAN OF THE NORTH WEST SECTION, WEST OF THE MILL BURN

This section of the Longman Landfill site has been graded off into a generally level area which is at an elevation of 6m AOD or above. This area will be subject to long term variable settlement due to the decomposition of the landfilled waste.

It has been landscaped with woodland on the south west side, carries the access road which extends from the existing site entrance to a culvert crossing of the Mill burn, and has recently been protected from erosion by the sea using rock armour stone.

The landfill consists of mixed domestic and commercial waste including inert soils and some asbestos pits.

The area drains naturally towards the sea.



SOUTH EAST SECTION, EAST OF THE MILL BURN

This section of the site has been restored and landscaped into two long low dome shapes which rises to 14m AOD. The seaward edge of the landfill is protected from erosion by rock armour stone. This area will also be subject to long term variable settlement due to the decomposition of the landfilled waste.

The area has been lined and incorporates drainage which deals with surface run-off by discharging surface water to the sea.

Coastal Protection

The predominant wind direction at the site is in an offshore direction due to usual south west wind. The seaward boundary edge of the site is exposed to a 10 km fetch from a north east wind extending from Fortrose. The fetch for north west and south east winds is limited to around 3 km.

The foreshore limits the depths of sea to less than 5m. This shallow depth will limit the expected wave heights.

The whole of the seaward edge of the landfill is protected from erosion and waves by rock armour.

Flooding

There are only 4 possible sources of flooding for this site.

1. Groundwater
2. Pluvial flooding from within or outwith the site
3. Tidal flooding from the sea caused by high tides
4. Fluvial flooding from watercourses, Dell Burn or Mill Burn

The possible sources of flooding are considered in detail below.

1 Flooding from groundwater

The watertable within the site and the immediate surrounding area is monitored by standpipes. The watertable is below ground level during all times of the year and there is no possibility of flooding from groundwater. The watertable is however influenced by tide levels on some parts of the site and any development involving excavations will need to allow for this fluctuation.

2 Flooding from overland sources – Pluvial Flooding

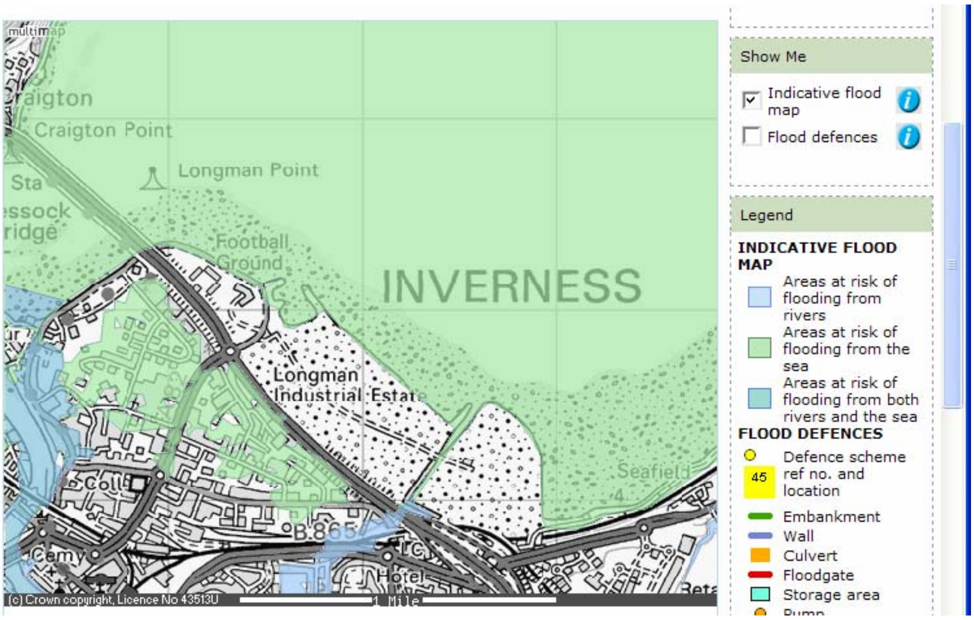
Apart from the accumulation of rainwater on the site which will need to be dealt with by drainage measures incorporated into any development there are no discharges or flows onto the site other than the two watercourses. The flows from these two watercourses are dealt with in the sections of this report below.

Pluvial flows onto the site from adjacent areas are prevented by the A9(T) Trunk road and the Inverness to Aberdeen railway. Both these transport routes are carried past the site on embankments and include positive drainage measures. These effectively cut off the site from pluvial run-off entering the site. Pluvial flooding of the site from sources outside the site can therefore also be discounted.

3 Tidal Flooding

Sepa Mapping

SEPA have mapped the whole of Scotland for flood risk and their mapping shows no flood risk caused by river or sea to the landfill site for the 1 in 200 year (0.5%) return period. The flood risk areas are shown on the following map.



SEPA FLOOD RISK MAP for 1 in 200 year risk (0.5% probability)

Flood Study Reports – predicted tide levels

A study entitled 'River Ness Flooding – Inverness, Pre-feasibility Study, Flood Protection, dated June 2005', was undertaken by consultants Mott MacDonald for the Council. This study includes the determination of sea levels for Inverness. This report states:-

'A tidal gauge was installed at the mouth of the Caledonian Canal in 1991. Although this does not yet provide a long enough record for useful frequency analysis, one of the actions of the 2004 review was to compare the 12 year common record of transposed Aberdeen levels with the levels taken from the local gauge. The difference between the locally recorded and transposed Aberdeen levels varied between -0.34m and +0.23m. The transposition therefore allows a reasonable estimation for the order of tidal peak levels in Inverness.'

The results of this study are taken from their report and are quoted in the table below:-

Table 6-2: Design Water Levels for Tidal Flooding

Location	Design Water Level (m AOD) for Given Return Period					
	2 year	10 year	50 year	100 year	200 year	1000 year
All locations downstream of Celt Street (node 35)	3.27	3.46	3.61	3.68	3.75	3.90

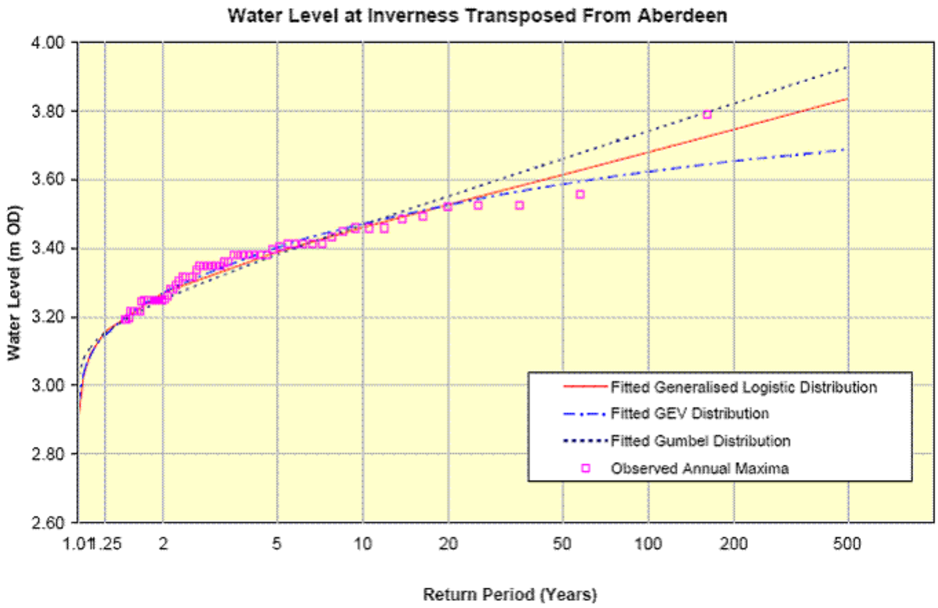
eg The table shows that the 1 in 100 year high tide level (1% annual probability of occurrence) has been estimated as 3.68m above Ordnance Datum.

These design water levels are applicable to the Longman landfill site.

These predicted levels were also given in a Mott MacDonald's previous report entitled 'River Ness Flooding Review dated January 2004' and are shown graphically below:-

An updated frequency analysis has been undertaken on the Aberdeen tide levels transposed to Inverness. Figure 2.4 shows various distributions fitted to the data. Some variation between the fitted distributions for high return period events is evident. As with the River Ness discharge, the Generalised Logistic distribution is adopted for representing tide level frequency for this study.

Figure 2.4: Frequency Analysis of Inverness Tide Levels



The estimated peak water level (tide level plus surge) at Inverness for a range of return periods is summarised in Table 2.6. The levels are taken from the Generalised Logistic distribution fitted to the transposed Aberdeen data. The levels are higher in comparison to the 1991 study, but only of the order of a few centimetres.

The effect of Climate Change on Tide Levels

In the same report Mott Macdonald also advised on the effect of climate change as follows:-

3.2 Sea Levels

As a result of global temperature increases, average sea levels are expected to rise. This is predominantly attributed to thermal expansion of ocean water and ice melt. The current predictions from the UKCIP02 Scientific Report, is for Global-average sea levels to rise between 9cm-69cm over the next 80 years for various global emission scenarios. On a regional level, incorporating global average sea levels and regional vertical land movements, the predictions for Eastern Scotland suggest up to 60cm rise in average sea level over 80 years.

Changes in extreme levels associated with storm surges will also increase. Current recommendation is to increase extreme sea levels in line with average sea level increases. So again for Eastern Scotland a prediction of up to 60cm rise in extreme sea level over 80 years is appropriate.

The number of years of sea level rise to incorporate in Flood Alleviation Schemes is a decision for the design authority. Also at question is the rate of rise. The predicted 60cm rise for Eastern Scotland is under the high emission scenario, with virtually no change in average sea levels for the low emission scenario. Taking a median value of 30cm over the 80 years gives an approximate sea level rise of 5mm/year.

On this basis it is recommended that an allowance for sea level rise of 30cm be taken for the Longman Landfill site.

Potential flooding of the site by tides

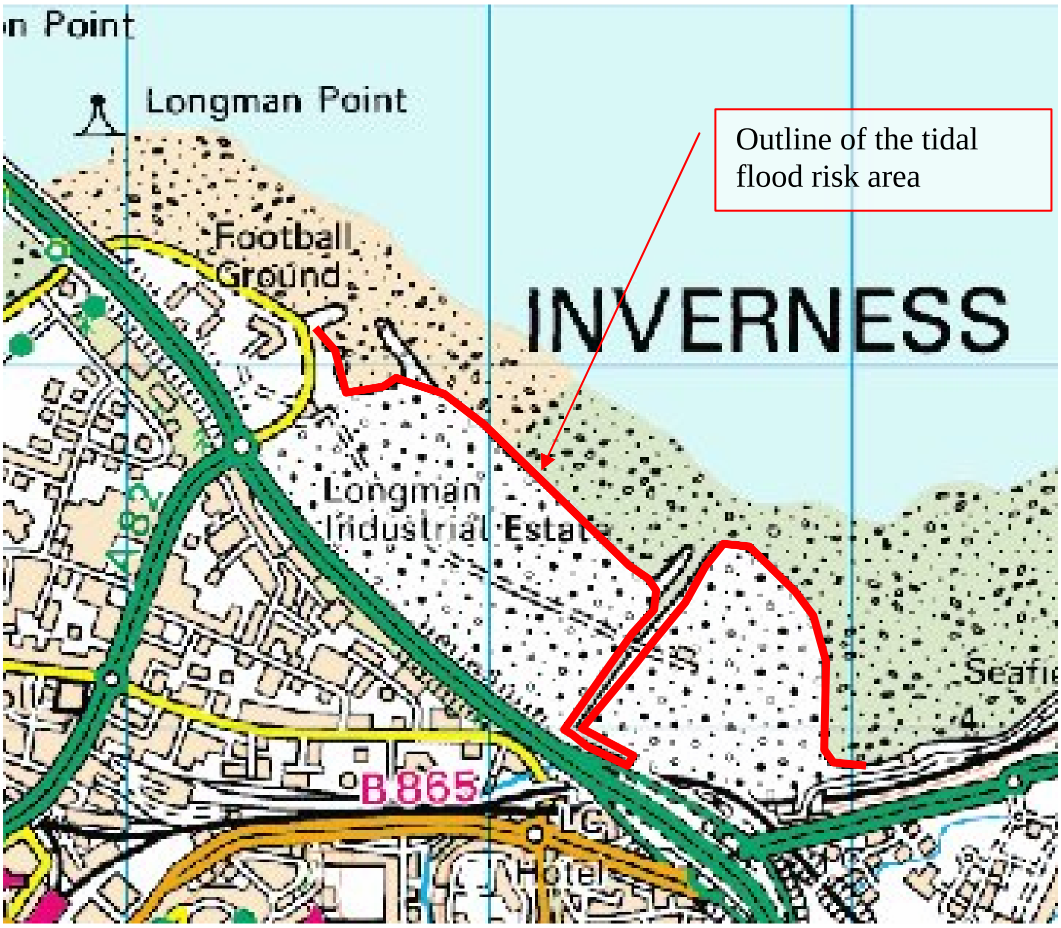
Only very limited areas of the site can be inundated by a high tides.

- The predicted tide levels are 3.68m AOD and 3.75m AOD for the 1 in 100 year and 1 in 200 year events respectively.
- These levels are increased to 3.98m AOD and 4.05m AOD including an allowance for climate change.

The duration of the high tides and consequently the volumes of flood water will be limited by the cyclic nature of the tides. These highest levels of tide would be expected to be less than 2 hours in duration for any event.

A topographical survey of the site has been compared to the set of predicted tide levels. The edges of the site are all relatively steep and the outlines of all the predicted tidal flood levels are effectively the same.

The outline of the flood risk area subject to tidal flooding from the 1 in 100, 1 in 200, 1 in 100 plus climate change and the 1 in 200 plus climate change are shown on the map below :-



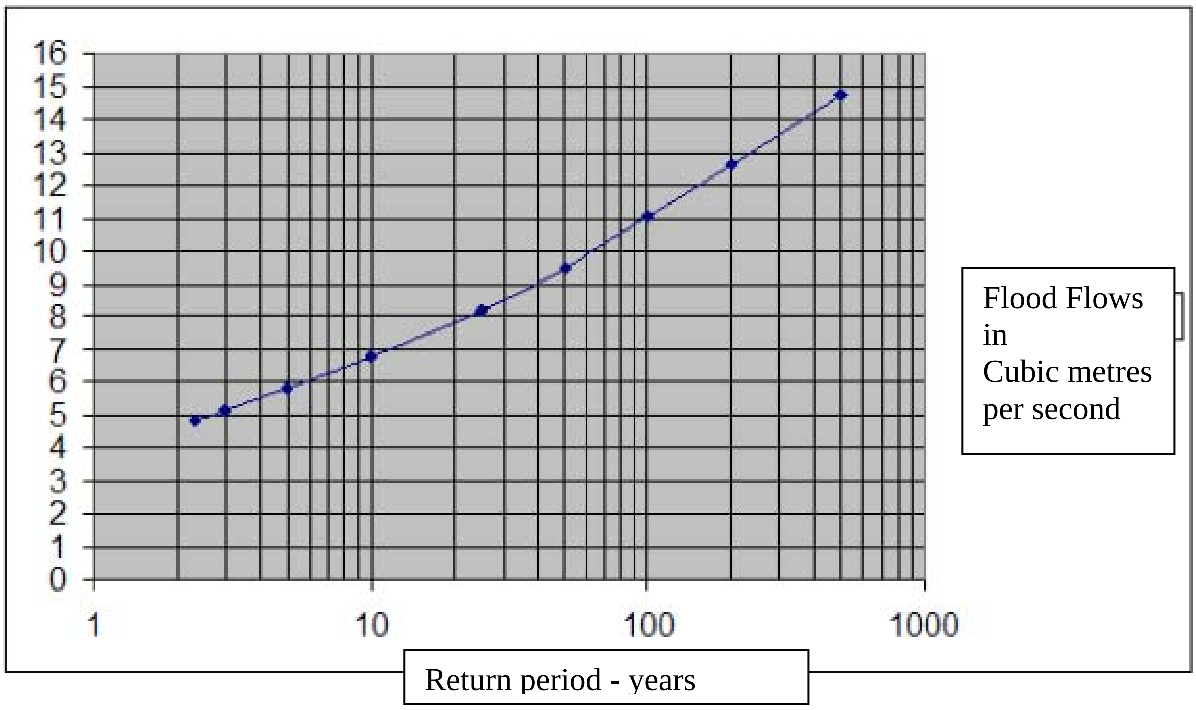
OUTLINE OF THE TIDAL FLOOD RISK AREA

It can be seen that the predicted outlines from the various studies and the topographical survey mirrors the flood risk area identified by SEPA. The flood risk area of the site is very limited.

4 Fluvial Flooding

Flood Flows for the Mill Burn

Mott Macdonald completed a study of the flooding of the Mill Burn entitled ‘Mill Burn Flood Study dated September 1989. It predicts the volumes of flood water for various return periods which can be extended and represented by the graph and table below.



Return period-years	Flood Flow cumecs
2.33	4.86
3	5.17
5	5.81
10	6.76
25	8.18
50	9.45
100	11.06
200	12.6
500	14.7

The catchment was also studied for the Council by the consultant Parkman. Their report dated October 2002 entitled ‘South West Inverness Storm Water Relief - Feasibility Study, Volume 1 of 2, gave the following information:-

‘Mill Burn Flood Study
The scope of the Mill Burn Flood Study was to:

- *identify the capacity of the Burn and frequency of flooding;*
- *determine the consequences of urban development in the upper catchment;*
- *recommend methods of improving the capacity;*
- *provide cost estimates of alternative flood alleviation measures.*

The Flood Studies Report (FSR) methodology was used to analyse the rural catchment for the pre- and post-development conditions. Development was anticipated at the time in the Milton of Leys and Inshes areas. (Development is now underway in both areas.) The rural catchment was split into three sub-catchments and assessed using Mott MacDonald's in-house FSR software (FSRDESFL & FSRUH). The resultant hydrographs were combined to give aggregated flood flows for winter and summer storms, for pre- and post-development, for return periods from 2.33 to 100 years. The highest flows were obtained from the winter pre-development simulation (Q100=9.51m3/s) and summer post-development simulation (Q100=11.06m3/s).

The urban areas within the Mill Burn catchment were found to discharge via five outfalls, two of which were storm overflows. The Modified Rational Method was used to assess the flows from the urban outfalls, while the storm overflow discharges were assessed using WASSP modelling. Some approximation was made to simplify the range of flows for varying return periods.'

These two reports give the same flood flows.

Flood flows for the Dell Burn

The consultant Parkman completed a study for the Council in December 2002 entitled 'Inverness Area Flood Studies - Dell Burn'. Their report summarises the flood flows for the Dell Burn as follows:-

'Rural Hydrology
The rural catchment has been taken to consist of the narrow strip that drains to Dell of Inshes, at the confluence of Dell Burn and Inshes Burn, a total area of 1.7km^2 over a length of 5.4km. The hydrological assessment of this area is based on the digital descriptors from the FEH CD-ROM, checked against site inspection and location knowledge. The Standard Percentage Runoff (SPRHOST) values have been modified, to correct for the relatively coarse 1km grid of soil types on which the CD-ROM data are based. (The SPRHOST value from the CD-ROM of 41.5 was revised to 43.3, as shown on the calculations in Appendix 4).

In accordance with the Flood Estimation Handbook, the rural runoff was assessed using the FEH pooling method. This is a statistical approach, whereby gauging stations throughout the United Kingdom are sampled, to form a dataset that is hydrologically similar to the subject site. The rural runoff estimated by this method was lower than that estimated using the FEH rainfall-runoff model. The precautionary principle implies that the worst realistic scenario should be adopted in the absence of scientific evidence to the contrary. At 1.7km^2, the catchment is extremely small, compared to the 1000 stations in the FEH database. Consequently, there are not sufficient sites available to constitute a reliable statistical sample. It is therefore considered that the rainfall-runoff model should be adopted. For completeness, the FEH pooling calculations are included in Appendix 4.

The peak rural flows generated using the FEH rainfall-runoff model are given below:

1 in 50 year rural runoff	*1.9m^3/s*
1 in 100 year rural runoff	*2.2m^3/s*
1 in 200 year rural runoff	*2.5m^3/s'*

Combined Fluvial Flood Flows

If the flow figures for the two catchments are simply combined, then the flows for the Mill and Dell Burns can be conservatively given as:-

Return period-years	Mill Burn Flood Flow	Dell Burn Flood Flow	Combined Flood flow for the Dell and Mill Burns Cumecs
2.33	4.86		
3	5.17		
5	5.81		
10	6.76		
25	8.18		
50	9.45	1.9	11.35
100	11.06	2.2	13.26
200	12.6	2.5	15.1
500	14.7		

Potential flooding of the site from the watercourses

The combined flow for the Dell and Mill Burns is 13.26 and 15.1 cumecs for the 1 in 100 and 1 in 200 year return periods respectively.

The Mill burn watercourse is partly lined with tyres. The channel is along a straight alignment, generally 6m wide at the invert at a level of 0m AOD. It has 1 vertical to 1.5 horizontal sloping sides. The bank height is generally 5m AOD on the west. There is a narrow 15m wide fringe adjacent to the watercourse at a level of 3.5m AOD on the east, right bank. The east, right bank extends to a level of 14m AOD and rises to 5m AOD within 20m from the watercourse.

If the concurrent sea level is limited to the 1 in 10 year tide level of 3.46m AOD then the effective watercourse is effectively 20m wide with 1.5m high banks.

Calculations show that the watercourse can deal with:-

- a flow of 13.25 cumecs and a top water flood level of 4.15m AOD
- a flow of 16 cumecs and a top water flood level of 4.5m AOD

The predicted flood flows are therefore retained within the watercourses with no out of bank flows.

SUMMARY

There are only 4 possible sources of flooding for the Longman landfill site.

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1. **Groundwater -** The flooding from groundwater can be discounted

2. **Pluvial flooding from within or outwith the site** - Pluvial flooding (overland surface flow) is prevented by topography.

3. **Tidal flooding from the sea caused by high tides** - Tidal flooding is very limited and is confined to the very narrow coastal fringe and part of the Mill Burn watercourse but with no out of bank flooding other than the narrow fringe on the east, right bank.

4. **Fluvial flooding from watercourses, Dell Burn or Mill Burn** - Fluvial flooding (from watercourses) is contained within the watercourse banks with no predicted out of bank flow other than the narrow fringe on the east, right bank.