



LIBERTY CONSTRUCTION LTD

Reservoirs Act 1975

Name of Reservoir: *Marlbrook Quarry Reservoir*

Report under Section 8

Robert J Mann, BA, MICE, MCIWEM, AR Panel Engineer

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Date: January 2015

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1. Name and situation of Reservoir

Marlbrook Quarry Reservoir situated situated 4 kilometre north east of Bromsgrove in the County of Worcestershire, at National Grid Reference SO 980 750.

2. Name and Address of Engineer

Robert J Mann, BA, MICE, MCIWEM
AECOM
1 Tanfield,
Edinburgh,
EH3 5DA

3. Name of Panel of which the Engineer is a member

All Reservoirs Panel (appointment to 13th August 2015)

4. Name and Address of Undertakers

Liberty Construction Ltd
20 Westley Street
Dudley
West Midlands
DY1 1TS

5. Date of engineer's inspection

The reservoir was inspected on 25 November 2014. The inspection was made accompanied by Mr E McIntosh of Liberty Construction. This was followed immediately by a meeting and site visit at the request of Bromsgrove District Council attended also by Ruth Bamford (Head of Planning) and Sarah Sellers (Principal Solicitor) of Bromsgrove DC; James Penman, AR Panel Engineer of CH2MHill (Advisors to Bromsgrove DC); and, Fiona Upchurch of the Environment Agency Reservoirs Team (Enforcement Authority).

The engineer had made a previous visit on 11 November 2013 in his role at that time as Qualified Civil Engineer under Section 10(6) of the Act.

6. Engineer's findings

This report is prepared following issue by the Environment Agency of a Notice dated 22 September 2014 requiring appointment of a Construction Engineer under Section 8 of the Act. Up to that time, the reservoir had been subject to periodic inspections under Section 10 of the Act, with remedial measures in hand supervised by an appointed Qualified Civil Engineer under Section 10(6) of the Act, and with a Supervising Engineer duly appointed under Section 12 of the Act. The Notice from the Environment Agency (EA) was issued as a result of legal advice given to the EA and not as a result of any known non-compliance by the Undertaker.

6.1. Information available

Documents made available to the Inspecting Engineer that inform decisions on the acceptability of the construction and alteration of the reservoir are listed in Appendix A1. These include Reports of Inspections carried out under Section 10 of the Act, the latest of which is by Mr Peter Kelham of Ove Arup & Partners dated 6 March 2013. The list also includes further supporting documentation available from the period of construction and alteration of the reservoir works.

6.2. Conditions found

6.2.1. Background

Marlbrook Quarry Reservoir is an impounding reservoir formed by the construction of a landfill embankment across the Catshill Brook. Originally the embankment formed part of an active landfill and the brook was carried in culvert beneath the fill embankment. The embankment was constructed in sometime between 1940 and 1987. Later the culvert collapsed (in whole or in part is not known) resulting in the formation of a reservoir.

The reservoir has an uncontrolled bottom outlet similar to a flood storage reservoir, and normally stands at or near empty with normal operational water level at 200.7m OD. At this level, the reservoir has an area of about 610 m². The upper overflow level is at 210.6 m OD approx, which gives a maximum potential depth of about 10 m during extreme floods. With impoundment to this elevation provisional estimates have derived the surface area as about 17,000 m² and the impounded volume as approximately 66,000 m³.

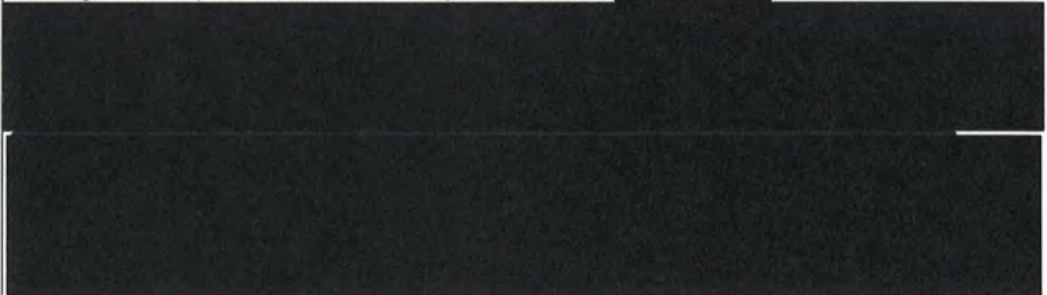


Reservoir pool area – looking north

Descriptions and drawings of the embankment and appurtenant works are available from earlier reports and documents including those listed in Appendix A1. A full description will be prepared in full in due course as the Annexe to the Certificate of Efficient Execution of the Works.

The previous Statutory Inspection under Section 10 of the Act by Peter Kelham dated 6 March 2013 gave findings and made recommendations including matters recommended in the interests of safety. The Findings and Recommendations are reproduced below, including a note on implementation of the safety measures.

Findings from Report under Section 10 by Peter Kelham



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4. The earthworks to the landfill around the reservoir area are incomplete and need to be completed as soon as practicable [REDACTED]
 [REDACTED] However a flood study is required to determine the maximum storage volume, maximum still water level and requirement for a high level overflow.
6. The embankment dam appeared to be stable with no evidence of distress [REDACTED]
 [REDACTED]
7. There are no apparent changes in seepages and none are of immediate concern.
8. The instrumentation monitoring shows an upward trend in leachate levels. [REDACTED]
 [REDACTED]
9. There is no evidence of any settlements or movements that might endanger the safety of the reservoir, but settlement stations should be installed once the earthworks have been completed.
 [REDACTED]
 [REDACTED]
12. The Undertaker is complying with his obligations under the Act in terms of supervision and keeping records.

Recommendations as to measures to be taken in the interests of safety under Section 10(6) of the Act , from Report under Section 10 by Peter Kelham - Section15.3	Action taken
I recommend that:-	
1. the upstream face of the embankment around the reservoir are regraded to ensure no part of any slope is steeper than the design gradients (4H:1V) previously agreed with AECOM;	Outstanding - held pending approval of planning permission
2. the upstream face of the embankment around the reservoir and the crest shall be covered with 300mm of restoration soils and seeded to provide a good grass sward;	Outstanding - held pending approval of planning permission
3. the part of the site that forms the direct catchment to the reservoir shall be covered with 300mm of restoration soils and seeded to provide a good grass sward to limit erosion and siltation of the reservoir;	Outstanding - held pending approval of planning permission
4. the remainder of the site not already restored shall be covered with 300mm of restoration soils and seeded [REDACTED] [REDACTED]	Outstanding - held pending approval of planning permission
5. an accurate topographic survey of the catchment is undertaken to include the section upstream of Alvechurch Highway and the junction of Marlbrook Lane and Alvechurch Highway. The survey shall include the high level overflow section between the northern end of the western embankment and the junction of Alvechurch Highway and Marlbrook Lane. This is required to determine the reservoir capacity, surface area, maximum depth and overflow characteristics. The results shall be passed to an All Reservoir Panel Engineer who will determine the appropriate capacity, surface area, height, crest level and overflow level;	Completed: Topographical survey carried out in June 2013 as given on files P-6004-MARL-SU-CDR-A01. Provisional estimates of reservoir capacity and related characteristics have been determined and are included in this Report.
[REDACTED] [REDACTED] [REDACTED]	[REDACTED] [REDACTED] [REDACTED]
7. a flood study of the current arrangement is undertaken to determine the [REDACTED] still water level, freeboard and duration of the event. The results shall be passed to an All Reservoir Panel	In hand, recommended for completion [REDACTED] [REDACTED]

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Engineer for a recommendation;	[REDACTED]
[REDACTED]	[REDACTED]
9. a detailed geotechnical analysis of the western embankment is carried out once the maximum flood storage level has been determined. The results of the analysis shall be passed to an All Reservoir Panel Engineer for a recommendation. In addition the All Reservoir Panel Engineer should also advise on the level to which water may be stored and changes made to the Prescribed Form of Record if required.	Complete: Geotechnical analysis carried out and given in Report <i>Marlbrook Landfill – Slope Stability Assessment</i> , by Aecom Ltd dated 2 March 2012; Changes to Record in hand in course of Certification process
The Reservoirs Act requires that safety recommendations be put into effect as soon as practicable. It is considered that the above safety recommendations should be implemented within twelve months of the date of this report	Outstanding measures delayed principally by planning approval process.

There is a dispute with Bromsgrove Borough Council about finished levels, that has prevented further earthworks being undertaken to complete the restoration soils. [REDACTED]

The recommendations made in this report supersede the recommendations contained in any previous inspection report. Where recommendations made in the interests of safety in the latest inspection report have not been implemented, the matter has been reviewed and either made subject of a recommendation in this report or an explanation given above as to why they are no longer required.

6.2.2. Scope of inspection

The inspection on 25 November 2014, and the previous visit on 11 November 2013, were carried out by me, accompanied by Mr E McIntosh of Liberty Construction, and on the 2013 visit also by Philip Smart, Technical Director, Aecom. The weather at the 2014 visit was cloudy with occasional light rain and a light NE wind, and at the 2013 visit misty, calm and mild. On each occasion the reservoir water level was just over 1 m on the gauge board (just above the soffit of the bridge beneath Alechurch Highway).

Inspection covered the exposed surfaces of the landfill embankment, and viewing of the [REDACTED] surface water drainage arrangement. The valley downstream was viewed from the landfill area and adjacent roads.

In the Inspection Report dated 31 March 2013, the principal findings were as reproduced above, [REDACTED] Recommendations were made in the interests of safety as scheduled above.

Account has been taken of conditions found and recommendations made in the Supervising Engineer's reports to date.

6.2.3. Dam

The Inspection Report dated 31 March 2013 found that the embankment had been raised above its previous level [REDACTED]

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As stated in the 2013 inspection report, this is not considered necessary for this reservoir which is for flood balancing and is normally empty, and lies in a situation well sheltered from wind.



Reservoir pool and adjacent landfill slope – looking south

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[REDACTED] Completion of restoration soil cover has been recommended in previous inspections, and this is affirmed in this Report.



Top of embankment looking towards Right (north-west) end



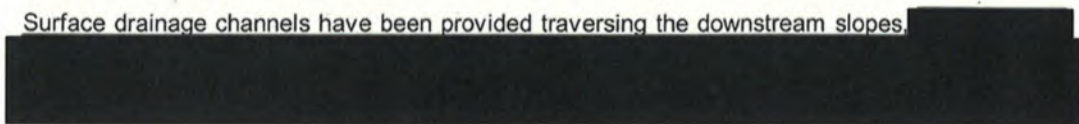


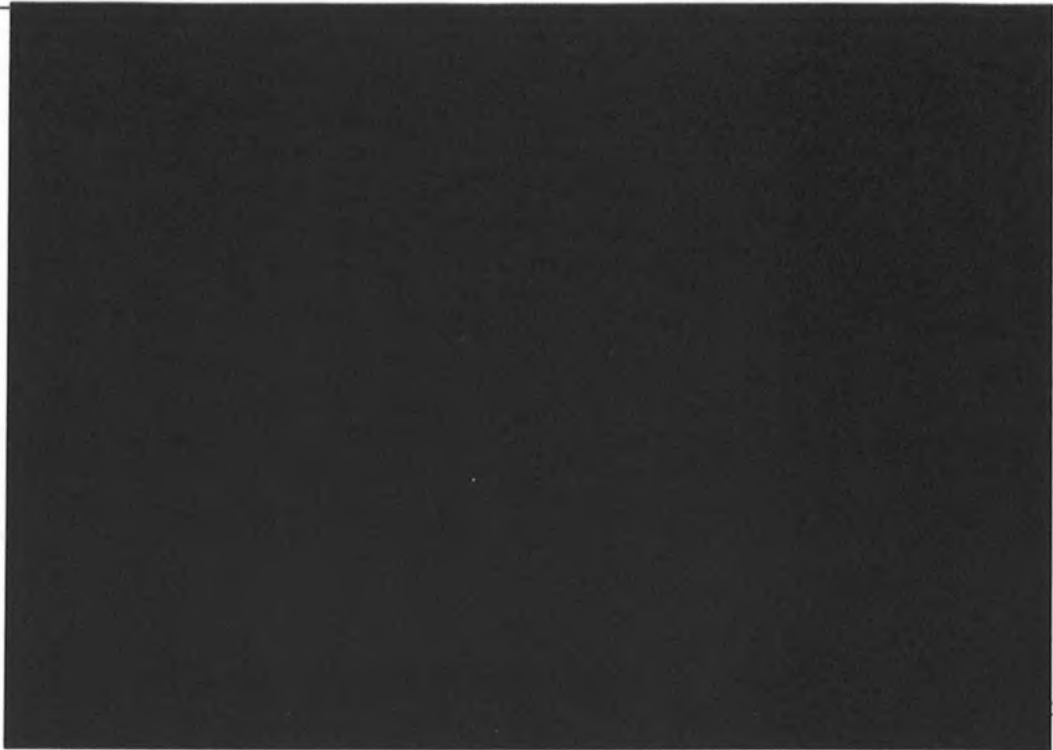
The lower parts of the downstream face on the west and south faces have been restored and are grazed by sheep, that maintains a good grass sward protecting the surface and facilitating visual surveillance (Photograph below).



Restored part of downstream face of embankment

Surface drainage channels have been provided traversing the downstream slopes.





Many of the drainage channels are lined with polymer lining, [REDACTED]
[REDACTED]
[REDACTED]

[REDACTED] Surface drainage arrangements are generally satisfactory [REDACTED]
[REDACTED]

6.2.4. Seepage and Drainage Flows

In the Inspection Report dated 31 March 2013, no seepage or drainage flows were evident.



Leakage is assessed visually and current observations are consistent with previous observations
[REDACTED]
[REDACTED]

As directed in the Inspection Report of March 2013, continued visual monitoring for any seepage issues is advised

6.2.5. Settlement and Movement



The matter of installation of settlement and movement monitoring points has been reviewed for this inspection. In Richard Doake's inspection report, a direction was made to *"install settlement and movement monitoring points on the overflow region of the crest of the embankment and adjacent to the open channel as soon as possible after completion of all works"*. The locations selected serve to monitor the settlement of areas serving as overflows from the reservoir.



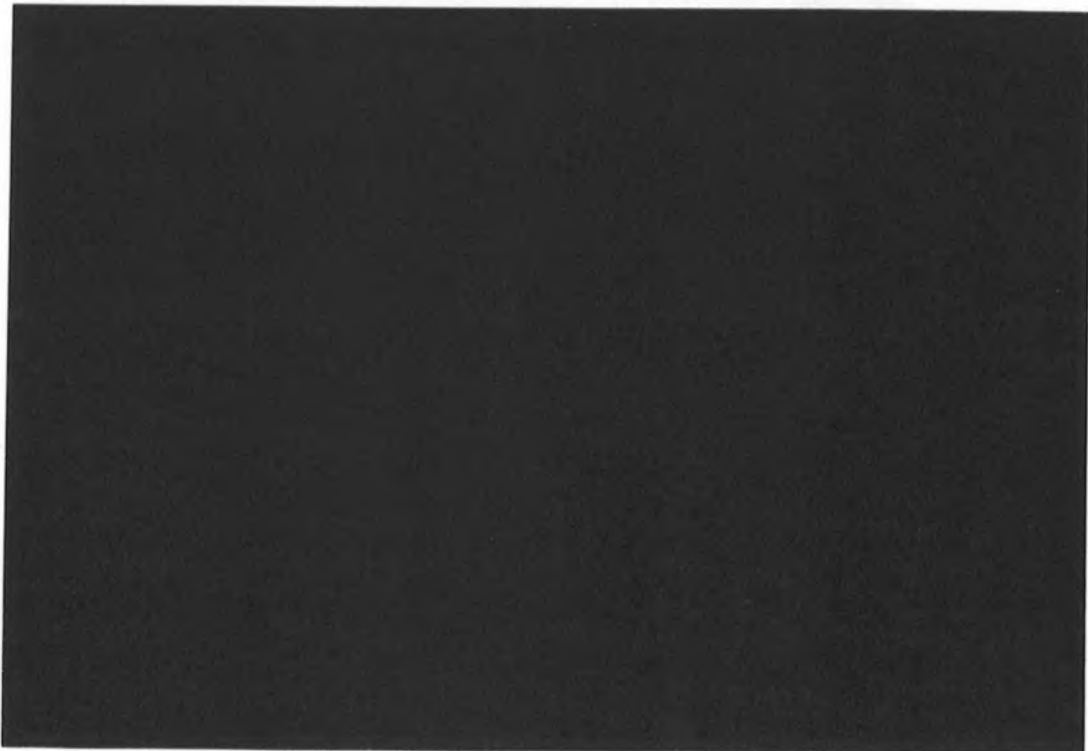
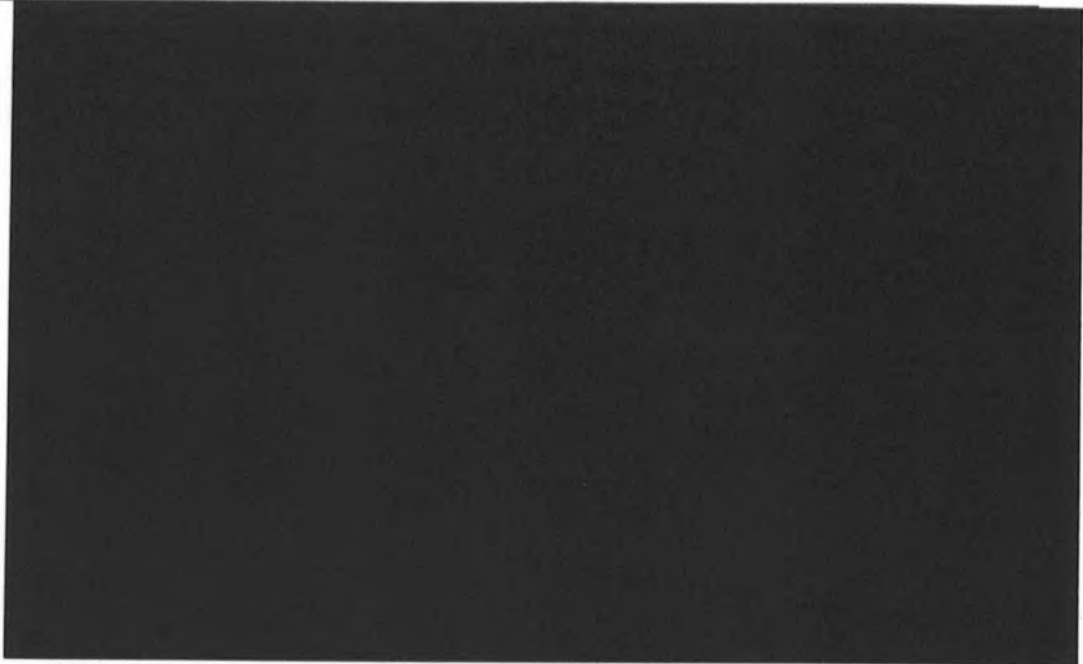
In my view, survey stations on the remainder of the embankment would need to be at very close spacing [redacted] and it is considered preferable to provide a limited number of survey stations for general level monitoring purposes after placement of restoration soils.



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[REDACTED]

[REDACTED]

In the Inspection Report dated 31 March 2013, [REDACTED] an agreement is apparently still in place with the local council that the reservoir should be used for flood detention during any heavy rain. [REDACTED]

[REDACTED] A recommendation was made that the Undertaker holds discussions with the local council, Highway Authority, Police and Environment Agency flood risk staff [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

6.2.9. Reservoir banks, basin, and any movement of surrounding land which might affect the stability of the reservoir

No evidence of movement of the surrounding land was observed which might affect the stability of the reservoir, [REDACTED]

[REDACTED]

The stability of parts of the slopes of the landfill forming the reservoir basin is addressed below under 6.2.16 *Seismic Risk and Stability*.

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

6.2.12. Catchments and Controls on Inflow

In the Inspection Report dated 31 March 2010, the catchment area is stated as being 2.16 sq.km.

[REDACTED]

6.2.13. Monitoring

A gauge board is installed on the headwall of the culvert under Alvechurch Highway with the base at the invert of the culvert. Water levels have been recorded based on this as a local zero datum level.



Gauge board on bridge under Alvechurch Highway

Two piezometers (L3 and L4A) have been installed in the embankment crest region to monitor groundwater levels. Groundwater monitoring boreholes BH 3, 4 and 6 are located at the southern end of the site, and two leachate monitoring boreholes L8 and L9 are located at the southern end of the site.

Provisions for monitoring are currently adequate except that a data logger shall be installed in piezometer L4A to record leachate levels daily as advised in the stability assessment report, and survey monitoring points should be provided on completion of the restoration soils.

6.2.14. Adequacy of the overflow and spillway



[REDACTED]

[REDACTED]

[REDACTED]

Flood assessment

The March 2013 inspection report noted that [REDACTED] the finished embankment levels differed from those adopted in the previous flood assessment, and that survey had not been made of the basin upstream of the road to provide information on the corresponding reservoir storage. A recommendation was made to take this into account in a revised flood assessment and routing. The relevant information is now available to enable a revised assessment to be made. The previous assessment found that a 10,000 year flood would produce a flood rise of 5.39 m (below the upper overflow level) and a PMF flood would produce a flood rise to overtop the smaller reservoir basin considered at that time. The increased temporary reservoir storage provided by the current arrangement will increase attenuation and avoid flow over the embankment. This is to be taken into account in the review of the final design [REDACTED]

[REDACTED] A recommendation in this respect is made under 6.4 Recommendations in the interests of safety.

Freeboard

The freeboard at the embankment dam has been increased from that provided at the time of the previous flood assessment as stated above, and is adequate.

[REDACTED]

[REDACTED]

6.2.16. Seismic Risk and Stability

The seismic risk is unchanged from assessments made in previous inspection reports, [REDACTED]

Stability

The March 2013 Inspection report by Peter Kelham referred to and generally concurred with findings of the Inspecting Engineer (D Morris) in the 2007 Inspection Report, that referred to the findings of the Gibb Report of May 1993, as follows:

[REDACTED]

[REDACTED]

Peter Kelham in his March 2013 Inspection Report generally concurred with this assessment, and stated that *"although the leachate situation appears to be stable, the effect of completing the relatively small amount of outstanding earthworks and landscaping should secure the situation. Since the above was written, the site has been capped using clay."*

[REDACTED]

It would be prudent to finish off the earthworks by providing a topsoil layer and seeding with the aim of providing a good grass sward."

[REDACTED]

These recommendations were that the relevant areas should be covered with 300mm of restoration soils and seeded to provide a good grass sward. The relevant areas were the upstream face of the embankment around the reservoir and the crest; the part of the site that forms the direct catchment to the reservoir; and the remainder of the site not already restored.

I concur with this recommendation to complete the restoration soils,

[REDACTED]

The Draft Specification given in the report *Restoration of Marlbrook Landfill: Planning Statement* prepared by Aecom in May 2014 refers to a 300 mm layer of restoration soils, and this should be regarded as a minimum depth to achieve the objectives. A "Specification for Earthworks, Compound Clearance, Drainage and Landscaping, prepared for Bromsgrove DC by Halcrow, June 2013, shows sections

[REDACTED]

Peter Kelham in his March 2013 Inspection Report also made a recommendation to *"have a geotechnical analysis carried out on the western embankment"*

[REDACTED]

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Reference is made to the Report *Marlbrook Landfill – Slope Stability Assessment*, by Aecom Ltd dated 2 March 2012, prepared following a suggestion by Bromsgrove District Council that the restored material on the southern edge of the site to the rear of properties off Ashgrove Close were steeper than those shown on the restoration contours in the planning consent. That report provides a slope stability risk assessment of the completed restoration profile of the landfill site, and addresses the issue raised in the safety recommendation. The report identifies the most critical slope sections on the south and west parts of the embankment selected on the combined basis of height and gradient. The geotechnical parameters include groundwater based on the maximum recorded levels, with a pore pressure ratio (r_u) incorporated to 1.5m below ground in the restoration to allow for wetting up of shallow soils during rainfall events.

Stability under and following flood events is also a consideration. Floods will cause temporary impoundment [REDACTED]. Flood assessment and routing carried out [REDACTED] has established that the flood rise would be significant for extreme floods approaching the PMF design flood. [REDACTED]

[REDACTED] This is likely to result in limited infiltration into the body of the landfill, [REDACTED]

[REDACTED] A maximum slope of 1 Vertical in 4 Horizontal has been directed in original designs for the embankment prepared by Aecom, and is referred to and affirmed in Peter Kelham's Inspection Report. Therefore a recommendation in the interests of safety is made to re-grade the upstream slopes forming the shores of the reservoir pool to the specified maximum slope of 1 Vertical in 4 Horizontal. [REDACTED]



A direction was made in the Inspection Report dated 31 March 2013 as follows: *Until the works covering the site are completed I recommend that the monitoring of the water levels in the piezometers should be undertaken at two monthly intervals to monitor the leachate levels*

Additionally a data logger shall be installed in piezometer L4A to record leachate levels daily.

This Direction is affirmed in this Report.

6.2.17. Supervision Provided by the Owner/Undertaker

The Supervising Engineer was Mr David Crook of Ove Arup, until my appointment as Construction Engineer following the Notice from the Environment Agency dated 22 September 2014. The duties of Construction Engineer include supervision of the site, that is carried out by Aecom staff as required, together with the Undertaker's staff who carry out routine surveillance visits.

6.2.18. Correctness of Particulars in the Form of Record

The Prescribed form of record is kept by the Undertakers. It requires updating in a number of respects, to be advised separately in the process of certification. Results of monitoring are kept up to date.

6.3. Water level

6.3.1. Any alterations to overflow sill

[REDACTED]

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6.3.2. Any alteration in level to which the water may be stored

[REDACTED]

The upper overflow level is estimated to be 210.6mAOD approx, which gives a maximum potential depth of about 10m during a severe storm event and an estimated maximum capacity of the reservoir estimated provisionally as approximately 66,000 m³.

[REDACTED]

SUMMARY OF FINDINGS

- (1) The surfaces of the landfill embankment forming the dam are unfinished. [REDACTED]
- (2) Surface drainage arrangements are generally satisfactory [REDACTED]
- (4) Settlement of the embankment surface is to be expected from normal consolidation of the landfill. [REDACTED]
- (8) No evidence of movement of the surrounding land was observed which might affect the stability of the reservoir. [REDACTED]
- (10) Provisions for monitoring are currently adequate except that a data logger is required in piezometer L4A to record leachate levels daily as advised in the stability assessment report, and survey monitoring points should be provided on completion of the restoration soils.
- (11) The performance of the overflow and outlet arrangements [REDACTED] is satisfactory [REDACTED]. The freeboard at the embankment dam has been increased from that provided at the time of the previous flood assessment, and is adequate. [REDACTED]
- (13) Previous reports recommended completion of the restoration soils, and this is affirmed [REDACTED]

_____ The Draft Specification prepared by Aecom in May 2014 refers to a 300 mm layer of restoration soils, _____

- (15) The Prescribed form of record is kept by the Undertakers. It requires updating in a number of respects, to be advised separately in the process of certification. Results of monitoring are kept up to date.

6.4. Recommendations in the Interests of Safety

- (1) Re-grade the upstream slopes of the embankment around the shores of the reservoir pool to the specified maximum slope of 1 Vertical in 4 Horizontal.
- (2) Complete restoration soils over the upstream slopes of the embankment around the shores of the reservoir area to a minimum 300mm depth and include a growth medium to establish suitable grass cover.
- (3) Re-profile the erosion channels on the left shore of the reservoir pool and extend the restoration soil layer specified to the areas draining from the site to the channels and the reservoir shores, in conjunction with re-profiling of the steep parts of the upstream face.
- (4) Complete the restoration soils over the unrestored areas of the site to a minimum 300mm depth and include a growth medium to establish suitable grass cover _____

- (6) Provide a data logger in piezometer L4A to record water/leachate levels as advised in the stability assessment report and directed below, and provide survey monitoring points on completion of the restoration soils.

- (9) Repair the polymer lining of the drainage channels where disrupted, or replace it with a suitable alternative, _____

- (10) Modify the flood studies to take account of the altered impounding height and related surface area and volume. _____

The period specified for completion of the recommendations is within one year of the date of this report. To avoid risk of delay the work should commence within a fortnight of the date of this report.

6.5. Other matters

6.5.1. Advisory measures

- (1) To be determined by the Construction Engineer in developing detailed design of the main work items.

6.5.2. Directions for Monitoring Supervision under the supervision of the Construction Engineer

Monitoring should be carried out and included in the Record as follows:

Item	Frequency of recording
Part 1	
Water level in the reservoir	Not less than weekly
Part 2	
[REDACTED]	[REDACTED]
Settlement or movement of the walls and embankment	By visual surveillance, pending installation of permanent markers following completion of the restoration soils
Pore water pressures in the embankment fill	Not less than Daily for Piezometer 4A, and the remainder as directed by the Construction Engineer in consultation with geotechnical advisors. To be recorded in a table and plotted as <ul style="list-style-type: none"> • Time series plot with rainfall and reservoir water level • Pore water pressure vs reservoir level
Repairs	On completion
Rainfall, from rain gauge to be provided or from Met Office or other suitable local data	Weekly

7. Scope of Statutory Inspection

The Inspecting Engineer has formed a general opinion of the overall condition of the reservoir. In accordance with normal practice on inspection under the Act he has not assessed in detail such matters as the overall stability of the structure, the conditions of the foundations, the forces on the foundations, the internal condition of the structural elements of the dam and the condition of buried or inaccessible elements of the works. This is distinct from giving due consideration, in his role as Construction Engineer, to all relevant design matters as far as can be ascertained for a structure already built and having regard to existing studies and information available. His opinion is based on his observations on his site visits, the examination of the information provided to the Construction Engineer listed in Appendix A1, and discussions with Liberty Construction Ltd.

This report is not an assurance or guarantee of reservoir safety in the future.

Signature: 

Robert J Mann, Construction Engineer under Section 8 of the Act

Date: 27 Jan 2015

APPENDIX A DESIGN AND CONSTRUCTION INFORMATION

A1 Information provided to the Construction Engineer

1. Reservoirs Act Reports and Certificates:-

- 6 March 2013 under Section 10 of Reservoirs Act 1975 – P Kelham
- Certificate 10(5) dated 6 March 2013
- 25 February 2008 under Section 10 of Reservoirs Act 1975 – R M Doake
- Certificate 10(5) dated 25 February 2008
- January 2007 under Section 10 of Reservoirs Act 1975 – D Morris
- Certificate 10(5) dated 11 February 2007
- March 2005 under Section 10 of Reservoirs Act 1975 – D Morris
- Certificate 10(5) dated 30 March 2005
- December 2003 under Section 10 of Reservoirs Act 1975 – D Morris
- Certificate 10(5) dated 5 December 2003
- May 2003 under Section 10 of Reservoirs Act 1975 – D N W Earp Esq.
- Certificate 10(5) dated 15 May 2003
- September 2002 under Section 10 of Reservoirs Act 1975 – D N W Earp Esq.
- Certificate 10(5) dated 30 September 2002
- May 2002 under Section 10 of Reservoirs Act 1975 – D N W Earp Esq.
- Certificate 10(5) dated 26 March 2002

2. Monitoring Records

Prescribed Form of Record

Piezometer readings

Water levels recorded on occasional visits.

3. Supervising Engineer's statements

Most years from 2000

4. Other Records

- Correspondence from the Engineer's records relating to the flood studies for the reservoir, and works carried out to the outlet culvert.
- Restoration of Marlbrook Landfill: Planning Statement, Final Draft, Aecom, May 2014
- Bromsgrove DC, Specification for Earthworks, Compound Clearance, Drainage and Landscaping, Halcrow, June 2013
- Worcestershire Wildlife Consultancy – Ponds at Marlbrook Tip, Great Crested Newt Habitat Suitability Assessment and Badger Assessment, August 2013
- Marlbrook landfill – Slope Stability Assessment, Aecom, 2 Mar 2012
- An Assessment Of The Impacts On Leachate And Landfill Gas Of The Proposed Restoration To A Golf Course Of The Former Marlbrook Landfill – FaberMaunsell February 2003.
- Marlbrook Landfill – landfill condition – FaberMaunsell April 2003.

- Proposal for Nine Hole Golf Course, Marlbrook Tip, Bromsgrove – Landscape and Visual Assessment, A.L.S Landscape Architecture – in Association with Chesterton on behalf of Link Property Development Ltd., February 2003 (extracts of layouts only).
- Marlbrook Landfill Development, Catchment Study, Halcrow, January 2000. (Not seen)
- Marlbrook Quarry, Gibb Environmental, May 1993 (extract of layout only).

5. Drawings and Documents

Drawing No	Description	Date
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
Sheets 1 & 2 of 2	North Plan View (surveyed 6 & 7 June 13)	June 13

