Stephen Buss Environmental Consulting

David Fowler
Principal Planner
London Borough of Camden

19 August 2016

29 New End, London NW3 1JD

Dear David

I am writing in response to the basement impact assessment audit recently completed by CampbellReith, to provide clarification of points that are made in the hydrogeology and hydrology section of the BIA for 29 New End, London NW3 1JD.

I would also like to present a significant body of new data collected since the BIA was written. To reduce the uncertainties that were identified in the BIA the applicant has collected a much longer time series of data; the older boreholes BH1, BH2 and BHA have been found and dipped; a new multi-level borehole, BH105, has been constructed in the car park of the Duke of Hamilton pub; and a constant head test was undertaken on BH102 to better understand the potential for using a soakaway in the deep aquifer.

For ease of review I have structured this letter in the as with the audit query tracker in Appendix 2 of the CampbellReith audit.

Query No 3: Clarification of items 4.8 to 4.12 and details of modelling software and parameters.

I assume that referring to 4.8 is a typo as points 4.8 and 4.9 are not related to hydrogeology.

Item 4.10 raises a question about the representativeness of data from borehole BH103, when making conclusions about the upper aquifer. I feel that evidence from BH103 is not the only indication of a shallow water table at c. 113 to 114 m AOD. This is especially the case now, given the new data, and I have listed my evidence below; more recent monitoring data is presented in Table 1 of this letter.

- BH103 comprises a short (2 m length) standpipe between 110.5 and 108.5 m AOD. The standpipe is open across a sand unit from which there was the first water strike during drilling at 109.9 m AOD. Rest water level is at c. 114.3 to 114.4 m AOD.
- BH102 struck water at 113.15 m AOD, near the base of a sand unit, and the water rose to 113.55 m AOD after 20 minutes; however, this inflow was cased and sealed out of the borehole and there is no further record. It is not unreasonable to expect this to be representative of a water table at 113.55 m AOD or a little higher.

- BHA has now been monitored simultaneously with the other boreholes and the rest level is c. 114.2 m AOD to 114.6 m AOD.
- BH2 has also now been monitored simultaneously with the other borehole and the rest level is c. 113.5 m AOD.

Based on these new levels, the hydraulic gradient is actually lower than anticipated in my previous report. I had assumed that the BH103 to BH2 gradient was 0.037, whereas in August 2016 it was 0.031. The consequences of this are: 1) the assumption in my model is too conservative, so any groundwater level rise will be less than predicted, and 2) baseflow beneath the building is less than anticipated.

A useful point to note at this stage is that an engineer on site spoke to the landlord of the Duke of Hamilton pub who had recently discovered that the water ingress to his cellar is related to surface water, not shallow groundwater.

This is reinforced by the findings of monitoring in the shallow borehole BH105, which was specifically constructed in July 2016 to monitor any groundwater that might be at or near the cellar floor. Site engineers surveyed the cellar floor at c. 113.78 m AOD, and the base of the shallow borehole BH105 is 112.25 m AOD. The shallow borehole has, so far, been consistently dry. Also no sandy horizons were identified in the borehole to 13 m depth (103.75 m AOD); the stratigraphy here is entirely clayey.

To summarise, I feel that evidence for a water table in the upper sand aquifer is now robust and it shows that the original estimate, used in scoping calculations and the model, was a little conservative. Therefore the conclusions of the BIA report may stand. The cellar has now been surveyed at an elevation 0.78 m above that which I had originally assumed, so the impact assessment becomes more conservative.

Item 4.11 requests 1) a discussion of how the basement will intercept the discharge through the upper aquifer, and 2) a review of the potential impacts of the proposed soakaway discharge to the deep aquifer.

Intercepting discharge

It is noted in the audit that the excavation will cut off a significant amount of flow in the upper aquifer. The estimate of flow in the upper aquifer in the audit, 7.3 m^3/day, is correct and I apologise for the typo in the BIA report. I have looked back at the MODFLOW model results and this gives a corresponding flow beneath the site of 6.6 m^3/day so this is in good agreement with the (amended) scoping calculation.

Hence the question in the audit about the interception of flows, and redirection around the basement, is answered in part by the model. The model results shown in Figure 5.4 in the BIA indicate the effect of introducing the basement to heads. If the groundwater level were to reach ground surface it would be to the east and south east where the ground surface is lowest. Groundwater levels are expected to rise by 0.5 m at BH102 and 0.4 m at BH2. But the unsaturated zones at these boreholes are 5 m or more in thickness. Moving further from the basement, where the groundwater level may reach ground surface (Environment Agency LIDAR data is not available for this area so I cannot tell exactly where this), the change in groundwater level becomes less than 0.2 m. I suggest that there are likely to be no locations in the vicinity where the local water table is within 0.2 m of ground level, due to drainage from subsurface infrastructure.

Clearly the model does not represent all of the complexity of the geometry of the water table and the topography here. But the key point I would like to emphasise is that the model shows heads rising most where there is a thick unsaturated zone close to the basement. Further away, I suggest that the rise in levels is minor and likely to be ameliorated by near-surface high permeability drainage along pipe trenches etc.

Soakaway design

Despite including the modelling results for this scenario in the BIA, we are not proposing to construct a soakaway in the shallow aquifer, just the deep aquifer. The actual SUDS design was not finalised when the BIA was written.

In March 2016, a constant head test was undertaken on BH102 to assess whether the deep aquifer was likely to be able to accept sufficient water to make it useful for a soakaway discharge. BH102 was chosen for this test because: where it intercepts the lower aquifer, the aquifer is more sandy than silty; it is better to discharge water in the back garden to get a higher head on the soakaway; and it is relatively far from the pavement vaults at 10, 12 and 14 New End.

In this test a constant flow rate of 0.25 l/s, when applied to BH102, maintained a constant head at close to ground level. Test data collected is shown in Figure 1. No other groundwater levels were monitored.

A radial flow model, using the Theis equation, of the rise in groundwater level ('draw-up') has been developed for the deep aquifer (Figure 2). It has been calibrated to match the result of the constant head test, cited above, and the following parameters are suggested: transmissivity of 2.6 m^2/day for a storage coefficient of 10^{-5}. The model is intended only to demonstrate a rough fit, as there are more complexities in this situation than described in the simple Theis equation: one key observation is that the draw-up very quickly stabilised; so in the aquifer there must have been a discharge boundary condition (perhaps into road drainage, granular fill in pipe trenches, or downwards into a lower aquifer).

This model can be used to estimate the rise of groundwater level at 69 m from the discharge – which is the distance from BH102 to the pavement outside 10, 12 and 14 New End. After 110 minutes (the duration of the test) the modelled rise is expected to have been 1.5 m. After 12.75 hours (the longest duration of the 100 year storm that would lead to a discharge of 0.25 l/s) the modelled rise is 2.7 m. (This is expected to be an upper estimate as the head in the soakaway will have been stable for all that time, rather than rising as predicted by the model.)

I estimate that the floors of the pavement vaults are at 108.4 m AOD. BH101 is closest to the pavement vaults, with an average rest water level of 107.25 m AOD. The hydraulic gradient in the lower aquifer, from BH102 to BH101, was 0.032 before March 2016. If this gradient is extrapolated linearly to the pavement vaults, at 32 m from BH101, then the level at the pavement vaults is expected to be 106.2 m AOD, about 2.2 m below the floors. Seasonal variation is small in this aquifer, with an average range of c. 0.23 m. It seems reasonable, therefore, to assume that under present conditions the groundwater level will never be less than 2.1 m below the pavement vaults.

The borehole log of BH101 indicates that the top of the lower aquifer layer is at 105.1 m AOD. Above this is a silty clay. This is broadly the same geology and levels as in BH102 (see Figure 4.3 of the original BIA), which suggests that the stratigraphy is level here. Strata may camber but assuming that the stratigraphy is level is conservative. Therefore the pavement vaults are separated from the lower aquifer by a little more than 3 m of silty clay.

So during the 100 year storm, 12.75 hours of discharge at 0.25 l/s appears likely to lead to the groundwater level beneath the pavement vaults rising to c. 0.6 m above the level of the bases of the vaults. But the aquifer (in which that head change has occurred) and the pavement vaults are separated by 3 m of silty clay. Therefore whilst the water pressure may be rising below the vaults, the actual upward flow of water is likely to be very low and would need to saturate the porosity of the unsaturated zone before it reaches the base of the vaults.

Item 4.12 refers to the risk of infiltration to the upper aquifer causing break-out of water at the ground surface.

I agree that this is a risk and this is the main reason we do not propose to discharge any rainwater to the upper aquifer. The lower aquifer, where rainwater is intended to be discharged, seems to be more persistent in logs.

Also I note that the hydraulic gradient under current conditions is about 0.03 – indicating that the groundwater in that aquifer is flowing. Hence I do not expect the discharged water to linger close to the site, so the risk assessment described above applies.

A review of the modelling software and parameters is requested, partly in response to a perceived difference in estimated baseflow beneath the site.

The audit identified a typo in the BIA and I have dealt with the new value for baseflow above. Hopefully the text above provides enough description but I would be pleased to provide the model, or discuss specific points further, if required.

Query No 4: Installation details for BHA and BH2.

Construction details for BHA, BH1 and BH2 are contained in a 2010 site investigation by MRH Geotechnical, and I am not at liberty to provide it to you as it was not produced for the current applicant. However, I can summarise the findings:

- BH1 was drilled using the shell and auger technique in July 2010. Ground level is 115.8 m AOD, and a piezometer was installed at the base of a sand layer at 8.8 m depth (107.0 m AOD).
- BH2 was constructed using shell and auger in July 2010. Ground level is 119.1 m AOD, and a piezometer was installed in a thick silty sand layer at 8.8 m depth (110.3 m AOD).
- BHA was constructed using a mechanical auger in January 2011. Ground level is 119.8 m AOD, and a piezometer was installed in a thick silty sand layer at 8.8 m depth (111.0 m AOD).

Query No 5: Details of longevity of piezometer installation and its distribution. Construction details of French Drain.

The principal behind the proposed dewatering system was that the very top of the water column, if groundwater levels rise behind the basement, is skimmed off and piped to a location downgradient of the basement. In this way we would aim to protect neighbouring basements without disturbing groundwater levels more than necessary. Now that we have investigated the groundwater situation and the level of risk at the Duke of Hamilton Pub further it is clear that this is a redundant system, as neighbouring basements appear to not be at risk from rising groundwater levels. Hence we propose to not include this in the final design.

Query No 6: Clarification of infiltration SUDS methodology.

There is more detail on the SUDS methodology in the SUDS report that was submitted to the Council with the BIA (though the BIA was written first). The appropriate section is as follows:

7.0 SUDS HIERARCHY – DISCHARGE TO THE GROUND

Infiltration testing within boreholes indicated the site was marginal for construction of conventional shallow soakaways. Furthermore, numerical analysis was undertaken (Stephen Buss Environmental, Appendix B) which indicated that such a soakaway could present a low risk of groundwater flooding to the cellar of the Duke of Hamilton public house approximately 50 m to the west of the site. The landlord of the public house reports that incidents of water ingress do occur pre-development at the existing cellar, and have done for some time. No formal records of these incidents are available.

A further stage of infiltration testing was implemented in March 2016 to establish the suitability of deep strata for acceptance of surface water discharge to the ground. This has been found viable at a rate of circa 0.3 litre/sec (26 cum/day). It is therefore proposed to provide adequate in-line tanked attenuation to accommodate a 1:100 year rainfall event, plus 30% climate change allowance, so as to enable discharge of surface water to the deep strata by a borehole soakaway sited to the north of the new building.

In event of surcharge of the borehole soakaway and attenuation a drain will divert any excess flow in accordance with the SUDS hierarchy.

I trust that this letter provides enough detail for you to be able to move the application forward. Please do contact me if you need any further details.

Yours sincerely

Dr Stephen Buss

Hydrogeologist / Owner

THE GEOLOGICAL SOCIETY CGeol CHARTERED GEOLOGIST Fellow No. 10004065

Table 1. Groundwater level measurements from 2016

	Depth to water level in borehole (m)										
	03/02/2016	25/02/2016	11/03/2016	23/03/2016	29/04/2016	13/05/2016	27/05/2016	09/06/2016	30/06/2016	26/07/2016	03/08/2016
BHA	-	-	-	-	-	-	-	5.63	5.60	5.22	5.50
BH1	-	7.40	7.40	7.41	-	-	7.40	7.30	7.30	-	7.33
BH2	-	-	-	-	-	-	-	-	5.60	5.57	5.60
BH101	-	-	-	8.57	8.37	8.46	8.70	8.50	8.30	8.30	8.40
BH102	11.76	11.74	12.17	11.85	9.34	-	9.33	9.32	9.15	9.23	9.20
BH103	6.15	6.15	6.14	6.15	6.07	6.15	6.15	6.13	6.10	6.02	6.10
BH104	8.65	8.66	8.65	8.67	8.55	8.65	8.60	8.63	8.50	8.60	8.63
BH105 (deep)	-	-	-	-	-	-	-	-	-	7.40	7.10
BH105 (shallow)	-	-	-	-	-	-	-	-	-	dry	dry

		Elevation of water level in borehole (m AOD)										
	Datum	03/02/2016	25/02/2016	11/03/2016	23/03/2016	29/04/2016	13/05/2016	27/05/2016	09/06/2016	30/06/2016	26/07/2016	03/08/2016
BHA	119.80	-	-	-	-	-	-	-	114.17	114.20	114.58	114.30
BH1	115.80	-	108.40	108.40	108.39	-	-	108.40	108.50	108.50	-	108.47
BH2	119.10	-	-	-	-	-	-	-	-	113.50	113.53	113.50
BH101	115.70	-	-	-	107.13	107.33	107.24	107.00	107.20	107.40	107.40	107.30
BH102	120.35	108.59	108.61	108.18	108.50	111.01	-	111.02	111.03	111.20	111.12	111.15
BH103	120.50	114.35	114.35	114.36	114.35	114.43	114.35	114.35	114.37	114.40	114.48	114.40
BH104	117.10	108.45	108.44	108.45	108.43	108.55	108.45	108.50	108.47	108.60	108.50	108.47
BH105 (deep)	116.75	-	-	-	-	-	-	-	-	-	109.35	109.65
BH105 (shallow)	116.75	-	-	-	-	-	-	-	-	-	dry	dry

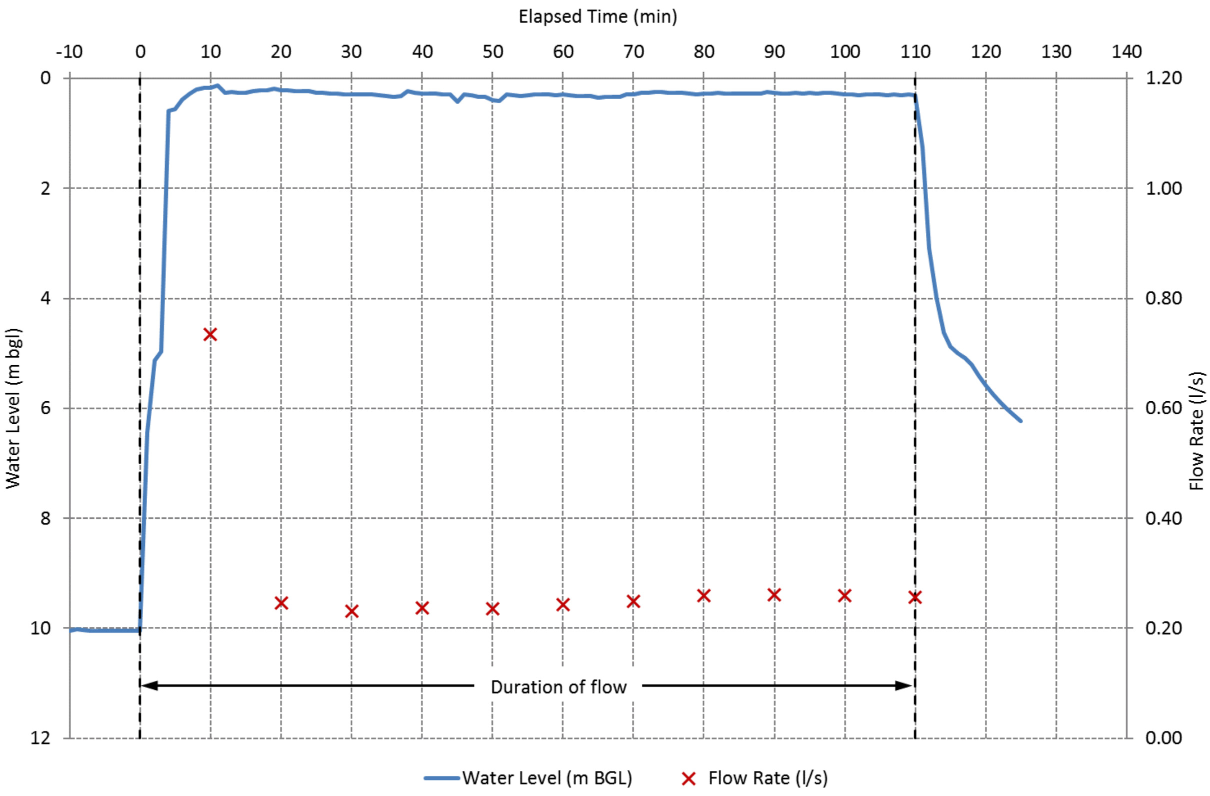

Figure 1 Constant head test results

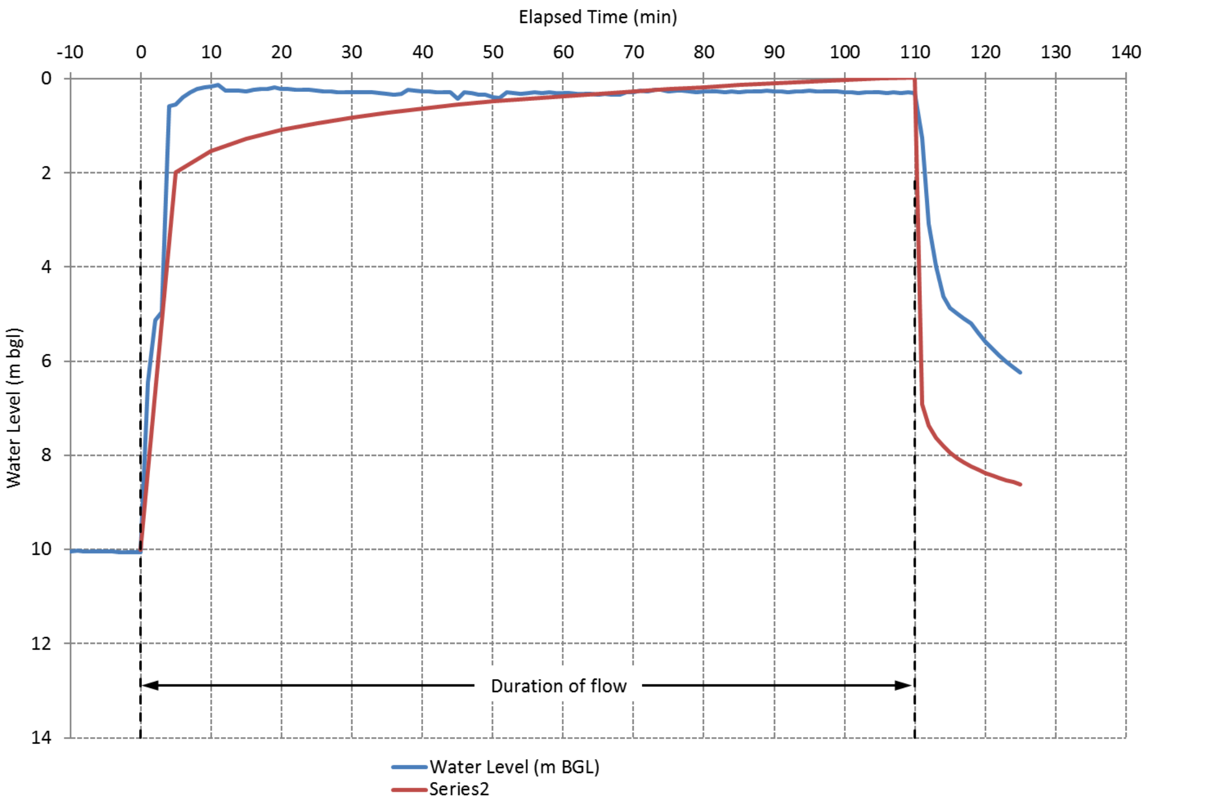

Figure 2 Modelled constant head test results