Appendix 8.1 Water Quality Assessment

Hampstead Heath Ponds Project

Water Quality Baseline Assessment

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Table of contents

List of Tables

List of Figures

Glossary of terms

BOD	Biochemical Oxygen Demand
cfu	colony forming units
CoL	City of London
DO	Dissolved Oxygen
EA	Environment Agency
EIA	Environmental Impact Assessment
EQS	Environmental Quality Standard
GIS	Geographic Information System
µg/l	Micrograms per litre
Mg/l	Milligrams per litre
UCL	University College London
UKAS	UK Accreditation Service
WFD	Water Framework Directive
WQ	Water Quality

Executive Summary

The Hampstead Heath Ponds Project has, as one of its objectives, a requirement to improve water quality (WQ) across the Hampstead and Highgate chains of ponds. In order to provide evidence of this following the future construction and WQ enhancement works on the Heath, a set of baseline conditions must first be derived for each pond. This report outlines the current status of the WQ for the Hampstead and Highgate chains of ponds, thereby forming the WQ baseline.

Following a review of existing WQ data for the Hampstead and Highgate Ponds it was considered appropriate that a full suite of water quality monitoring be undertaken on all ponds to provide: a robust platform for pond/water quality enhancement; inform the potential Environmental Impact Assessment (EIA) process; determine any further future monitoring, and; inform the detailed design process in 2013/2014.

WQ monitoring was subsequently conducted on three occasions between July and September 2013 with samples analysed by an independent Environment Agency (EA) accredited laboratory.

The full WQ dataset was initially screened against Environmental Quality Standards (EQS) in order to highlight the key determinands showing non-compliance. In this respect, Dissolved Oxygen (DO), ammonia and phosphorous were considered to be the key determinands driving WQ issues within the ponds.

Low DO levels were widespread across the ponds, most likely as a result of nutrient enrichment causing increased algal activity and subsequent decomposition of material, a process which removes oxygen from the water.

Ammonia levels were only above EQS levels on the Hampstead chain, with elevated concentrations most likely caused by decomposing material within the ponds.

Phosphorous levels are considered to be excessively high, with many ponds recording levels 10 times greater than the EQS, affecting WQ within the ponds. Under low DO conditions, more phosphorous can enter the water column from the bed sediment, exacerbating problems.

Importantly, the WQ within the three designated EU Bathing Waters (Mixed, Ladies' and Men's Ponds) showed compliance with the EQS.

In order to address long term water quality issues, the ponds should preferably be aerated to increase DO levels (particularly during the summer) with some consideration given to the option of dredging the large volumes of decaying leaf litter and silt from the highest priority ponds. This will help alleviate eutrophication problems and will reduce algal blooms, particularly toxic blue-green algal blooms.

Some consideration should be given towards investigating the potential sources and pathways of nutrients (such as from dog waste and leaf litter), in order to help reduce the amount of phosphorous entering the ponds.

The WQ of the Heath's ponds should be carefully monitored throughout any construction phase in order to help prevent deterioration, resolve any arising WQ issues, and ensure that bathing waters remain open.

The information from this baseline assessment should be used in the EIA and detailed design process in order to determine the best WQ solutions for the ponds.

1. Introduction

Background

1.1 The Hampstead Heath Ponds Project has as one of its objectives, to improve water quality (WQ) across the Hampstead and Highgate chains of ponds. In order to provide evidence of this following the future construction and WQ enhancement works on the Heath, a set of baseline conditions must first be derived for each pond. This report outlines the current status of the WQ for the Hampstead and Highgate chain of ponds, thereby forming the WQ baseline. It is envisaged that the data from this assessment will provide further information to aid deriving a preferred WQ improvement option for each pond and will feed in to an Environmental Impact Assessment (EIA) covering the proposed works and their future operation.

Historical data

1.2 Atkins undertook a review of existing WQ data for the Hampstead and Highgate Pond chains in order to determine its suitability for use in informing options for pond/water quality enhancement, potential environmental impact assessment and the detailed design process in 2013/2014.

1.3 This review included data sources obtained from:

- Existing reports and data sheets provided by the City of London (CoL)
- Desktop searches using freely available web sources
- Consultation with University College London (UCL) who have previously undertaken sampling as part of Degree and Masters courses

1.4 A review of the above sources identified the existence of only a limited number of water quality reports and data sheets relating to a number of ponds within the two chains (as presented in Table 1 and Table 2 below). The only information of real value was the CoL Dissolved Oxygen (DO) data, which exists weekly during the summer months for all of the ponds from 2007. All other data was deemed too intermittent to be of satisfactory use.

Table 1 – Summary of Historic WQ data availability

Date	WQ Parameter				
	Bacteria	Dissolved Oxygen	Water temperature	Phosphorous	Algal information
1998	Limited	None	None	None	None
1999	Limited	None	None	None	None
2000	Limited	None	None	None	None
2001	Limited	None	None	None	None
2002	Limited	None	None	Limited	None
2003	Limited	None	None	Limited	None
2004	Limited	None	None	Limited	None
2005	Limited	None	None	None	None
2006	Limited	None	None	Limited	None
2007	Limited	Seasonal data	Seasonal data	Limited	Limited
2008	Limited	Seasonal data	Seasonal data	Limited	Limited
2009	Limited	Seasonal data	Seasonal data	None	Limited
2010	Limited	Seasonal data	Seasonal data	None	Limited
2011	Limited	Seasonal data	Seasonal data	Limited	Limited
2012	Limited	Seasonal data	Seasonal data	None	Limited

Table 2 – Description of Historic WQ data

Parameter	Description
Bacteria	CoL data is limited to Ladies pond only. Environment Agency (EA) Data available for EU Bathing Water compliance at Ladies', Men's and Mixed bathing ponds
Dissolved Oxygen	Predominantly spring and summer readings at most ponds, weekly during summer 2007-2012. Some winter readings. Measurements taken at depth in 2011
Water temperature	Predominantly spring and summer readings at most ponds, weekly during summer 2007-2012. Some winter readings. Measurements taken at depth in 2011
Phosphorous	2002-2004 annual spot samples at a few sites. 2006-2008 and 2011, annual spot samples at most sites
Algal information	Limited notes from specific ponds
Other WQ parameters	Some metals data from UCL, as well as secchi depth measurements from CoL

1.5 Following the review it was considered appropriate that a full suite of water quality monitoring be undertaken on all ponds within the Hampstead and Highgate Chains to provide: a robust platform for pond/water quality enhancement; inform the EIA process; determine further monitoring requirements moving forward, and; inform the detailed design process in 2013/2014.

Current Sampling

1.6 In order to provide a more comprehensive understanding of the current WQ conditions, water samples were taken from three different locations within each pond (see Figure 1) on three separate occasions between July and September 2013. The ponds that were sampled include:

- **Kenwood Ponds:** Wood Pond, Thousand Pound Pond
- **Highgate Chain:** Stock Pond, Ladies' Bathing Pond, Bird Sanctuary Pond, Model Boating Pond, Men's Bathing Pond, Highgate No. 1 Pond
- **Hampstead Chain:** Vale of Health Pond, Viaduct Pond, Mixed Bathing Pond, Hampstead No. 2 Pond, Hampstead No. 1 Pond
- **Additional sample locations:** inflow location to viaduct pond, catch pit, inflow to Ladies' Bathing Pond

1.7 All water samples were analysed by an Environment Agency (EA) UK Accreditation Service (UKAS) accredited laboratory for the following determinands:

- **General inorganics:** Alkalinity, Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), Electrical Conductivity, Hardness, pH, Suspended Solids
- **Nutrients:** Ammonia, Nitrate, Nitrite, Phosphate
- **Metals:** Arsenic, Cadmium, Calcium, Chromium, Copper, Iron, Lead, Magnesium, Mercury, Nickel, Phosphorus, Zinc
- **Microbiology:** *E. coli*, Intestinal enterococci

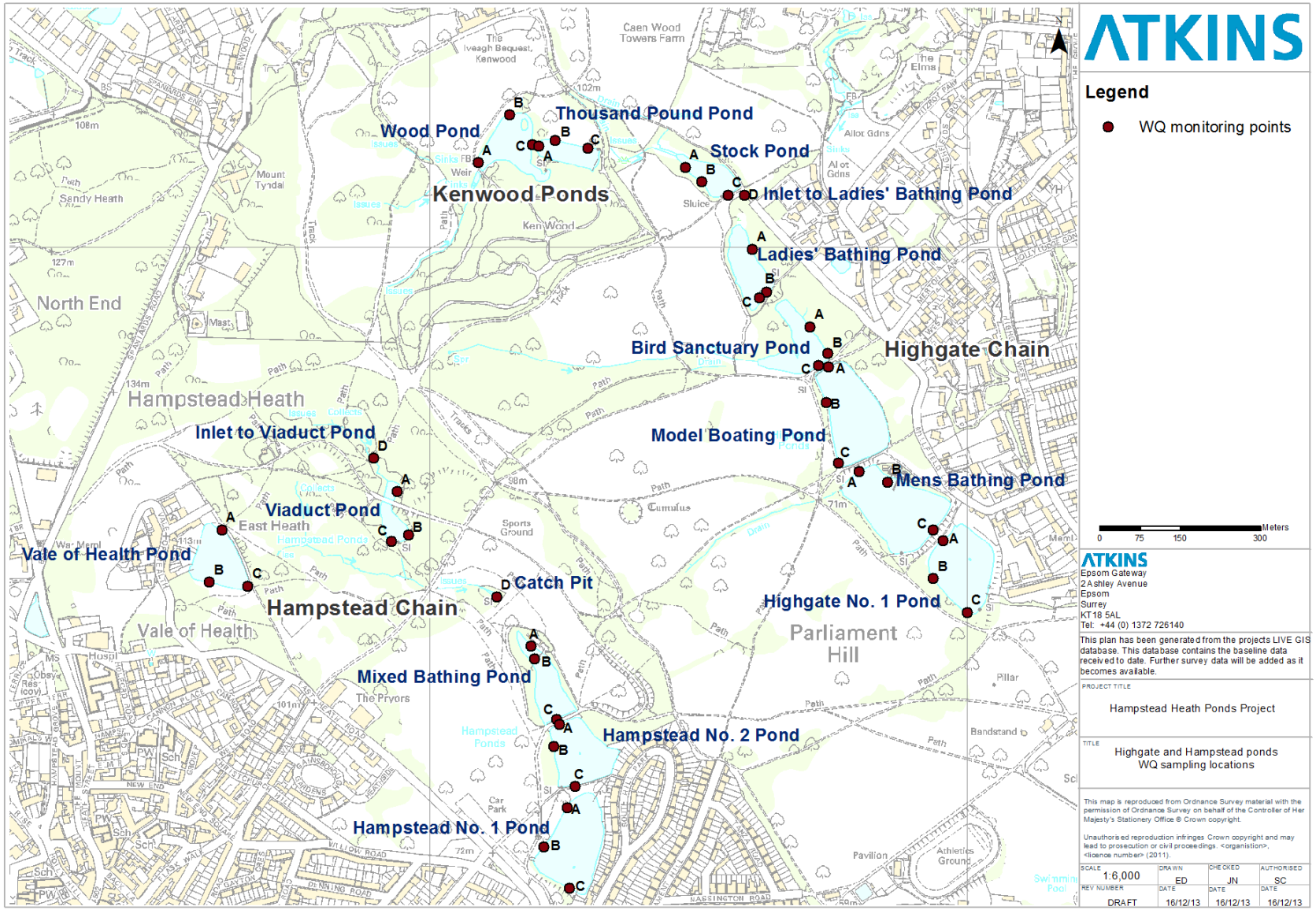

Figure 1 – WQ Monitoring locations

2. Pond descriptions

2.1 This section provides a brief description of each of the ponds in the context of water quality with information provided by Adrian Brooker, Assistant Ecologist, City of London (Personal communication, January 2013).

Kenwood Ponds

Wood Pond

2.2 This is one of the Kenwood Ponds owned by English Heritage and forms the top of the Highgate chain. It is significantly shaded around its perimeter by trees and a large amount of leaf litter is present within it. Iron levels are suspected to be elevated due to the presence of orange/red precipitates at the inflow in the south west corner of the pond.

Thousand Pound Pond

2.3 This pond is dominated by trees along most of its perimeter with a grassy bank on one side. There is a large amount of leaf litter present. This pond is popular for birds.

Highgate Chain

Stock Pond

2.4 This is a heavily shaded pond with significant tree cover around its perimeter. This gives rise to a large amount of leaf litter entering the pond. There is a large amount of sediment understood to be in Stock Pond. The pond is fed from the two Kenwood ponds upstream, which is believed to be iron rich, as orange/red precipitates are present in the water. There are some reed beds present within this pond. Blue green algae problems are experienced here.

Ladies Bathing Pond

2.5 This pond also has significant tree coverage, giving rise to leaf litter. The pond is fed from Stock Pond but also via a small stream entering to the north east end. This stream flows from private land through an allotment which has the potential to increase the nutrient load and bacterial load to the pond. It is understood that this pond also has a significant amount of sediment, particularly at the top end. Bacterial quality is usually worse than the Men's bathing pond. The pond experiences stagnation and splash mixers (small machines that suck up water and create turbulence) are in place to provide surface aeration. The water clarity is generally poor.

Bird Sanctuary Pond

2.6 This is one of the best ponds on the Heath for reed beds. Inflows to Bird Sanctuary come from the SW and NE corners. DO has historically been low and the pond experiences blue green algal problems.

Model Boating Pond

2.7 Model Boating Pond is a more open area with fewer trees surrounding its perimeter, with much less leaf litter input. It is one of the major fishing ponds containing carp which are bottom feeding fish that stir up the bed sediment. This is reflected in the poor clarity in this pond. There are a few stands of reed beds at the top end. The inflow to this pond is in the NW corner from the Bird Sanctuary. This pond experiences blue green algae problems during the summer months, particularly because it is not shaded and light can get to the pond surface.

Men's Bathing Pond

2.8 This pond is one of the deepest on the Heath and is understood to have less sediment than others. However, there are blue green algae problems during the summer and there are aerators installed at this pond, which bubble in air to the pond bed. The pond has some tree coverage surrounding its perimeter.

Highgate No. 1 Pond

2.9 This pond is one the best for aquatic plants and wading birds, with historically good DO. Water clarity is good. The notable presence of filamentous algae and other pondweed species in this pond prevents blue green algae problems.

Hampstead Chain

Vale of Health Pond

2.10 This pond is located at the top of the Hampstead chain and has a fair amount of leaf litter entering it. The pond is fed by underground inflows with a small stream entering the SW corner from a private house which has a potential greywater drainage misconnection as well as a guttering system with a direct connection to the stream. The level of sediment is less than other ponds. Clarity in this pond is good despite the fishing activity.

Viaduct Pond

2.11 Viaduct pond is heavily sedimented with very low water depth. There is a significant pond weed problem, which covers most of the top end of the pond. Historical DO problems and fish deaths have been recorded.

Catch Pit

2.12 This is a small engineered structure designed to capture sediment. In its current form there is only a small amount of stagnated water present.

Mixed Bathing Pond

2.13 Mixed Bathing Pond is fed from the Vale and the Catch pit upstream. It is heavily wooded and sedimented at the top end and the perimeter is heavily covered by trees, giving rise to significant leaf litter input. The pond is significantly shaded and has poor clarity.

Hampstead No. 2 Pond

2.14 This is one of the main fishing ponds on the Heath, with large carp stirring up bed sediment. The pond experiences blue green algae problems as well as significant quantities of duckweed and filamentous algae. There is also a significant amount of sediment present. Some stagnation of the water occurs during summer months.

Hampstead No. 1 Pond

2.15 This pond, which is the last in the Hampstead chain, is the best for supporting aquatic plants and birds. The pond has good clarity but experiences blue green algae issues and scumming (a frothy film on the water surface). There is a greater amount of marginal vegetation in this pond, potentially helping to improve WQ.

3. Results

3.1 The full WQ dataset was initially screened against river and lake Environmental Quality Standards (EQS) in order to highlight the key determinands showing non-compliance. It should be noted that EQS have been used for interpretative purposes only and cannot be applied implicitly (assessments are based on 12 month datasets). Where lake EQS are not available, river EQS have been used as a substitute.

3.2 Table and Table below provide summaries of the data for these determinands. The average concentration data has been presented in order to aid interpretation. The full WQ data set is available upon request in excel and GIS formats.

3.3 Of the key determinands, DO, ammonia and phosphorous recorded greater non-compliance across the ponds and are considered the main parameters potentially driving WQ issues on the Heath. The average data for these determinands has therefore been presented in Figures 2 and 3 for comparison and provides the focus of this results chapter.

3.4 **Dissolved Oxygen** – concentrations ranged from 4.0 mg/l (Mixed Bathing Pond) to 10.1 mg/l (Hampstead No. 2 Pond) on the Hampstead Chain and from 4.1 mg/l (Stock Pond) to 8.4 mg/l (Highgate No. 1 Pond) on the Highgate Chain. Non-compliance against the <6.0 mg/l EU Water Framework Directive (WFD) "Good status" EQS was recorded at Viaduct Pond, the Catch Pit and Mixed Bathing Pond on the Hampstead chain and at Stock Pond, Ladies' Bathing Pond, and Bird Sanctuary Pond on the Highgate Chain. These results are in line with the historic DO data, which recorded low concentrations (poor quality) in Stock Pond, Ladies' Bathing Pond, Bird Sanctuary Pond and Viaduct Pond, with high concentrations (good quality) recorded at Men's Bathing Pond, Highgate No. 1 Pond, Vale of Health Pond, and Hampstead No. 1 and No. 2 Ponds (Brooker, 2010). The widespread occurrence of low DO levels across the ponds is an issue which needs to be addressed.

3.5 **Ammonia** – concentrations ranged from 114 µg/l (Vale of Health Pond) to 5140 µg/l (Catch Pit) on the Hampstead Chain and from 8 µg/l (Thousand Pound Pond) to 391 µg/l (Men's Bathing Pond) on the Highgate Chain. Non-compliance with the 600 µg/l WFD "Good status" EQS was recorded at three ponds on the Hampstead Chain (Catch Pit, 5140 µg/l; Mixed Bathing Pond, 730 µg/l; and Hampstead No. 2 Pond, 755 µg/l), with full compliance recorded on the Highgate Chain. With the exception of Catch pit, ammonia levels are comparatively low across the Heath and are not of major concern.

3.6 **Phosphorous** – concentrations ranged from 61 µg/l (Vale of Health) to 1147 µg/l (Catch Pit) on the Hampstead Chain and from 14 µg/l (Thousand Pound) to 583 µg/l (Stock Pond) on the Highgate Chain, with only the Kenwood Ponds being compliant with the 49 µg/l WFD "Good status" EQS. Phosphorous concentrations are excessively high at almost all of the ponds, making them hypereutrophic in nature (excessive nutrients). The Vale of Health, Model Boating and Men's Bathing Ponds have comparatively much lower phosphorous concentrations, with Stock, Viaduct and the Catch Pit having the greatest phosphorous loads.

3.7 **Bathing water indicators** – the *E.coli* and intestinal enterococci data has been included to highlight full compliance with the revised EU Bathing Water "Good quality" EQS. Of the three designated bathing waters on the Heath, Mixed Bathing Pond recorded the lowest bacterial levels and Ladies' Bathing Pond recorded the greatest, with particularly greater numbers of *E.coli*. However, all three ponds recorded very low bacterial levels and would also be compliant with "Excellent quality" EQS.

3.8 **Other determinands** –

- an elevated Biochemical Oxygen Demand (BOD) result was recorded at Catch Pit (7.2 mg/l) most likely due to the markedly high ammonia concentrations causing an oxygen demand for the process of nitrification (conversion of ammonia into nitrite and then into nitrate)
- elevated iron (1.02 mg/l against a WFD EQS of 1mg/l) and nickel (28.33 µg/l against an EQS of 20 µg/l) at the inflow to the Viaduct Pond sampling location
- elevated nitrite levels at Catch pit, Mixed, and Ladies (380 µg/l, 98 µg/l and 51 µg/l respectively), most likely as a result of incomplete nitrification. With low DO concentrations, there is not enough oxygen available to convert ammonia into nitrate, so the process results in nitrite as an end product
- pH levels were outside tolerable range at the inflow to Viaduct Pond (more acidic due to presence of naturally occurring iron-rich water from the springs at this site), Hampstead No1 and No2 and Men's and Highgate No. 1 (more alkaline most likely due to increased algal activity – photosynthesis causes an uptake in CO_2 which increases pH)
- suspended solids levels were elevated at the inflow to Viaduct Pond and Highgate No. 1 (55 and 36 mg/l respectively)

3.9 On the Hampstead Chain, the best WQ was recorded at the Vale of Health Pond with the worst recorded at Catch Pit. Poor quality water was also recorded at the inflow to the Viaduct Pond

3.10 On the Highgate Chain, the best WQ was recorded at the two Kenwood Ponds and Model Boating Pond, with the worst recorded at Ladies' Bathing Pond.

Table 3 – Average WQ concentrations for key determinands against indicative EQS, Hampstead Chain

Determinand:	Ammonia	BOD	Dissolved Oxygen	Iron	Nickel	Nitrite	pH	Phosphorus	Suspended Solids	E. Coli	Intestinal Enterococci
Units:	µg/l	mg/l	mg/l	mg/l	µg/l	µg/l	pH Units	µg/l	mg/l	cfu/100ml	cfu/100ml
EQS:	600	5	<6	1	20	30	6 to 9	49	25	1000	400
Vale of Health Pond	114	1.8	6.6	0.09	0.98	5	7.64 - 8.04	61	12	10	34
Inflow to Viaduct	690	0.5	4.4	1.02	28.33	5	3.84 - 4.08	51	55	170	39
Viaduct Pond	451	1.6	4.8	0.06	7.27	5	7.52 - 7.76	651	10	1	15
Catch pit	5140	7.2	4.7	0.36	5.23	380	7.56 - 7.8	1147	7	1	1
Mixed Bathing Pond	730	3.4	4.0	0.05	3.67	98	7.04 - 7.7	343	14	3	13
Hampstead No. 2 Pond	755	2.2	10.1	0.67	0.94	11	8.94 - 9.34	362	10	14	48
Hampstead No. 1 Pond	511	1.8	9.2	0.68	1.60	5	8.2 - 9.58	201	7	33	0

Table 4– Average WQ concentrations for key determinands against indicative EQS, Highgate Chain

Determinand:	Ammonia	BOD	Dissolved Oxygen	Iron	Nickel	Nitrite	pH	Phosphorus	Suspended Solids	E. Coli	Intestinal Enterococci
Units:	µg/l	mg/l	mg/l	mg/l	µg/l	µg/l	pH Units	µg/l	mg/l	cfu/100ml	cfu/100ml
EQS:	600	5	<6	1	20	30	6 to 9	49	25	1000	400
Wood Pond	73	1.2	7.0	0.19	6.16	5	7.82 - 8.52	24	8	17	4
Thousand Pound Pond	8	0.8	6.6	0.07	5.79	5	7.62 - 8.18	14	8	35	80
Stock Pond	341	2.6	4.1	0.13	3.13	7	7.54 - 7.8	583	12	2	8
Inflow to Ladies	28	0.9	7.6	0.15	6.17	20	7.82 - 8.06	153	23	5	80
Ladies Bathing Pond	304	2.6	4.9	0.03	3.58	51	7.63 - 7.88	303	9	88	20
Bird Sanctuary Pond	204	1.8	5.3	0.02	2.46	5	7.64 - 7.98	496	5	50	11
Model Boating Pond	48	1.7	6.1	0.16	4.78	5	7.68 - 8	71	25	50	9
Men's Bathing Pond	391	2.5	6.9	0.10	4.31	8	7.7 - 9.38	62	11	3	31
Highgate No. 1 Pond	264	2.0	8.4	0.07	1.63	9	8.92 - 9.48	473	36	6	13

*Green cells show compliance with indicative EQS levels. Red cells show non-compliance

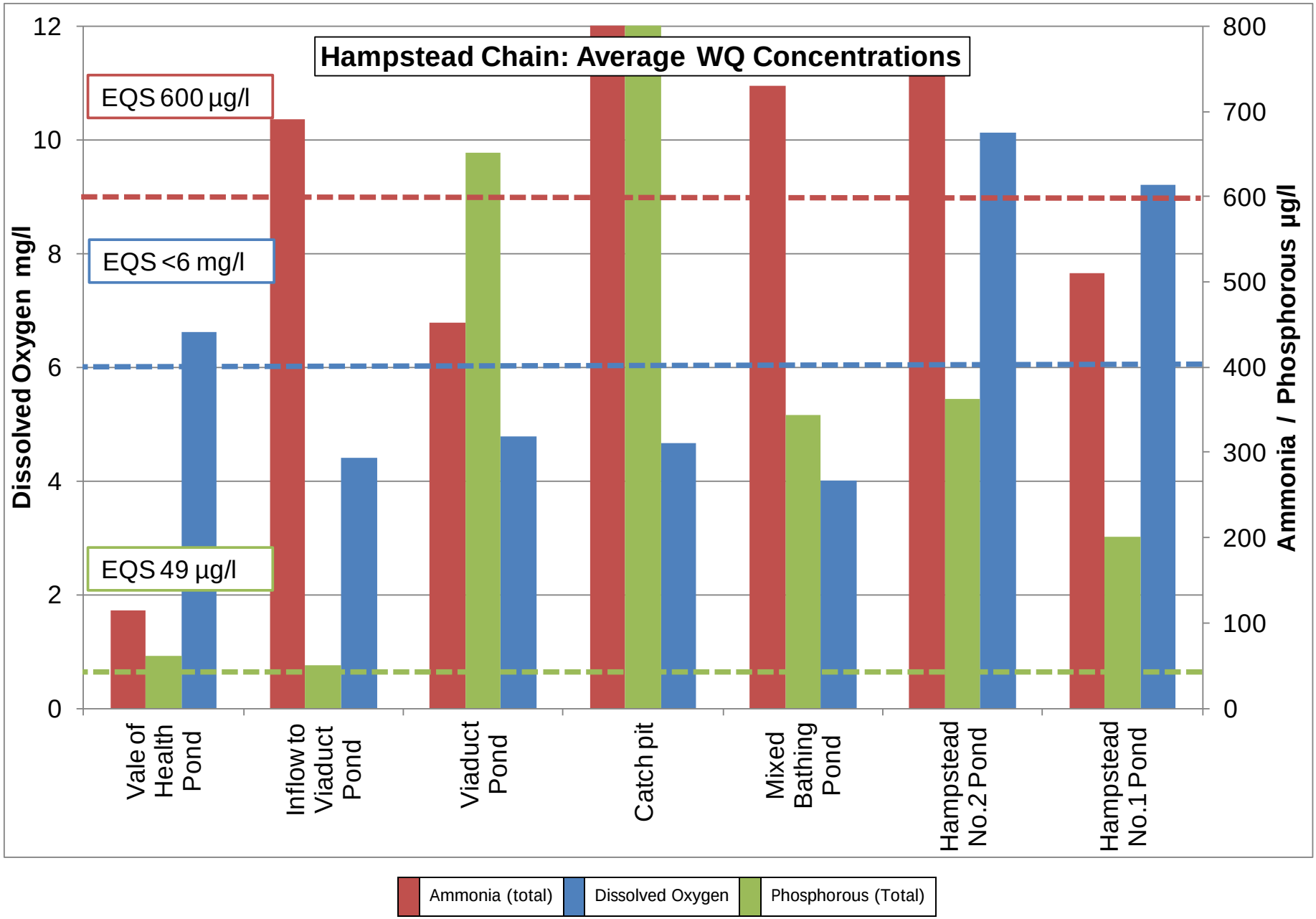

Figure 2 – Average WQ concentrations for key determinands, Hampstead Chain

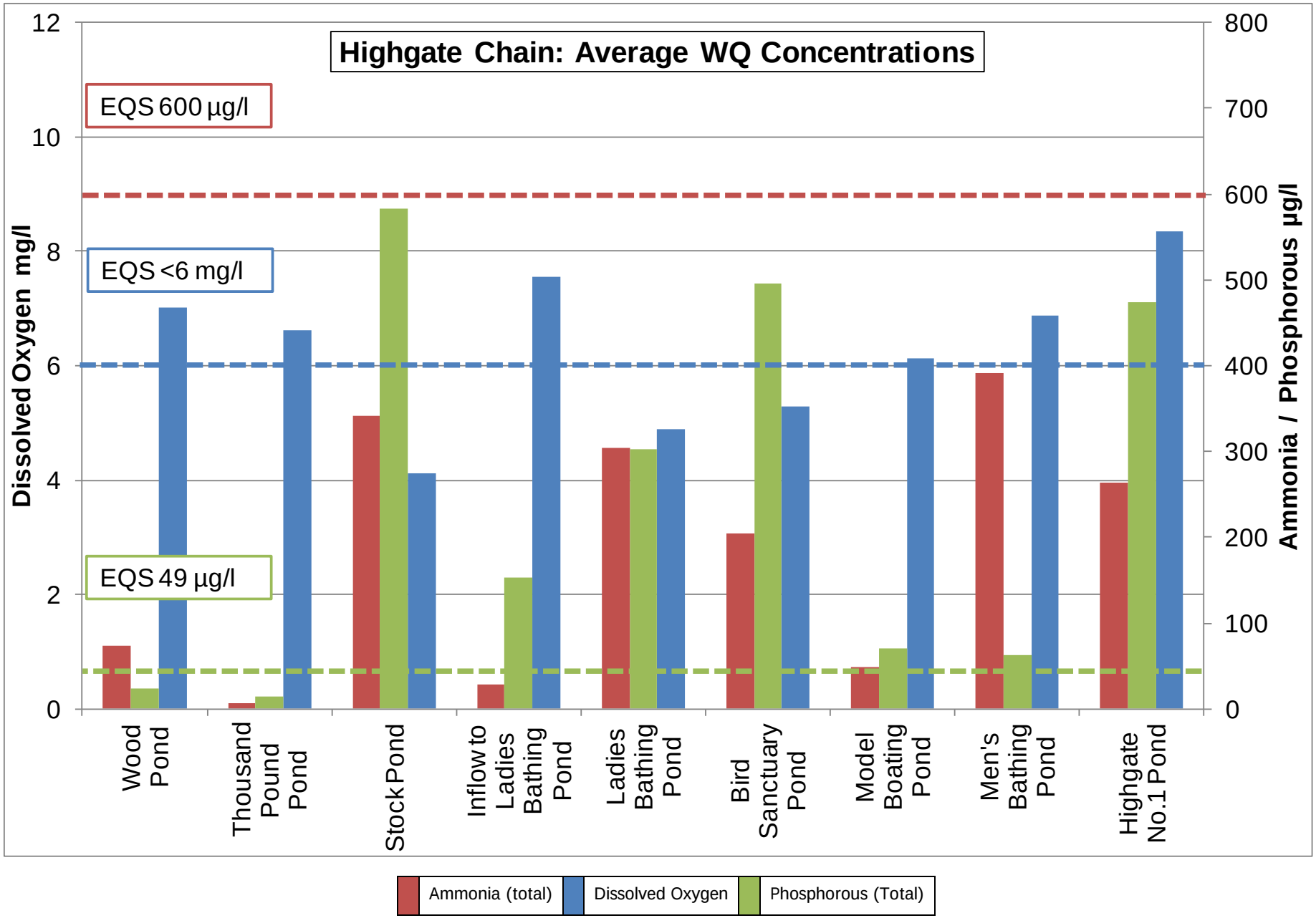

Figure 3 – Average WQ concentrations for key determinands, Highgate Chain

4. Discussion

4.1 Following the review of historic WQ data for the ponds at Kenwood and within the Highgate and Hampstead Chains, it was decided that further WQ monitoring was required on all ponds in order to have a sufficient baseline (current status) condition to be used to inform the EIA and detailed design processes in 2014.

4.2 The Hampstead and Highgate chains of ponds (including the two Kenwood Ponds) were monitored on three separate occasions between July and September 2013. Additional samples were taken from the Catch Pit and inflows to the Viaduct and Ladies' Bathing Pond respectively. Triplicate samples were taken for all ponds on each sampling occasion and samples were tested by an independent EA accredited laboratory for a suite of determinands.

4.3 The entire dataset was screened against indicative EQS in order to highlight which determinands were recording non-compliant concentrations. The level of Non-compliance varied between both the ponds and the chains but was highlighted for ammonia, BOD, DO, iron, nickel, nitrite, pH, phosphorous and suspended solids. Summary data for these determinands alongside bathing water quality indicators can be found in Section 3 of this report.

4.4 Of these key determinands, it is considered that DO, ammonia and phosphorous are the main parameters driving WQ issues within the ponds on the Heath.

4.5 Low DO levels were recorded at a number of the ponds of the Heath, particularly on the Hampstead Chain. This is most likely being driven by increased algal activity within the ponds at time of sampling. During the spring and summer seasons, the ponds experience eutrophication where phytoplankton species (in particular) bloom as a result of high nutrient levels in the water and increased photosynthesis activity. This causes rapid growth, followed subsequently by increased decomposition, a process that removes oxygen from the water. The Heath experiences problems with toxic blue-green algal blooms in particular, which can be a hazard to both humans and animals alike (particularly dogs).

4.6 The large volumes of decomposing leaf litter already on the bottom of the ponds will almost certainly exacerbate this issue. Due to the combined effect of stratification (layering of the water) and the limited mixing of the water column, DO levels at the bottom of the pond could become dangerously low for aquatic species, particularly fish.

4.7 The greatest DO levels were recorded at the two most downstream ponds, Hampstead No. 2 and Highgate No. 1, most likely due to the presence of large amounts of submerged macrophytes, which are present throughout the water column, serving to re-oxygenate the water during the daytime. However, during the night, when only respiration occurs, oxygen can be removed from the water and DO levels can deteriorate quickly.

4.8 Ammonia levels were not particularly high within the ponds, and were considered good throughout the Highgate chain, however recorded elevated levels were most likely caused by decomposing algal and leaf material. The excessively high concentration at the Catch Pit is not unexpected due to the stagnation of the water at this location and the amount of material contained within the structure. This is likely to be increasing concentrations downstream at Mixed Bathing Pond.

4.9 The total phosphorous concentrations within the majority of the ponds were excessively high and in some cases more than 10 times greater than the EQS (Viaduct Pond, Catch Pit, Stock Pond, Bird Sanctuary and Highgate No. 1 Pond). Only the Kenwood Ponds recorded low concentrations. Although essential for plant growth,

excessive levels of phosphorous within the water column lead to eutrophication as previously explained, resulting in reduction in DO levels and the rise in ammonia concentrations.

4.10 Phosphorous is certainly the most important determinand causing WQ deterioration within the ponds. It is most likely entering the ponds from a number of sources such as from dog waste, wastewater misconnections/overflow (sewage incidents recorded to east of Ladies' Bathing Pond, and housing drainage believed to enter Vale of Health), algal/plant matter (including leaf litter) and other inputs such as from the allotment to the east of the Highgate Chain.

4.11 In a majority of the ponds, there is a considerable volume of silt, leaf litter and decaying material. This acts as a sink for phosphorous, however under low DO conditions phosphorous will actively dissolve back in to the water column from the silt material. Ponds such as Viaduct and Stock, which have large volumes of silt and little water volume, have the greatest phosphorous concentrations. This is because there is a large source of phosphorous and little water volume to dilute the concentration. In deeper ponds with less sediment, concentrations are markedly lower, such as in Men's Bathing Pond.

4.12 It is therefore important to keep the ponds aerated to increase DO concentrations and help control the phosphorous and ammonia levels. However, there is the concern that increased mixing of the water column in the ponds could physically disturb the sediment, which would also encourage phosphorous release into the water column.

4.13 Ideally, some consideration should be given to the option of dredging the highest priority ponds (such as Viaduct Pond, Mixed Bathing Pond and Stock Pond). This is where the greatest opportunity for improving long term WQ issues lies.

4.14 The phosphorous source pathways also need to be further investigated in order to consider the most appropriate measures for reducing the loading of phosphorous in to the ponds.

4.15 Importantly, the WQ within the three designated EU Bathing Waters (Mixed, Ladies' and Men's Ponds) showed compliance with EQS.

4.16 The WQ of the Heath's ponds should be carefully monitored throughout any construction phase in order to help prevent deterioration, resolve any arising WQ issues, and ensure that bathing waters remain open.

5. Conclusions and recommendations

5.1 WQ monitoring of the Hampstead and Highgate chains of ponds was conducted on three occasions between July and September 2013 and samples were analysed by an independent EA accredited laboratory.

5.2 Following an initial screening assessment against EQS, nine WQ determinands were reported as recording elevated concentrations. Of these, DO, ammonia and phosphorous were considered to be the key determinands driving WQ issues within the ponds.

5.3 Low DO levels were widespread across the ponds, most likely as a result of eutrophication causing increased algal activity and subsequent decomposition of material, a process which removes oxygen from the water.

5.4 Ammonia levels were above EQS levels on the Hampstead chain, with elevated concentrations most likely caused by decomposing material within the ponds.

5.5 Phosphorous levels are considered to be excessively high, with many ponds recording levels 10 times greater than the EQS, deteriorating WQ within the ponds. Under low DO conditions, more phosphorous can enter the water column from the bed sediment, exacerbating problems.

5.6 In order to address long term water quality issues, the ponds should preferably be aerated to increase DO levels (particularly during the summer) with some consideration given to the option of dredging the large volumes of decaying leaf litter and silt from the highest priority ponds. This will help alleviate eutrophication problems and will reduce algal blooms, particularly toxic blue-green algal blooms.

5.7 Some consideration should be given towards investigating the potential sources and pathways of nutrients (such as from dog waste and leaf litter), in order to help reduce the amount of phosphorous entering the ponds.

5.8 The information from this baseline assessment should be used in the EIA and detailed design process in order to determine the best WQ solutions for the ponds.

6. References

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