030 EARA presentation
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Dr Michael O. Rivett

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CURRENT POSITIONS

GroundH$_2$O plus Ltd,
Quinton, Birmingham
Director and founder, 2016 –
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GroundH$_2$O plus Ltd is an environmental consultancy specialising in research-informed hydrogeological assessment and technical review of groundwater contamination issues that are of topical concern to contaminated land, water-industry, nuclear, energy-development, groundwater regulation and developing-world sectors. Dr Rivett, has 30 years' experience in contaminant hydrogeology, 20 years as a university academic. He has a significant track record of published research and project experience serving these sectors.

University of Strathclyde
Department of Civil & Environmental Engineering
Research Fellow part-time (Birmingham based) 2016 –
michael.rivett@strath.ac.uk

Dr Rivett is a part-time Research Fellow focused on the delivery of published research from the Scottish Government funded Climate Justice Fund - Water Futures Programme. A research programme designed to support the Government of Malawi in meeting SDG 6. His 22 publications since 2014 may be downloaded from: https://strathprints.strath.ac.uk/view/author/1104214.html

SPECIALIST AREAS AND KEY EXPERIENCE

- Technical peer review and research-informed advice on groundwater contamination issues
- Groundwater research: university academic / applied research experience over 30 years
- Contaminated land assessment/remediation: specialising in groundwater, complex sites
- DNAPLs / LNAPLs, chlorinated solvents, VOCs, hydrocarbons, emerging organic contaminants
- Surface water impacts from groundwater plume discharges, highway de-icing salt runoff
- Innovative groundwater monitoring methods, e.g., multilevel monitoring, tracer tests
- Nuclear legacy/disposal sites: radiological contaminant fate - management in groundwater
- Onshore oil and gas: environmental baseline monitoring, groundwater protection
- Developing country hydrogeology: SDG-6 relevant groundwater development / protection
- Experienced BSc/MSc/CPD groundwater lecturer and university programme / PhD examiner
- Experienced author, presenter and reviewer of journal papers, technical guidance, etc.
- Experienced chair/member of professional bodies, industry advisory panels, conferences

PUBLICATIONS

- Rivett publication listing: https://scholar.google.com/citations?user=8H8pUbUAAAAJ&hl=en
- Google Scholar: 2393 citations received to Rivett's publications (>100), h-index 25

EARLIER CAREER & EDUCATION

- **1997-2016** Senior Lecturer / Lecturer in Contaminant Hydrogeology - Earth Sciences, University of Birmingham, School of Geography, Earth & Environmental Sciences
- **1996-97** Area Hydrogeologist, Environment Agency, Leeds
- **1994-96** Area Hydrogeologist, National Rivers Authority, Leeds
- **1989-93** Post Doctorate, Waterloo Centre for Groundwater Research, Univ. of Waterloo, Canada
- **1985-88** PhD Earth Sci. (Hydrogeology), Univ. of Birmingham with Water Research Centre (WRc)
- **1980-84** MA Hons. Chemistry, University of Oxford

CITIZENSHIP, MEMBERSHIPS, PROFESSIONAL BODIES, EXTERNAL POSITIONS - examples

- **2014-18 University of East Anglia (UEA)**, School of Environmental Sciences - External Examiner
- **2012-... International Association of Hydrogeologists**, British Chapter - Committee Member
- **2008-... CL:AIRE** - Technology & Research Group – Member of expert advisory group
- **2008-... Sellafield Ltd**, Land Quality Independent Peer Review Panel - Member (via NNL)
- **2006-... Journal of Contaminant Hydrology**, Editorial board member
- **PhD examiner** – 33 occasions at 13 universities in the UK and internationally
- **International Association of Hydrogeologists**, British Chapter – Chair, 2012-17
- **Geological Society** - Council of the Geological Society – Member 2006-09
- **Hydrogeological Group, Geological Society** - Chair 2004-06, Committee member 2001-06

RELEVANT / RECENT PROJECTS - a selection (**bolding** relevant personal / organisations / topics)

GroundH$_2$O plus Ltd (**Rivett**) – consultant to CL:AIRE (2018) to provide authoring and editing of a CL:AIRE report on 'Natural Source Zone Depletion (NSZD)' prepared for the **Environment Agency**.

GroundH$_2$O plus Ltd (**Rivett**) – consultant to **BGS** to provide expert technical groundwater input to the BGS led multi-university consortium project (Phase 4, 2018-19) (and Phases 1-3, 2015-18). Science-based environmental baseline monitoring associated with **shale gas development**, (funded by **BEIS**)

GroundH$_2$O plus Ltd (Rivett) – consultant to NNL (National Nuclear Laboratory) (2018) to provide expert scientific review to Sellafield Ltd (SL) Land Quality on the '**Beach Springs'** research project.

Rivett (2012-13) - Contracted by **Environment Agency** to act as Scientific Advisor to provide external peer review of the Birmingham Sherwood Sandstone groundwater modelling ESI Ltd (**Buss**).

RELEVANT / RECENT PUBLICATIONS - a selection

McMillan, L.A., **Rivett, M.O**., Wealthall, G.P., Zeeb, P., Dumble, P., **2018**. Monitoring well utility in a heterogeneous DNAPL source zone area: insights from proximal multilevel sampler wells and sampling capture-zone modelling. Journal of Contaminant Hydrology, 210, 15-30. https://doi.org/10.1016/j.jconhyd.2018.02.001

Tomlinson, D.**, Rivett, M.O.**, Wealthall, G.P., Sweeney, R., **2017**. Understanding complex LNAPL sites: Illustrated handbook of LNAPL transport and fate in the subsurface. *Journal of Environmental Management*, 204, 748-756 https://doi.org/10.1016/j.jenvman.2017.08.015

Rivett, M.O., Cuthbert, M.O., Gamble R., Connon, L.E., Pearson, A., Shepley, M.G., Davis, J., **2016**. Highway deicing salt dynamic runoff to surface water and subsequent infiltration to groundwater during severe UK winters. *Science of the Total Environment* 565, 324-338. http://dx.doi.org/10.1016/j.scitotenv.2016.04.095

Rivett, M.O., Dearden, R.A., Wealthall, G.P., **2014**. Architecture, persistence and dissolution of a 20 to 45 year old trichloroethene DNAPL source zone. *Journal of Contaminant Hydrology, 170, 95-115. http://dx.doi.org/10.1016/j.jconhyd.2014.09.008*

Rivett, M.O., Turner, R.J., Glibbery, P., Cuthbert, M.O., **2012**. The legacy of chlorinated solvents in the Birmingham aquifer, UK: Observations spanning three decades and the challenge of future urban groundwater development. *Journal of Contaminant Hydrology*, 140-141, 107-123. http://dx.doi.org/10.1016/10.1016/j.conhyd.2012.08.006

White, R.A., **Rivett**, M.O., Tellam, J.H., **2008**. Paleo-roothole facilitated transport of aromatic hydrocarbons through a Holocene clay bed. *Environ. Science & Technology*, 42(19), 7118-7124. http://dx.doi.org/10.1021/es800797u

Rivett, M.O., Chapman, S.W., Allen-King, R.M., Feenstra, S., Cherry, J.A., **2006**. Pump-and-treat Remediation of Chlorinated Solvent Contamination at a Controlled Field-Experiment Site. *Environmental Science & Technology*, 40, 6770-6781. http://dx.doi.org/10.1021/es0602748

Expert opinion on:

Groundwater contamination aspects of the proposed quarrying activity at Hatfield Aerodrome

Date: 14 December, 2019

Author: Dr Michael O. Rivett, Director, GroundH_2O Plus Ltd, Quinton, Birmingham.

Client: Ellenbrook Area Residents Association (EARA)

Preamble, report aim and disclaimer

The expert opinion provided below by Dr Rivett of GroundH_2O Plus Ltd is based on his preliminary assessment of data provided relating to the groundwater contamination circumstance and planned quarry activity at the Hatfield Aerodrome site. The primary aim of this short report is to meet the need to provide expert opinion prior to planning determination and indicate to EARA some of the possible groundwater contamination-related issues that they could reasonably expect consideration of in the planning process given the contamination scenario outlined. The intent is to be constructive. Due to the time constraints, there is no claim made to be comprehensive. Also, the primary work undertaken has been to consider the contamination circumstance and groundwater quality data provided, it has NOT been to review and critique documentation, submissions, reporting and correspondence associated with the planning application. As such, it is possible that some points raised may be covered fully, or to some degree, or perhaps not at all by those documents; the degree of coverage would need to be verified by EARA (or others to which this short report may be made available); this coverage has not been checked by Dr Rivett. The report below is, however, cognisant of the context of the proposed groundwater-related 'conditions' indicated in recent Environment Agency letters (excerpted in part below). This report is made having read papers provided for DCC meeting scheduled for Dec 18th 2019.

The expert opinion is founded upon Dr Rivett's expertise and long experience in groundwater contamination research dating from the mid 1980s; he has a significant track record of published research (https://scholar.google.com/citations?user=8H8pUbUAAAAJ&hl=en). Whilst he has been aware of the bromate plume in the area primarily through its reporting in the research community, he has not directly worked on this contamination scenario. He has previously supervised a University of Birmingham MSc Hydrogeology project relating to flow aspects in part of the Chalk aquifer in the wider catchment.

Disclaimer: GroundH2O Plus Ltd will not be responsible for any loss, however arising, from the use of, or reliance on, the information contained in this report, nor do they assume responsibility or liability for errors or omissions in this report.

Dr Michael Rivett

Director, GroundH_2O Plus Ltd

Some context having read papers provided for DCC meeting scheduled for Dec 18th 2019

The paragraphs quoted immediately below provide a specific context to the 'expert opinion' following is the 'Environment Agency position' as indicated per the Environment Agency letter of 10 October 2019 (NE/2016/124652/04-L01) - Land at Hatfield Aerodrome, Off Hatfield Road. For ease of reference, the bold-marked groundwater-related key advice bullet points are referred to as *'EA conditions'* in the subsequent Expert Opinion. It is recommended a reader accesses this letter (and related items) within the planning system submission for the full context of the excerpt that follows:

*"**Environment Agency position***

Controlled waters are particularly sensitive in this location because the proposed development site lies close to groundwater pollution of bromate and bromide from an off-site source. As previously stated, we advise that:

- ***No mineral is extracted from within the existing plume of bromate and bromide groundwater pollution***
- ***any activities close to the plume must not change the existing hydrogeological flow regime***
- ***any activities close to the plume must not interfere with the remediation of the bromate and bromide pollution.***

The submitted information demonstrates that it will be possible to fulfil these points and manage the risks posed to controlled waters by this development. Further detailed information will however be required before built development is undertaken. We believe that it would place an unreasonable burden on the developer to ask for more detailed information prior to the granting of planning permission but respect that this is a decision for the local planning authority.

In light of the above, the proposed development will be acceptable if a planning condition is included requiring the submission of a Water Monitoring & Management Plan. This should be carried out by a competent person in line with paragraph 178 of the National Planning Policy Framework."

Expert opinion on groundwater contamination related issues

Expert opinion below is provided as a set of numbered points that are headed for ease of reference.

1. **Insufficiency of interpreted groundwater data to allow meaningful planning determination** - Whilst the groundwater-related 'EA conditions' above and the 'Water Monitoring & Management Plan' approach requested by the Environment Agency do not appear unreasonable to achieve protection of controlled waters, the sufficiency of groundwater contamination related data made available to date to underpin a planning application and assess the likelihood of successfully meeting the EA conditions appears, however, debatable. Given the stringent EA conditions, the onus is on the developer to demonstrate that the aquifer resource to be quarried is not contaminated, or at significant risk of becoming contaminated through the planned quarrying activity. Proving this is the case ahead of planning determination, with conclusive data to provide reassurance that the EA conditions can be met, is not viewed in the opinion herein to constitute "*an unreasonable burden on the developer"* given the scale of development in the complex groundwater contamination setting. To note, per underlined Environment Agency text

above, the local planning authority make the decision on burden. Further collection and interpretation of site-specific data (e.g. in the LMH) and more advanced supporting calculations (or predictive modelling) to support the proposed quarrying activity and better quantify the groundwater-related risks involved, in particular the possible exacerbation of groundwater pollution could be reasonably expected. Raised below are specific elements that it would reasonable to anticipate coverage and clarity of within the planned activity, cognisant of the complex groundwater contamination scenario at hand.

2. **Definition of groundwater plume concentration thresholds** - Pivotal to groundwater-related 'EA conditions' advised by the Agency is the setting of actual concentration values that define the groundwater 'plume' of bromate and bromide referred to in each of the three conditions. The Agency indicate various concentration values in their response letter of the 28/8/19 and appear to settle on "the 2 ug/l limit of detection may be used to define the boundary of the bromate plume". This is based on an agreed neighbouring quarry extension planning consultation. Although some precedence has been set, and the value appears practical, it should be recognised that this bromate plume definition could still be debated. There is some concern that 'goal posts could be moved' and cases made by parties arguing for lower (e.g. 0.5 µg/l) or indeed higher (e.g. 10 µg/l) bromate values that are also indicated in the Agency letter. The Agency fail to define a plume concentration value for bromide that is to be regulated or acted upon. Possible bromide plume values of 125 and 500 µg/l are indicated by the Agency for bromide with a noted equivalence by them of "*concentration contours of 0.5 ug/l bromate and 125 ug/l bromide are broadly coincident*" [which could be reasonably assumed as the lowest possible plume boundaries capable of practical definition]. They further note "*background levels of bromide in groundwater, in the Hatfield Area, are 50-100 ug/l*", and then note "It is difficult to define the bromide plume boundary caused by pollution from the Contaminated Land Special Site because bromide occurs naturally in groundwater and in road-grit-salts." The Agency finally conclude, "If further evidence comes to light demonstrating that current background bromide concentrations near Hatfield in the groundwaters of the Lower Mineral Aquifer and the Chalk aquifer are higher than 125 ug/l then we will reconsider the bromide plume boundary definition.". The setting of the bromide plume concentration condition is hence left open to debate and later agreement. But as an analysis of the existing data (per below) will show, this is critical to implementation of the "EA Condition' that "*No mineral is extracted from within the existing plume of bromate and bromide groundwater pollution*" at this particular site. It appears bromide and bromate data do not always follow the anticipated bromide – bromate plume trend relationships encountered elsewhere. It is suggested further clarification should be sought from the Agency as to how the bromate plume and bromide plume contamination are to be co-regulated based on the existing site data available as this appears material to the scheme viability, and the ease or difficulty of meeting the 'EA conditions' suggested by the Agency. Overall, the uncertainties in plume definition and potential 'moving of goalposts' that could occur is a noted concern and of material influence to the planned activity.

3. **Sensitivity and complexity of the quarry setting and possible shortfalls in site investigation** - The quarry site is in an unusually sensitive and complex setting. It is partly within the immediate edge of what is Europe's largest (~ 20 km) groundwater plume in a chalk aquifer (this being the UK's most important groundwater resource unit). Inspection of the various plume maps produced by the Agency (Fig. 1 attached) shows the proposed quarry to be on a high concentration gradient edge (rapidly varying concentration in space) of the main bromate plume core. It is positioned directly in between the main contamination source area and the scavenger well at Bishops Rise. This groundwater abstraction critically operates to contain the on-going plume continuing to generate from the un-remediated source from further spreading. It may be reasonably anticipated (from the general longevity of source zones in chalk aquifer systems) that this abstraction is likely required for several decades in the absence of more proactive remediation of the

contamination source. The quarry site is hence quite likely to be threatened by bromate and bromide contamination throughout its lifetime. The quarry site positioning at a somewhat S-shaped inflection and broadening of the main bromate plume will cause groundwater bromate/bromide concentrations observed on or near the quarry site to vary rapidly in value spatially. They will be sensitive to both operation of the scavenger well and the rates at which it is pumped. Operation could tend to draw contamination variously through, or around the site over time. Concentrations will also be sensitive to seasonal conditions of varying rainfall and aquifer recharge (replenishment); hence evaluation of concentration data over long time periods is required to understand the temporal variations. Concentrations will also be sensitive to the geological heterogeneities that could cause preferential migrations. In terms of assessing concentrations at the site there is certainly value in examining the existing datasets, however, there is little substitute for a rigorous and detailed groundwater contamination investigation of the site that is targeted to assessing the risks posed by the quarry development. It is unclear (with the limitations of time in this review) to substantiate the degree to which monitoring and investigation data have arisen from targeted investigation directly supporting the development, or the use of existing monitoring wells/boreholes that may variously meet the present goal. The more targeted an investigation is the better the determination of the detail of actual site concentrations and hence scheme viability and its likelihood of meeting the 'EA conditions'. This is a complex site from both hydrogeological flow and contamination occurrence perspectives. Significant pre-investigation and assessment is required to scope the problem and determine its influence upon the safe design of site quarrying operations adequate to protect controlled waters. The preliminary assessment of data available below suggests that it may not be unreasonable to recommend further site investigation and analysis of data to clarify some of the uncertainties raised ahead of planning determination to inform that decision making.

4. **Preliminary assessment of contamination data available** - In terms of site investigations to date to assess the contamination condition and its probable influence, some preliminary evaluation has been made of bromate and bromide contamination occurrence data provided by EARA (provided to them from the developer). Fig. 2 (referred to below) segregates concentration occurrence data to aquifer type and uses colour-banding to show exceedance of various concentration thresholds. Preliminary assessment of the data in the context of meeting 'EA conditions' on groundwater is made below. It aims to raise various areas of potential concern.
    a. **Potential failure of existing boreholes to sufficiently document plumes** - The on-site (mainly perimeter boreholes) investigations to data together with nearby beyond-site boreholes fail to document as well as might be reasonably expected the extent of the bromate/bromide plume contamination in the quarry targeted LMH (Lower Mineral Horizon) (and underlying chalk aquifer) within the site. The plumes are most likely to occur on the north eastern side of the site (Fig . 1), however, only on-site boreholes numbered 4 and 6 and possibly 10 shown on Fig. 2 of the site monitoring installed sample the LMC of chalk (blue dots on Fig. 2) on the portion of the site most likely to be contaminated by the plume at higher concentrations. Monitoring could better target this portion of the site to make a better assessment of plume ingress to the site and improved understanding of its influence upon the scheme.
    b. **Widespread occurrence of elevated bromide** - Cognisant of the above shortfall in monitoring spatial coverage of the LMH (and CHK) on site, it is nevertheless clear from Fig. 2 that the occurrence of bromide above EA background in site groundwaters above the EA area background of 50-100 µg/l and the lowest plume threshold of 125 µg/l identified by the EA is widespread with concentrations also present exceeding the higher plume definition of 500 µg/l and with some concentrations in excess of 1000 µg/l in the north west corner of the quarry site. It is unclear as to why these concentrations are occurring, and often apparently

without higher concentrations of bromate expected (many are indicated as just 0.5 µg/l bromate (Fig. 2 amber circles) which is surprising given the high bromide (see below)). There is a need for the Agency to indicate how these bromide concentrations are to be regulated within the proposed scheme and also the implications on the development undertaken and the meeting of EA condition "No mineral is extracted from within the existing plume of bromate and bromide groundwater pollution".

c. **Risk of quarry operations drawing nearby high bromate groundwater on to site** - Whilst the documentation of higher concentrations of bromate over a plume threshold of 2 µg/l bromate remains uncertain in the LMH and chalk on site (only Borehole 4 on site showing bromate above this threshold, but Fig. 1 from the EA map showing significant bromate plume concentrations on site), it is very clear from Fig. 2 that much greater bromate concentrations exist extremely close to the site. There is risk of higher levels of bromate contamination being drawn into the site through the quarrying operations, particularly quarry operations targeting the LMH resource. The impact of withdrawal of geological deposits and associated groundwater will inevitably cause some groundwater flows and hence some migration of the bromate/bromide plume movement being induced towards and potentially into the operating area. This may be anticipated to increase with time as operations proceed. It would be reasonable to expect some calculations and, or modelling of the risks posed to underpin assessment of the proposed activity and its possible impact on controlled waters. This could be based on estimates of geological deposit – groundwater abstractions, water losses in the quarrying process, return water estimates that may together provide some estimate of groundwater migration towards the site and hence in turn prediction of plume movements towards the site. The drawdown of groundwater and consequent 'pull of any plume' towards the site has not only implications for the quarry site operations, but also the capture of plume contamination by the scavenger well operated down gradient. There should be some quantification of probable impacts of quarry mineral resource/groundwater abstraction activities and how perturbation of the high concentration bromate plume may be minimised. This would be required to meet the second and third EA conditions "any activities close to the plume must not change the existing hydrogeological flow regime, and any activities close to the plume must not interfere with the remediation of the bromate and bromide pollution". It has not been checked in this review as to the degree that these aspects have been addressed in the submissions associated with the planned development.

d. **Understanding the significance of apparent bromide – bromate plume anomalies** - Based on preliminary analysis of the two sets of data provided by EARA (see Fig. 3 and Fig. 4 graphs), the site bromide and bromate concentrations to date appear somewhat anomalous compared to relationships expected from the wider plume. This discrepancy needs explaining to allow effective regulation of bromate and bromide plume contamination conditions specific to the site. Fig. of groundwater data from boreholes in the vicinity of the quarry site exhibit a reasonable relationship between bromate and bromide concentrations 3 (data plotted as normal and log scales to examine the lower concentration detail). The relationship is consistent at low concentrations with the EA noted equivalence of 0.5 ug/l bromate and 125 ug/l bromide plume concentrations evident (red data point on graph near trendline). Only boreholes 23 and 24 containing elevated bromide appear anomalously low in bromate. These boreholes are both located to the immediate north-west of the quarry. This is in marked contrast with Fig. 4 that plots the available on-site and very near site borehole data. Fig. 4 exhibits some anomalously low bromate concentrations at boreholes displaying elevated bromide contamination. Boreholes with elevated bromide (boreholes, 10, 3, 13, 11) approach, or are below the bromate detection limit (< 0.5 µg/l). They fall

significantly below concentrations expected from the bromide – bromate trend line of Fig. 3. The only data occurring on the previous trendline are those samples that are common to both datasets (e.g. boreholes 5,8, 12, 9 in Figs 3 and 4). The anomalous occurrence of low or below detection limit bromate with elevated bromide requires investigation to allow effective regulation of the contamination condition. Possible explanations include: analytical / sampling / data recording issues and the bromate data that are in error; a real difference in the migration and behaviour of the bromide and bromate plumes that although originating from a similar source area may result in their slight separation over time (likely most obvious at the plume edges (the site scenario herein); or else alternative sources of bromide also exist (e.g. increased vulnerability to road salt impacts) or natural variations in bromide are locally occurring from differences in the local rock mineralogy. Whilst this may seem as a 'confusing detail', it is important that this is resolved at the present site to appropriately manage the development and risks posed.

5. **Increased risks posed by quarrying the LMH and significance of breaching the intervening unit** - The higher risk element of the proposed quarry development is the quarrying of LMH. Concerns are that this horizon has been shown to be contaminated by bromide/bromate with attendant risks therefore of exacerbating groundwater contamination. Also, that the protective intermediate layer of clay (an 'aquitard' that restricts vertical flows) is to be breached. The proposal may be in contrast to quarry operations elsewhere that can preclude quarrying below such protective layers. Quarrying into an aquifer unit that is known to be contaminated by a significant plume is obviously contentious. The lack of significant contamination in the near surface UMH suggests that the intervening aquitard has been important for decades (since the original pollution spill) in the protection of the near-surface environment and controlled waters. It is imperative that if quarrying is to proceed of the LMH (and even if it is just restricted to the UMH) that the role of the intervening aquitard unit is understood and rigorously quantified to allow decision making on the permitting of quarry activity. It should inform appropriate design of quarry operations and ensure that contamination of shallow controlled waters does not occur. Also, that risks are quantified and adequate migration measures in place to meet the EA conditions. Advanced works should establish, for instance, directions (upward or downward) and rates of seasonally variant natural flows through the aquitard, existence and control of confining pressures within the LMH/chalk, the integrity of the aquitard (its thickness to establish if there are thin 'weak' areas), impact of removal of the UMH overburden and potential for lift off of the clay and unexpected flooding of the shallow system, how effective the envisaged clay sealing proposed during operations will prove, the degree of contamination of the clay layer already existing (large contaminant masses of bromide/bromate may potentially long-term accumulate in clays in contact with contaminated LMH groundwater), and, finally, the integrity of backfill material used in the reinstatement to effectively re-seal the breached intervening aquitard unit.

6. **Operating agreement between the developer and water utility – a note**. It is noted that Affinity Water have been able to reach an operating agreement with the developers that appropriately allows them to be confident that operations can be agreed with the developers that will allow safeguard of public water supply. Whilst this is welcomed and does provide much needed assurance to the water utility and in turn their customer base, it is noted that the elements of control agreed under this operating agreement that have allowed Affinity Water to remove their original objections to the proposal are unfortunately not now transparent to the planning process and wider stakeholders involved. It is presumed likely that these agreements are substantially related to control of groundwater contamination risks and hence directly relevant to the concerns raised above. It would hence be reasonable to recommend, for transparency and benefit of all stakeholders, that the operating agreement relevant to the protection of public water supply (and controlled

waters) is made available to allow critical evaluation of its effectiveness in achieving that protection and assuring safety of the planned quarry development.

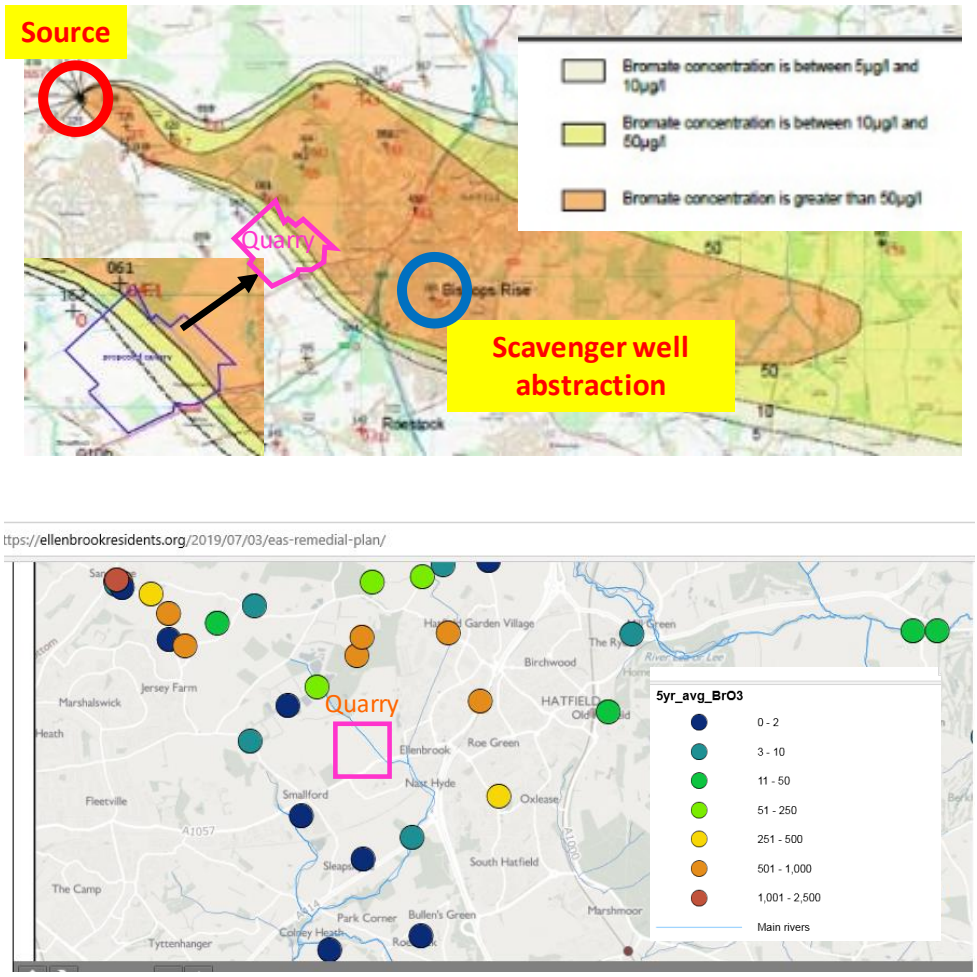

Fig. 1. Bromate plume maps drawn from Environment Agency sources.

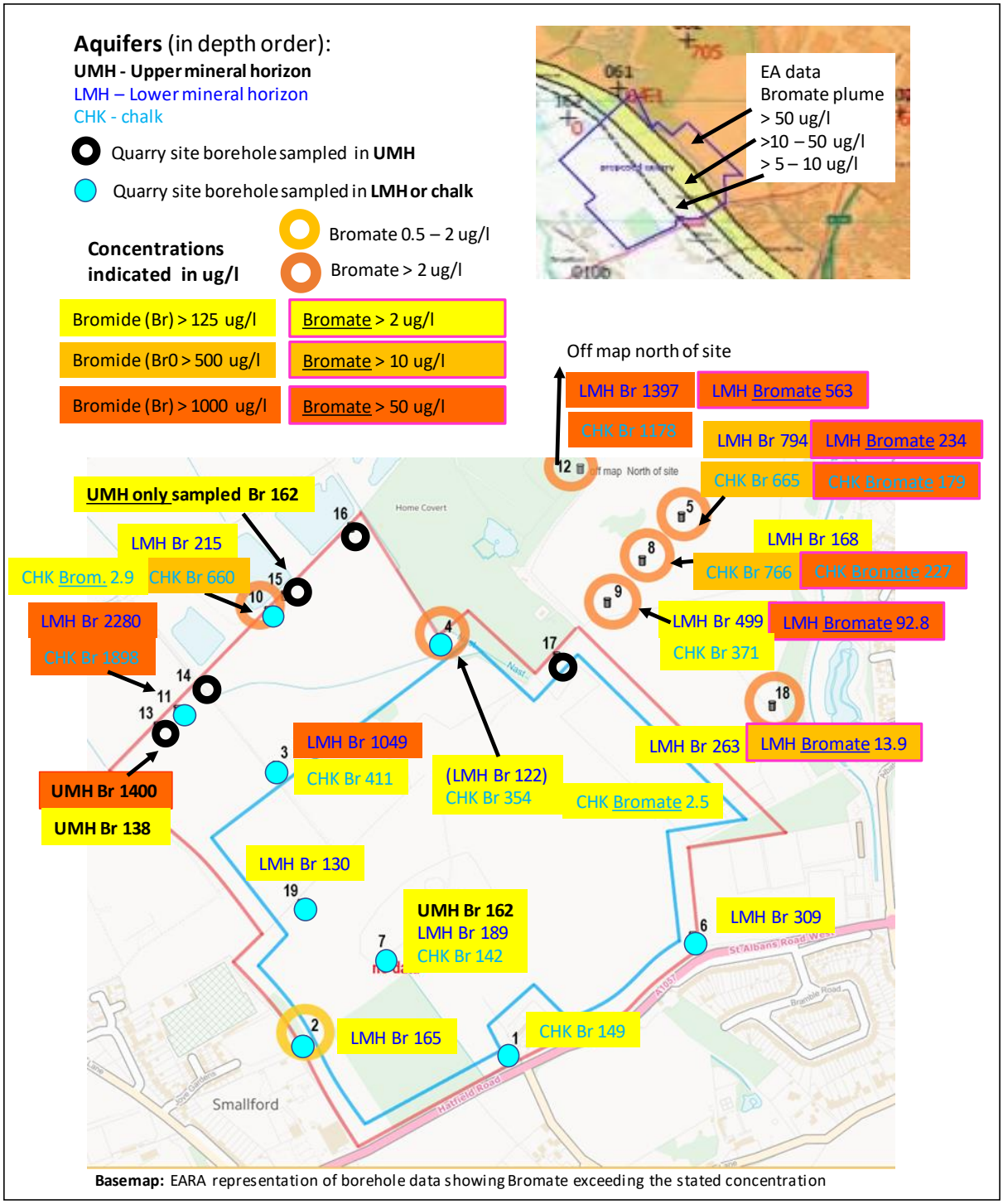

Fig. 2. Summary of Quarry site observed bromate and bromide contamination.

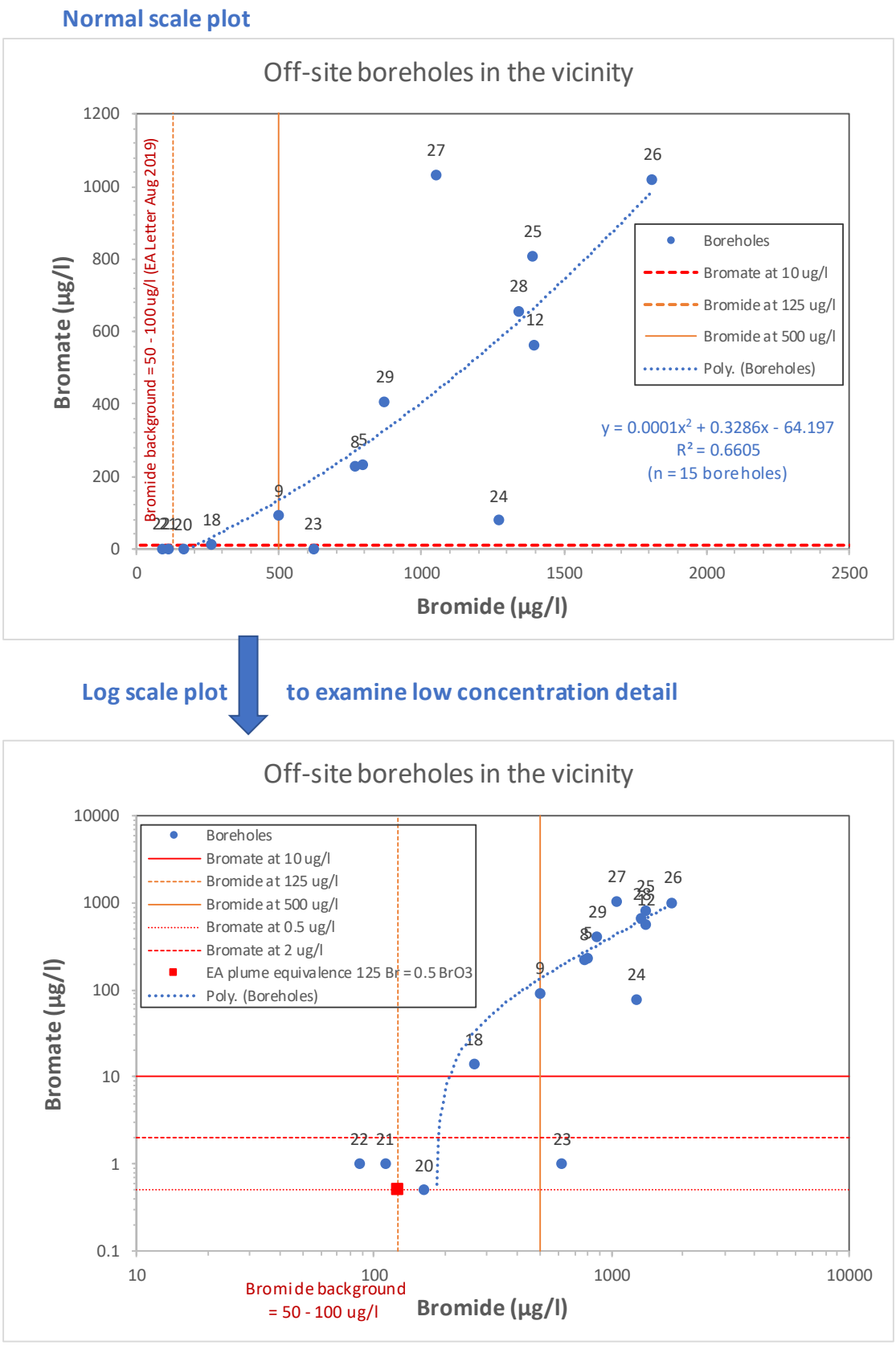

Fig. 3 Plots of bromide versus bromate concentrations observed in boreholes near the quarry site.

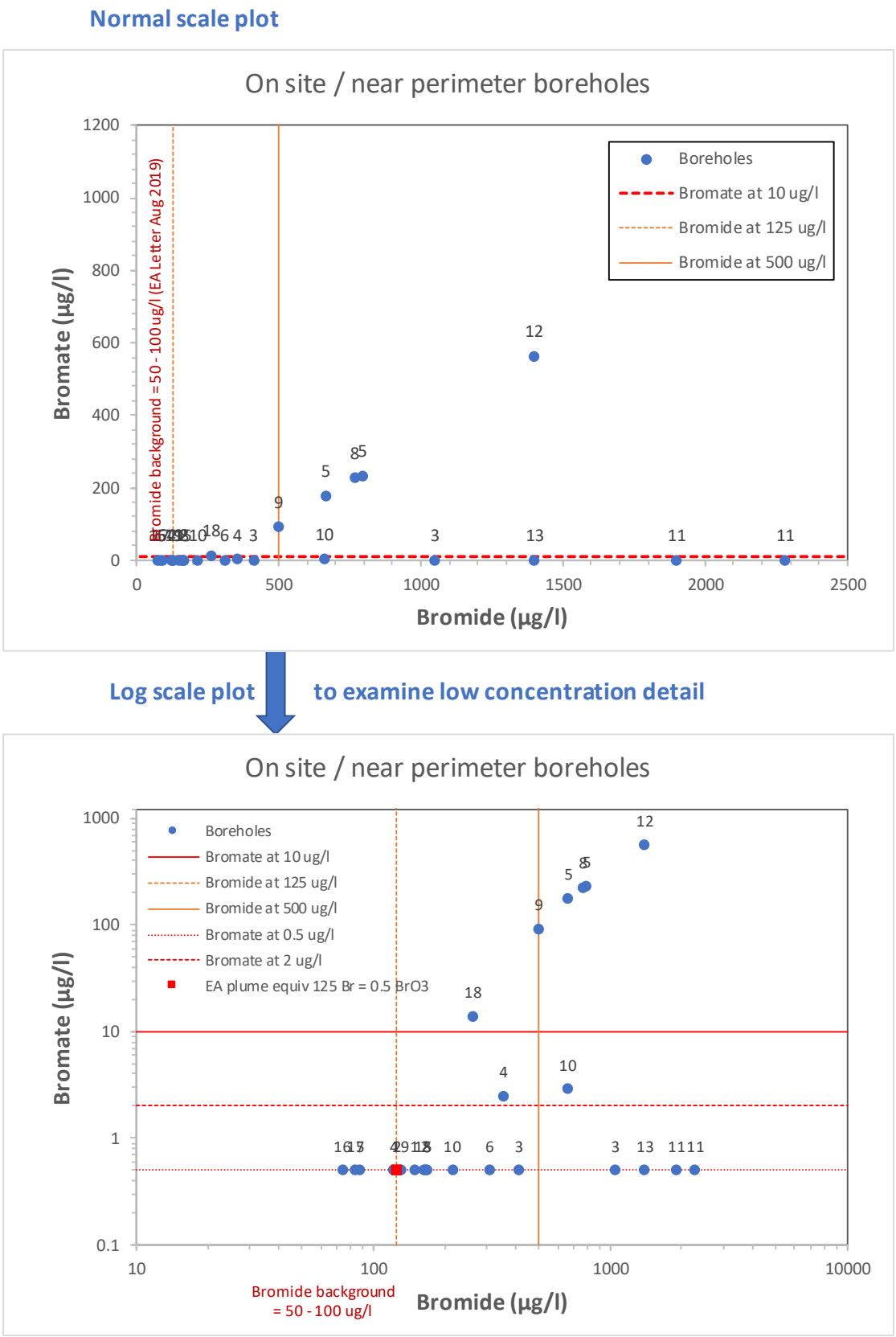

Fig. 4 Plots of bromide versus bromate concentrations observed in boreholes within and adjacent to the quarry site (most data shown at 0.5 µg/l Bromate are samples recorded as below detection limit, < 0.5 µg/l Bromate).