DRINKING WATER INSPECTORATE
Area 4A
Ergon House,
Horseferry Road
London SW1P 2AL

Enquiries: 0300 068 6400
Facsimile: 0300 068 6401

E-mail: marcus.rink@defra.gsi.gov.uk
DWI Website: http://www.dwi.gov.uk

Ref.2010-2661/2663

25 October 2011

Objectionable taste and odour in water supplies in North-East London between January and March 2010

Marcus Rink
Deputy Chief Inspector (Operations)

CONTENTS

1. Executive Summary

1.1. This reports sets out the conclusions and recommendations arising from the Inspectorate's assessment of an event where there was an objectionable taste and odour in water supplied from three treatment works (Coppermills, Chingford South and Chigwell) serving the North East London area and occurring in January through to March 2010. In total there were 1,114 recorded consumer contacts about the event to Thames Water and a further 97 recorded consumer contacts to Essex and Suffolk Water.

1.2. When notified of an event, the Inspectorate gathers information considered to be relevant and assesses this in conjunction with information provided by the company about the circumstances of the event and any actions taken. The Inspectorate then considers the way in which the event was handled and whether any breaches of regulatory duty or offences occurred. Thames Water notified the Inspectorate of this event on 09 February 2010 and notification by Essex and Suffolk Water was on 11 February 2010.

1.3. This event affected supplies managed by two water companies; one company because it relies on a source of raw water provided as a commercial bulk supply by the other and the other because it both uses and exports the same raw water source. The common causal factor in the event was the raw water abstracted from the River Lee into a complex series of surface water storage reservoirs.

1.4. About 10 miles upstream of the intake to the reservoirs is an outfall where final effluent from Rye Meads Sewage Treatment Works, (STW) is discharged. The STW has three treatment lines, one dedicated for use by a commercial licensed waste company. It was this commercial waste line which was found, on investigation by Thames Water, to contain waste from a resin manufacturer that contained the two organic substances which caused the objectionable taste and odour detected by consumers in North East London during January and February 2010. The same chemicals have been implicated in similar previous events worldwide (Pennsylvania, Barcelona and Worcestershire) during the 1990's. This report has been prepared to add to the body of published knowledge about the risks to drinking water posed by disposal of this type of waste material to the aquatic environment.

1.5. Two surface water storage reservoirs (King George V and William Girling) serve the Chingford South Water Treatment Works (WTW), owned by Thames Water Utilities Limited. The William Girling supplies Chigwell WTW owned by Essex and Suffolk Water a subsidiary of Northumbrian Water Limited. Together with the Lee Valley Complex reservoirs these reservoirs also serve Coppermills WTW owned by Thames Water.

1.6. An important contributory factor in this event was the particular conditions of low dilution of the sewage effluent in the small river receiving the discharge. A further confounding factor was essential maintenance work taking place on the embankment of the King George V. This reservoir receives 70% of its water from a point located upstream

of the STW. This water is derived from the River Thames and transferred to the Lee Valley by the Thames Lee raw water tunnel. Under normal circumstances and prior to January 2010 the reservoir contributed on average 8% of the water treated at Coppermills WTW. The embankment works commenced in the winter of 2009 and required Thames Water to reduce the volume of stored water in the reservoir by minimising draw off or closing the intake during December 2009 through to January 2010. On the week beginning 8 January the usage of King George V went up by around 10% to 17%, (maximum increase in usage during event was by 13% from 7% to 20%), at a time when the intake was closed and the demand on the Thames Lee Tunnel fell by 6%, (maximum reduction during event of 21% from 32% to 11% contribution). This change in operating regime to facilitate embankment works is considered retrospectively to mark the onset of the event with the first peak of customer complaints being received by Thames Water in a hydraulically consistent time period (around a week later). The operating regime inadvertently had the effect of increasing the concentration of contaminants in water entering the treatment works but it also identifies the point in time before which the contaminated waste entered Rye Meads STW, (before January 2010), as the contamination must have already been in the reservoir.

1.7. Looking at the Essex and Suffolk Water case, the single supply from William Girling reservoir of about 95 ML/day would have received the contaminants direct from the River Lee, the estimated time to fully turnover the William Girling reservoir is about forty days and recorded consumer complaints began to be received from 3 February 2010.

1.8. The population potentially affected was about 2.25 million Thames Water customers in North-East London and 0.5 million Essex and Suffolk Water customers in the North-East and East Greater London area including Ilford, Barking, Dagenham and Romford

1.9. Critical to the identification of the cause of the event was a telephone call made by Essex and Suffolk to Thames Water on the morning of 11 February 2010. This call was prompted by the company detecting a strong PVA glue and citrus smell at a consumer's tap following a routine programmed sample and subsequent investigation of calls from customers reporting similar unusual taste and odours in tap water. This communication connected the consumer contacts being received by both companies and raised awareness of the two events having a common cause which in turn pointed to this being the raw water quality.

1.10. Thames Water acted to cease abstraction from the River Lee and begin using the Lee Valley Complex reservoirs increasing the contribution from the Thames Lee Tunnel to 37% introducing uncontaminated River Thames water into the supply system from 11 February onwards.

1.11. Thames Water identified the chemicals 2-ethyl-5,5-dimethyl-1,3-dioxane (2-EDD) and 2-ethyl-4-methyl-1,3-dioxolane (2-EMD) in both the final and raw water on 16 February 2010 at levels considered by the Health Protection Agency not to be a risk to health. The identification was made using expertise available through the industry's mutual aid laboratory network. The request to this network was key to identification of the causative chemicals and was a commendable decision. In previous

historical events, the identification of these chemicals has proved to be problematic because they are small, polar and highly soluble which means they are not identified through routine analysis and require special methodology to be deployed. Delays in identification of contaminants were a significant criticism of the report into the River Severn Pollution (Wem) incident of 1994[3] and the establishment and use of a mutual aid network was an important recommendation to the industry at that time.

1.12. On 18 February sampling and analysis had linked the contamination in water to a single commercial waste stream at Rye Meads (STW).

1.13. The start of the event is defined by the change in consumer taste and odour reporting rather than by the contamination. Consumer contacts to Thames Water increased through January. Towards the end of January and into the first week of February the numbers rose significantly, coincident with the first complaint being received by Essex and Suffolk Water on 3 February which marked the beginning of the event for their consumers. Diagnosis of the significance of consumer contact data is generally an imprecise process because of the influence of other factors; for example, consumers have a known tendency to report quality concerns in response to receiving their water bill and in this event there was an unrelated outbreak of viral diarrhoeal illness focused geographically on the catchment of Whipps Cross Hospital which is within the water supply zone of this event. Notwithstanding these difficulties, both companies were unable to detect the objectionable taste and odour, despite it being discernible to consumers. This observation was common to the investigation of the River Trent (Wem) Pollution incident in 1994. The sensitivity of individuals to the contaminants, the temperature of the water when analysed, the time the water remains standing and the place of the analysis, in particular the ventilation of the surrounding area, all influence the ability to detect the odour. Neither company had optimised their taste and odour analysis or screened the panellists for their ability to detect these contaminants.

1.14. A further common finding with historical events was the lack of awareness of these two chemicals by all relevant company staff. As a result, Thames Water had failed to appropriately risk assess the hazard to enable mitigation and therefore did not have the information readily available to understand what to look for and what actions to take. Consequently, the Thames Water investigation focussed on a number of aspects whilst failing to consider the probable cause as part of the wider investigation. The absence of reliable information and the subsequent decisions, to some degree, unavoidably extended the duration of the taste and odour event.

1.15. Essex and Suffolk Water relied on Thames Water for these assessments and had no water quality agreement in place to ensure that the raw water provided was of suitable quality for treatment and secure prompt communications and action about any potential raw water quality problems; consequently Essex and Suffolk Water were not aware they were being supplied with contaminated raw water for a week.

1.16. There are many similarities between this event and those which have occurred in the past but the learning from these events appears to have

been lost largely because it appears not to have been embedded effectively in operational arrangements. This report therefore emphasises these learning points and contains new considerations in the context of today's water industry. Most important of these is the need to carry out a thorough risk assessment of waste streams including the identification of every customer within that waste stream and whether or not the waste originates from resin manufacturing. Equally water companies water safety plan approach should consider the specific risks pertaining to these chemicals and the wider effects that changes (temporary or permanent) in the configuration of raw water supply arrangements may have upon that risk assessment.

1.17. Wherever water is exported and imported, be it raw or treated water, there should be water quality agreements between importers and exporters and these should contain unambiguous accountabilities, contingencies, responsibilities, including the provision and sharing of risk assessments, and lines of communication in response should be set out in the event of any abnormal situations that may affect water quality.

1.18. Critically, taste and odour methodology and personnel performing this test on site lacked the capability to enable detection of the contaminants and so both companies failed to detect the raw water contamination as it entered the treatment works. Without this, the companies did not have the necessary information required to manage the circumstances effectively.

1.19. This event was diagnosed by consumers contacting the companies and unfortunately for Thames Water, information from the water quality call handling systems was not interpreted early enough to identify the beginnings of a wide scale problem in a large water supply area; this hindered prompt identification and remediation of the cause and also led to a loss in public confidence through untimely or inappropriate consumer communications.

2. Recommendations

2.1. Risk assessments for waste streams must examine each and every individual contributor to that waste so that any potential hazard to water supplies is identified. This should be the collective responsibility of the sewage treatment works operator and any water company drawing on the raw water for water supply purposes. This must not be solely a responsibility of the waste operator, commercial or otherwise, and information should not be withheld on the basis of commercial confidentiality. In a situation where information is withheld, waste should not be accepted. Where there are private water supply users relying on the same raw water source water companies should share the risk information with local authorities responsible for private water supply risk assessments.

2.2. All water and wastewater companies must ensure that any waste which maybe a source of 2-EDD and 2-EMD is closely monitored and any resin manufacturer should be classified as high risk. Waste where the risk is high or unacceptable and cannot be mitigated should not be accepted where it could subsequently enter a raw water source however remote.

2.3. Any unusual odour discerned at a sewage treatment works should be acted upon and resolved, whether or not it is connected to an external or public complaint.

2.4. Monitoring of sewage effluent, where a risk exists, should include 2-EDD and 2-EMD and this should be embedded in any contractual agreement in the acceptance of waste to a sewage treatment works.

2.5. The effect (or not) of any dilution of effluent by the receiving river should be risk assessed and understood in relation to its function in any downstream water supply risk mitigation.

2.6. Any planned or unplanned changes in raw water supply arrangements (abstraction, storage and blending) should be risk assessed in relation to the assumptions inherent in the water supply risk assessments and mitigation measures being relied upon routinely by all abstractors (public and private).

2.7. Where a bulk supply exists, be this raw or final water, there should be:

- unambiguous water quality criteria of suitability and
- contingency arrangements when criteria are not met and
- sharing of all relevant information to enable effective risk assessment and mitigation by each party and
- clear lines of communication and accountability for timely action in response to any change in the supply arrangements or any unusual findings, bi-directionally.

2.8. Companies should ensure that taste and odour methodology on site is sufficiently robust to detect contaminants like 2-EDD and 2-EMD by personnel who are screened for their capacity to detect them. There should be recognition of the variation amongst individuals in this regard

and where detection on-site cannot be reliably achieved then there must be arrangements for routine testing at a controlled laboratory facility with panellists who can meet these requirements.

2.9. Companies should put in place operational odour testing for raw water whenever the risk assessment identifies an odour risk, observing the conditions of 2.8 and health and safety requirements.

2.10. All water companies should support and maintain mutual aid analytical and emergency networks to ensure knowledge of unusual contaminants maintained and kept up to date and regularly disseminated.

2.11. Companies should invest in the development of methods of diagnosing and evaluating consumer contact data to improve upon the capacity for early identification of an event in water supply areas which serve large populations or where water from a common source serves several different communities or more than one operational or administrative area.

2.12. Water companies should embed within their response plans consideration of the early involvement of the Inspectorate in the development of communication strategies, particularly in relation to press releases and matters of wider public interest as well as any information directed specifically to the needs of their customers.

2.13. Water companies are reminded of their duty to provide all information relevant to the full assessment of an event by the Inspectorate.

2.14. Water companies are reminded of their duties under the Water Companies Information Direction which requires timely notification of all events potentially impacting on public confidence.

3. Introduction

3.1. Between 25 December 2009 and 31 January 2010, Thames Water received 70 general water quality complaints from consumers within the North East London area. A further 71 complaints in the week following and then 25 complaints in a single day on the 8 February 2010. Companies routinely receive consumer contacts and for Thames Water the typical number received for the area is about 10 per week. Whilst not exceptional during the first half of January, the number of contacts was rising beyond this threshold level and in particular the composition of contacts being received were specifically about taste and odour, as opposed to the wider range of contact types normally reported in the Woodford and Finsbury Park area. The rising number of contacts about taste and odour should have been obvious to Thames Water in the first week of February. By contrast, Essex and Suffolk Water received their first contact of an unusual taste and odour on 3 February 2010. A total of 11 contacts were then received between 6 and 8 February 2010. Thames Water notified the Inspectorate on 9 February 2010 and also consulted the Health Protection Agency (local unit). At this stage, Thames Water considered the taste and odour problem was probably related to the chloramination process at Coppermills WTW and this was the basis of the initial conversation with the HPU. The Inspectorate notes the omission in the company's report of the record of this first HPU consultation and the company is reminded to ensure it keeps and provides records of all communications with the HPA.

3.2. A range of taste and odour contacts were received by Thames Water consumers through January 2010 with descriptions varying from chlorinous, sewage, salty, onions and perfume. The company identified 119 contacts received from 29 of the 42 Water Supply Zones (WSZ) downstream of Coppermills WTW between 03 January and 02 February 2010 approximating to 3 or fewer contacts in any one zone in a single day. None of these contacts were from consumers downstream of Chingford South WTW during January. However, overall the rise in numbers of contacts of a similar type was unusual and only an handful were described as a medicinal or TCP taste, most being classified as "other". It is probable that the taste/odour descriptor type by the customer call centre masked the common factor for some time and meant that the company did not identify the beginning of the taste and odour event expeditiously.

3.3. Overall Thames Water collected more that 400 drinking water samples and over a quarter were in response to consumer contacts. Among consumers interviewed by the Inspectorate, less than 10% from both companies said they had been visited for sampling and none were contacted before they had themselves contacted their water company. The Inspectorate notes the low response rate of the companies to consumer contacts. This may have been a missed opportunity to identify the cause at an early stage. Essex and Suffolk Water who, whilst unable to identify a problem at Chigwell WTW, was more responsive to

consumer contacts quickly identified a strong unusual taste and odour described as PVA glue and citrus about a week following receipt of the first known contact associated with the event.

3.4. The first contact from a zone downstream of Chingford South WTW was on 08 February 2010. All Chingford South zones are also fed partially by Coppermills WTW.

3.5. The first evidence of onsite investigation by Thames Water at Coppermills was 8 February 2010 when treatment works sampling included taste and odour. Thames Water was focusing on the chloramination process as the likely cause of the taste and odour and no unusual taste or odours were identified in on site tests at this time. On the 10 February 2010, Thames Water staff reported an unusual odour in drinking water at a North London workplace. This provided a clear opportunity for Thames Water to be aware of and investigate the event from a different perspective.

3.6. Essex and Suffolk Water took samples on 9 February 2010 from each slow sand filter at Chigwell. Following overnight refrigeration and reanalysis of the taste and odour samples on 10 February 2010 an unusual odour was discerned. A routine consumer tap sample taken on 10 February 2010 also failed the quantitative odour test with a significantly high dilution number (DN) of 8 and a description of PVA glue and citrus.

3.7. Essex and Suffolk Water on 11 February 2010 visited a number of consumers who had reported taste and odour. Three samples had positive quantitative dilution numbers with a PVA glue and citrus description.

3.8. At 09:45 hrs on 11 February, Essex and Suffolk Water contacted Thames Water as the bulk supplier of raw water. From this contact it became evident that Thames Water was receiving similar taste and odour contacts. This critical information led Thames Water to consider that the taste and odour problem was associated with the raw water supply.

3.9. The Inspectorate noted how reliance on their own information and knowledge failed to lead Thames Water to determine a problem with the raw water supply up to this point.

4. Taste and Odour

4.1. Working on the basis that the raw water was the most probable cause, Thames Water stopped impounding water from the River Lee to the William Girling, King George V and High Maynard reservoirs at 19:00 on 11 February 2010 and contacted the Environment Agency (EA). However, under the raw water supply configuration, it was not possible to change the bulk supply to Essex and Suffolk Water's Chigwell WTW from the William Girling. The bulk supply continued to be derived from William Girling storage reservoir from this point forward.

4.2. Between 11 and 15 February Thames Water had detected nothing untoward by analysis and was considering the probable cause as geosmin or 2-methyl isoborneol, (MIB) as common natural taste causing contaminants caused by Actinomycetes or Cyanobacteria, (blue-green algae). These organisms exhibit a very characteristic earthy or musty taste and odour. Approximately 8% of the contacts to Thames Water but only 2% to Essex and Suffolk described the taste and odour in this way. On review it may appear therefore that the company in taking the view that the cause was the chloramination process was reasonable. The company had detected no odour or tastes within the upstream process locations or in the raw water using on-site tests on 8 February. However this investigative strategy would prove to be a key failing in the diagnostic process as it diverted the company's attention away from considering raw water as the root problem and led to the delay in the identification of cause until contacted by Essex and Suffolk Water about similar contacts from consumers.

4.3. Essex and Suffolk Water discerned a PVA glue and citrus taste and odour in seven consumer samples and one secondary filtrate sample from Chigwell WTW on 10, 11 & 12 February 2010. Taste and odour descriptors used by consumers can be variable and should not be relied upon wholly to direct investigations, however, the information provided by Essex and Suffolk Water's investigation was both specific and reliable highlighting how Thames Water's failure to diagnose and analyse its own consumer contact information was a missed opportunity. In particular, the recording of the contacts as "other" rather than recording the consumer description was unhelpful.

4.4. Taste and odour assessment is considered a core operational test and skill. However, it is only semi quantitative and subjective by nature and its results have inherent uncertainty. This uncertainty is due to differences of capacity of individuals to detect a taste and/or odour generally which can be exacerbated by other personal factors such as age, gender, health, smoking, preferred food type and recent food consumption. Individuals vary genetically in their balance of taste receptors between the four types: sweet, sour, salty and bitter. This coupled with the circumstances of when and where a sample is taken and the place of testing all contribute to uncertainty. Sensitivity to a given taste or odour will differ according to the chemical, the temperature of

the water and the environment such as tasting the water when outside, because of ventilation, and the vagaries of "grab" sampling which can miss contamination that is either transient or varying in concentration around the threshold of detection.

4.5. In the case of the particular contaminants in this event, they were present only in very low amounts (sub µg/l levels) in the drinking water, and they exhibit very low taste and odour thresholds so detection was particularly challenging. However in light of 166 consumer contacts by and on 8 February 2010, the action taken by Thames Water was to test two in process samples, one pre-disinfection and one post-disinfection alongside three ex-works network taste and odour samples. There were no further active investigational samples at the treatment works until the 11 February 2010 when the company was promoted to consider a raw water problem upon which investigational sampling for algal causes occurred on four days between 11 and 15 February and on two occasions included the Woodford Depot.

4.6. The company at this point knew the problem was associated with the raw water from information provided by Essex and Suffolk Water and the descriptors from customers were variably chlorinous, sewage, salty, onions and perfume, and this was added to by information from staff at their own depot in Woodford. An algal problem would characteristically have exhibited as an earthy, musty or woody odour. The interpretation of this data may have been a missed opportunity to focus effort. There are a number of publications that discuss the characteristic taste and odour causes and give a flavour profile analysis and two of these were available to the water industry through the Inspectorate's web site and specifically discuss taste and odours in water, consumer perceptions, methods and causes. The first is by the Standing Committee of Analysts: *The determination of taste and odour in drinking waters*[4] and the second is entitled *Factors causing off-taste in waters, and methods and practices for the removal of off-taste and its causes*[5]. Both describe a range of taste and odours, their origins and the chemical or biological causes.

4.7. The key diagnostic failing by Thames Water staff was probably the absence of any quantitative taste or odour analysis of samples from the network by their laboratory. The company took 269 samples in the course of 28 investigations covering 111 consumer contacts (the remaining were routine scheduled samples) between 4 January and 15 February inclusive (before the contaminants were known). Over the whole event up to 24 March 2010 Thames Water collected a total of 414 samples. In the equivalent event period (1 February to 19 March 2010) Essex and Suffolk Water took 87 samples at customer taps of which 19 were in response to consumer contacts and 14 were resamples and 12 had a description of the odour. The company also took 200 investigational samples at Chigwell WTW of which 46 exhibited a defined odour and in some cases a taste also.

4.8. Both companies took a similar percentage of samples in response to contacts and as part of investigations (approximately 18%). The contact rate for Thames Water was three times higher at 0.6 contacts per 1,000 population (average), for Essex and Suffolk the contact rate was 0.2 per

1,000. Therefore if all other factors had been equal the likelihood of detection of the odour by Thames Water was higher. The Inspectorate therefore considers there would be of merit in Thames Water carrying out a detailed review in order to understand why they were unsuccessful and how their diagnostic processes can be improved upon for the future.

4.9. The similarities with the River Severn (Wem) pollution incident in April 1994 are numerous. In both events the odour was noticed at the sewage works but not considered significant, and no odour was detected in the river or at the water treatment works until consumers began reporting the problem. None of the staff either in 1994 or 2010 detected an odour on site from the raw water intake through to treated water at taps. In 2010 Thames Water did not detect an odour in any sample throughout the event, (other than the anecdotal report from staff at the Woodford Depot on 10 February 2010). The identification of the causative compounds took considerable time; two weeks in the case of the River Severn (Wem) pollution incident and a week in 2010 if the start point was taken as 11 February, although considerably longer otherwise. However, a key difference is that in 1994 the National Rivers Authority (now the Environment Agency) took 16 hours to pin the source to the Wem sewage treatment works, 120 km upstream from Barbourne WTW. The reason why the NRA were successful was for twofold; the personnel knew the odour they were "looking for" having been provided with a description and secondly and most importantly they used a specific sampling and testing procedure where water was taken into a sampling vessel, shaken and then vapour was sniffed rather than water decanted from the bottle for assessment.

4.10. In the case of Essex and Suffolk Water, the company recognised the need to adapt their taste and odour protocol which then started to provide diagnostic results Unfortunately the company had failed initially to carry out the test at 25^0C, (a requirement of Regulation 16(5)(d)), which meant they missed the early warnings. By chance, the company had retained a sample overnight and repeated the test the next day. This led to the first detection from a sample taken at the works on the 9 February.

4.11. Essex and Suffolk Water were using a smell bell which is a device that sprays water into an upside-down glass bell with an aperture at the top. (An example of which can be seen in the Standing Committee of Analysts publication[4]). This device enhances odours by creating a vapour. The water should be heated to 25^0C as this further enhances any organic odours. In 1994, Seven Trent Water reported that the odour caused by these organic contaminants could not be detected at any temperature below 25^0C[3]. Essex and Suffolk were running their smell-bells at 20^0C. Thames Water was not using smell bells contrary to the third recommendation of the report on the Wem incident to use smell bells. Thames Water and none of its staff at the treatment works or taking samples were trained or screened for their ability to detect odours. The lack of training applied equally to Essex and Suffolk Water staff. The fourth recommendation of the report on the Wem incicent recommended that staff involved in this work should be trained and tested for their suitability. The Inspectorate notes that Thames Water did not appear to

adapt to the developing situation and in particular did not appreciate that some odours develop over time requiring changes to the routine testing protocol.

4.12. Many tastes and odours are caused by decomposition of plants, algae and fungi and as both companies were working on this assumption as to cause, Thames Water reinstated the out of service ozone plant at Coppermills WTW on 10 February and Essex and Suffolk Water's Water Quality Team requested that the ozone plant at Chigwell WTW be returned to service on 11 February and following re-commissioning, it was put into service on 12 February. Additionally, Thames Water commenced algal analysis on 11 February. The decision by both companies to reinstate the ozone plant was reasonable in the absence of other information. Such treatment is beneficial in removing tastes and odours including geosmin and methyl isoborneol and together with treatment with granular activated carbon removes a wide range of organic compounds from water. However for the particular contaminants in this event the benefit of ozone is small.

4.13. In summary and because of the failure to either interpret, understand or identify initially the cause by Thames Water, there was a significant delay in taking effective remedial action for about a fortnight in early February. Some of the early decisions, whilst sensible in the context of the dearth of understanding and knowledge at the time, were a distraction, particularly the reinstatement of the ozone plant, and then increasing the dose twice which imposed additional operational effort and risks to water treatment to be managed. Decisions were based on generalised assumptions about raw water seasonal variability, there was not a focus on the specific taste and odour event information being given by consumers. This was in stark contrast to the Wem event where the company used taste and odour information to guide operational decisions. Accordingly the Inspectorate notes with concern that there was a failure of application of risk assessment principles and this reveals weaknesses in the water safety plan methodology as applied.

5. Identification of the Contaminants

5.1. On 16 February Thames Water obtained analytical confirmation that the specific cause of the taste and odour was due to the presence of the two chemicals 2-ethyl-5,5-dimethyl-1,3-dioxane (2-EDD) and 2-ethyl-4-methyl-1,3-dioxolane (2-EMD). The information that led to this discovery was acquired through mutual support between laboratories and scientific experts who recognised the event as having features in common with the 1994 River Severn (Wem) pollution incident of April 1994[3]. This was a key observation which was made on 15 February 2010. This reconfirms the value inherent in industry-wide collaboration to manage situations outside the everyday. The Inspectorate commends the use of mutual support but notes that its value was not acknowledged in the Thames Water report. The company needs to reflect again and in more depth on the benefits to be derived from promoting more active participation by its staff in industry wide networks and forums to maintain knowledge and to keep itself up-to-date with new knowledge. All companies would benefit from similar reflections about investing in and sharing knowledge as a matter of course.

5.2. The identification of contaminants capable of causing taste and odour problems from raw water pollution incidents poses special monitoring difficulties and this was a particular feature of this event. The compounds are highly soluble polar compounds, low in concentration and they pose difficulties in extraction, concentration and detection. It is therefore unsurprising that the company did not detect these compounds initially on GC/MS analysis.

5.3. There have been several documented reports of drinking water contamination with 2-EDD and 2-EMD. The first was reported in the journal Analytical Chemistry in August 1993[6]. This occurred at Neshaminy WTW owned by the Philadelphia Suburban Water Company in Middletown Township. In January 1992 a commercial waste facility accepted wastewater from a resin coatings manufacturer. This directly resulted in an objectionable taste and odour experienced by consumers for two weeks. It took the company approximately 20 days to determine the cause which then led to the identification of the two as then unknown compounds.

5.4. The second incident was the Worcester or Wem incident in April 1994[3] where on the 11 April 1994 organic chemicals were discharged into a sewer by Vitalscheme Limited (who specialised in the recovery of solvents used in the production of resins) passed through the Wem sewage works and then on into two small tributaries feeding the River Severn, most likely on 12 April 1994. Three days later on 15 April, consumers began to complain of a taste and odour. The identification of the organic chemicals took two weeks. The report into the incident, published in August 1994 considered this to be an excessive time and that much time would have been saved had a paper describing the Philadelphia incident come to light earlier.

5.5. From October 1993 the Tordera aquifer located in Barcelona[7] was contaminated by a factory producing saturated and unsaturated

polyester resins and sited in the upper course of the river. This caused contamination of a number of boreholes used for drinking water supply purposes with subsequent taste and odours. As a consequence of this study which looked at 48 groundwater supplies over 1994 and 1995, complaints from consumers of Barcelona's tap water were noted in November 1994 and January–February 1995. This led to the discovery of the contamination of the Llobregat River 15Km from Barcelona's WTW by a factory specialising in the elimination of industrial residues.

5.6. In September 2003 in South America[8] a major works to several million consumers had to be shut down due to many consumer complaints. In this particular instance there were a number of contaminating chemicals which prevented easy identification of the cause of a characteristic olive odour. After six weeks both chemicals were isolated and it was this information that led to the identification of the source which was a polyester resin manufacturing plant.

5.7. In all these cases the identification of the causative chemicals was difficult. In this case Thames Water identification of the chemicals occurred on 16 February 2010, five days after the company was alerted to the fact that the problem was one of raw water by Essex and Suffolk Water on 11 February 2010. It was a day later that Thames Water appeared to take remedial action because on 12 February the River Lee intake was closed, the ozone dose was turned up and the laboratory requested assistance. The 1994 Wem incident was resolved within this timescale therefore it was time taken by Thames Water to recognise a raw water event, rather than the time taken to identify the chemicals, that was the issue on this occasion. Notably, the identification of the causative chemicals in the Wem incident was a secondary consideration because the event was solved by the most practical of ways, source tracking using the human nose. In hindsight the criticism of the laboratory in the report of the Wem incidentt[3] was overly harsh given that only one previous event world wide had been recorded at the time[6]. The Inspectorate's own report on the Wem incident (Number 36/2/1) did not endorse this criticism of analytical science and this is the case in this event also because by 15 February the laboratory mutual network suggested the answer and on 16 February the laboratory was able to identify 2-EDD and 2-EMD. Indeed the Inspectorate notes this was the fastest identification of these compounds in any of the recorded and known events worldwide. The industry is reminded of the value to be derived by collective investment in the knowledge and information systems and expertise to be called upon promptly.

5.8. For the purposes of industry learning and understanding the mass spectra of both organic compounds together with a brief outline of methodology is provided in Appendix VI.

6. Source of the Contaminants

6.1. Rye Meads STW is located about 10 miles upstream of the intake to the Lee Valley reservoirs. Sewage arrives at the works via three sewers carrying sewage sludge, waste from inter-site tankers and a dedicated commercial waste stream. The treatment processes comprise of preliminary treatment, to remove grit and screenings, followed by primary sedimentation and activated sludge treatment in aeration tanks. After settlement of the activated sludge, the effluent passes through a lagoon system to provide further effluent polishing. The effluent is monitored for suspended solids, BOD, ammonia and phosphate. Sludge from the primary and secondary settlement stages is thickened and blended and then passes through primary and secondary digesters after which it is dewatered by presses. The solids from this process are recycled to land and the water fraction returns to the head of the works and passes into the effluent line for processing through the works.

6.2. The commercial sewage stream, managed by a large commercial waste company, enters at the blending point prior to primary and secondary digestion. The waste company was responsible for the receipt of the waste, and sampling and blending of their tankers. Control of this is by chemical oxygen demand and volume up to a limit of 270m^3/day. Site quality control for their own waste stream was carried out within the terms of the contract set up in April 2004 which required only waste that is biodegradable and contained specific exclusions such a pharmaceuticals, petroleum and the Environment Agency list of 88 substances of concern. The waste company assessed their own clients' waste however it was the responsibility of Thames Water to ensure that the waste did not affect the treatment process, the effluent quality, the environment and specifically the quality of the raw water abstracted for water supply purposes. This was assessed through analysis twice a week for ammonia, metals, solids, COD and oils and four times a year using GC/MS for organics. The contract was managed by a Senior Consultant for Waste Water employed by Thames Water. The site manager and operational staff at Rye Meads had no control over the commercial waste company activities nor did they have knowledge of the individual clients of the commercial waste provider because this information was classed as confidential.

6.3. Rye Meads STW is located within the Chingford South and the Enfield Lock Intake community and was deemed to be high risk due to its proximity to the intake. The risk assessment required that the company identify the highest risk potential contaminants through consideration of licence and discussion with the Environment Agency as necessary. The company had committed to monitor these sufficiently to validate the risk assessment under normal conditions.

6.4. The commercial waste company was identified as part of the drinking water safety plan, (DWSP), but not specifically in the risk assessment, although the consequential risk score was said to be in the highest category of risk available. Thames Water within the risk assessment considered that this was an acceptable risk through mitigation by audit,

review and implementation processes. However, the agreement with the commercial waste company which lists the Environment Agency chemicals of concern did not list either 2-EMD or 2-EDD. The risk assessment produced by Thames Water with assistance from an external consultancy did not include identification of 2-EMD or 2-EDD because the person who was responsible for the risk assessment did not know of the existence or significance of these two chemicals.

6.5. Both water companies' risk assessments identified contamination of the River Lee by sewage effluent as a separate hazard and listed the risks as BOD, Ammonia, Solids, and Dangerous/Priority substances. Both companies considered these risks to be mitigated and therefore acceptable. The only unacceptable risks assessed by Thames Water for the Chigwell community intake, (the raw water supply to Essex and Suffolk Water), was operator competency with poor visibility of staff competency and inadequate system for training record updates. The only unacceptable risk at Coppermills WTW was the risk associated with power loss and the lack of emergency power back-up for the site. In 2009 the company included a scheme to address this risk in its business plan for the Ofwat price review process.

6.6. The Rye Meads STW manager and Process Control Engineers, (PCE's) were not involved in, or aware of, the water safety plan process and methodology. In practice their only involvement with staff at Coppermills WTW was to highlight a risk when the ammonia concentration in effluent increased when they would contact staff at Coppermills WTW to alert them of the need to close the intakes.

6.7. After identification of the contaminants, Thames Water sampled the raw water reservoirs on 16 February 2010. Within the Lee Valley storage reservoirs on 16 February the highest concentration of 2-EDD was 0.352µg/l and for 2-EMD this was 0.192µg/l (semi-quantitative analysis only) in the William Girling reservoir.

6.8. Thames Water's report states that on 16 February 2010, on-site inspections were conducted at all of its 26 Sewage Treatment Works in the catchment and this identified an unusual odour associated with a process stream treating commercial waste at Rye Meads sewage treatment works, (STW). In statements given to the Inspectorate, neither the Rye Meads Team Manager nor the Process Control Engineers, mentioned this. One knew about the drinking water taste and odour problem in North London via an internal e-mail around the 12 February 2010 and another became aware by word of mouth on 21 February 2010 and then subsequently through a call from the catchment Manager on 22 February 2010. The Manager was on leave at the time.

6.9. On 18 February 2010 analysis of a Rye Meads STW final effluent from a routine retained sample from 12 February detected 2-EDD at 2.52µg/l and 2-EMD at 1.761µg/l. Samples by the Environment Agency on 24 February detected both 2-EDD and 2-EMD downstream of Rye Meads but not upstream. These findings proved beyond reasonable doubt that the cause of the taste and odour issue was the presence of low levels of 2-EDD and 2-EMD in the River Lee was treated sewage effluent from Rye Meads STW.

6.10. Retrospective analysis of a four week combined Rye Meads sample from January from the dedicated waste stream gave values in this waste stream of 8.1mg/l 2-EDD and 2.8mg/l 2-EMD. There was no historic material for December 2009 so it was not possible to determine when the contamination first started. Thames Water was also able to sample the head of the works before and after the liquid return from the dedicated waste stream and this did not identify any of the compounds before the return and showed levels of 1.36µg/l and 0.36µg/l for 2-EDD and 2-EMD after liquid return This conclusively proved that the source was the commercial waste. The contamination persisted into February with retrospective samples of the waste stream from 13 February measuring 5.6mg/l and 1.3mg/l for 2-EDD and 2-EMD respectively.

6.11. Thames Water collected samples from traders whose waste had been handled and discharged at Rye Meads STW via the commercial waste company However, this testing did not yield information to identify the trade source. Subsequently a review of other traders whose waste is managed by the commercial waste company was conducted and samples examined. This exercise identified one company where the target compounds were identified at high concentrations (2000µg/l and 2350µg/l respectively). Investigations identified this trader as a resin manufacturer. This source is common to all historical incidents involving 2-EDD and 2-EMD. It is however also worth pointing out that the mixing of wastes containing aldehyde and glycol may also have the same outcome.

6.12. The sewage treatment including blending the sewage had the effect of reducing the contaminant level (hundred to one thousand fold) compared to that found in the final effluent at the outfall.

6.13. 2-EDD is the most odorous and distinct of the two compounds as demonstrated by the historical incidents. The report on the 1994 Wem incident[3] made a series of recommendations but the first recommendation states that “An observation on any unusual smell detected in an effluent should be a standard requirement in routine tests, at sewage treatment works.” The second recommendation required a method to assess the odour of effluents to be developed, taking into account health and safety of the staff.

6.14. At Rye Meads STW in 2010, there was no formal odour monitoring other than the odour management plan for external public complaints which are followed up by the Team Manager. In the most part he was successful in resolving complaints, but not always, which he then escalated within the company. However, any subsequent action and its effectiveness when odours were found is questionable. This was particularly the case when any odour was not associated with a complaint but only noted on site. It is notable in statements to the Inspectorate that the staff were disinclined to report such matters in recent years because no action was taken, most notably when there was a previous petrol like odour. This situation represents a missed opportunity by Thames Water because relevant odours had been noticed and investigation of them may have identified issues with the commercial waste stream.

6.15. One of the two PCE's had a call from the catchment Manager on 22 February 2010 to advise him of the taste and odour event and to arrange for the shutting down of dewatering, (liquor return) from the commercial waste stream because the taste and odour had been traced back to the sludge stream. The return was stored on site and subsequently tankered away for disposal in another way with the agreement of the EA. The Team Manager was only informed of this decision by the Catchment Manager on 23 February and the process Manager was on leave at the time. The process Manager understood that the commercial waste company had been stopped from putting any further waste into Rye Meads, however, the letter to this effect from Thames Water was not sent until 4 March 2010.

6.16. It was therefore at least 11 days before the source of the contamination was stopped and probably the contamination was occurring for a period of seven weeks, assuming that all four weeks of the combined sample contributed to the contamination, or longer using the reservoir turnover information described in the next section. This duration compares unfavourably with that of the 1994 Wem incident

7. Raw Water Management

7.1. In the absence of information suggesting that Rye Meads STW was contaminating the River Lee, Thames Water continued to abstract water into the raw water reservoirs up until 12 February. This could have been continuing for at least six weeks based upon the combined effluent sample, or longer if based on consideration of the turnover rate of the reservoirs.

7.2. The River Lee at the Rye Meads effluent channel is on average between 0.22 to 0.65 meters deep and the flows at Fields Weir was on average 8.3 cumecs (range 3.8 to 37.6) between January and March 2010. In comparison the River Thames flow at Walton Bridge in West London is on average 53 cumecs, (max 135). The River Lee is therefore a relatively small river. The discharges from sewage treatment works augment flows and support abstractions further downstream. Out of the 178Ml/d consented discharge into the catchment, 101Ml/d (57%) is from sewage treatment works. In some stretches, during long dry periods, discharges from STWs make up the only flow in the river[11]. Rye Meads STW together with Deephams STW are the source of the most significant sewage effluent discharge into the River Lee, and this forms part of The London Catchment Abstraction Management Strategy[12] as published by the Environment Agency

7.3. Based upon the analytical data, the River Lee dilution capacity between the outfall and the intake is from as little as 7 fold to 269 fold for 2-EDD and 3 fold to 65 fold for 2-EMD. The variance is likely to be due to changes in flow volume of the river and volume of outfall, as well as analytical and sampling uncertainty during the period. The distance between outfall and intake is around 10 miles so comparison has been made of data from the same days. The river being primarily composed of discharge clearly contributes only a small dilution effect of the contaminants from Rye Meads. As this event occurred in January/February the river would be expected to offer probably the best dilution possible, when compared with the summer when river levels are substantially lower. In one risk assessment, the contribution to the river of effluent in the summer from Rye Meads is recorded as being as high as 90% by volume. This is clearly an important factor to be taken into account in any drinking water risk assessment.

7.4. The River Lee on 12 February at the intake of the William Girling Reservoir contained 0.037µg/l 2-EMD and 0.013µg/l 2-EDD. The day before, the levels in William Girling were 0.154µg/l and 0.077µg/l and in King George V 0.042µg/l and 0.025µg/l for 2-EMD and 2-EDD respectively. In effect the concentration of contamination in the reservoirs was higher than in the river at the intake on that date. A higher concentration of contaminants in the reservoirs would imply that the water was either completely replaced from the inlet with a concentration that was previously higher, or if not completely replaced, then the concentration from the intake was significantly higher prior to 12 February 2010.

7.5. This is a very important observation because the nominal residence time calculated by volume for the William Girling reservoir is on average 116

days and at maximum flow is 89 days (divided by flow). This calculation implies all the water is replaced, but assuming this does not happen in practice due to factors of mixing/flow, then a calculation of 33 – 43 days has been assumed. This means the movement of a chemical from river to the intake would take between a week to ten days. Between 11 and 24 February 2010, the concentration of 2-EMD in the William Girling reservoir was twice that at the intake and four times for 2-EDD. The level of 2-EMD in William Girling was 10 -15 times above the odour threshold and in the King George V reservoir, 4 times higher than the threshold. This circumstance could not be explained by the ten day direct path as mentioned above. This points towards the importance of the embankment works on the King George V reservoir which meant the intake was closed between 26 December 2009 and 14 January for all but three days and Coppermills WTW remained in constant use at 8% draw down. On the week beginning 8 January 2010 the amount taken from King George V reservoir into Coppermills WTW increased by nearly 10% to 17%, (increase between 20 Nov and 5 February 2010 was a 6.8% to a 20% contribution), and the demand from the Thames Lee Tunnel which takes water from the River Thames fell by 6% to 14%, (decrease between 20 Nov and 5 February 2010 was 21% maximum to an 11% contribution) (Appendix II). This River Thames water was free from contaminants. The first spike in consumer complaints occurred shortly after this time and therefore the reservoir must have been contaminated on a date before 26 December 2009. It is likely that this routine change in the raw water management regime (mix) caused the contaminant concentration which was already likely to be within the reservoir to increase to above the taste and odour threshold enabling sensitive consumers to discern its presence.

7.6. The closure of the intake (downstream of Rye Meads STW) on 12 February, whilst an important action of remediation, was too late to be preventative. However, it is important to note that had Thames Water implemented learning from the 1994 Wem incident (third recommendation) by implementing improved odour tests then the early warning information would have been available to enable the intake to have been closed earlier. The recommendation suggested the use of smell bells at works and whilst Thames Water had initially followed this advice, they were removed by the company quoting health and safety reasons. Had this decision not been made then the 2010 event may have been prevented.

7.7. Coppermills WTW can be directly supplied through the Coppermills Stream and the Spine Tunnel from William Girling and King George V reservoirs and/or by Walthamstow reservoir and East Warwick reservoir which are in turn fed by High Maynard reservoir. Analytical data showed that all routes feeding Coppermills WTW contained both contaminants in some proportion and this is consistent with all these sources receiving River Lee water abstracted below Rye Meads STW in some proportion before changes to the raw water supply arrangement. As an example, 0.455µg/l of 2-EMD was measured in the Coppermills Stream on 21 February 2010 ten days after the intake closure. Changes in raw water configuration (with the proportion from the Thames Lee Tunnel rising to

36%) shows the influence of River Thames water upon the whole event. High Maynard Reservoir, Coppermills Stream and the Spine Tunnel are fed by the Thames Lee Tunnel. It is unsurprising that the consumer complaints continued to rise to a peak on 16 and 17 February before a subsequent decline as the water supply system was cleared of contaminants over five days in line with the increased flow of raw water from the Thames Lee Tunnel

7.8. When the company first became aware of the raw water problem they closed all the intakes from not only the River Lee but also from New River and contacted the EA. In hindsight the closure of the intake from the New River proved to be unhelpful because this river divides from the River Lee upstream of Rye Meads and was therefore free of contamination. Seventy percent of the raw water supply for the King George V reservoir came from this source and so by closing this intake, an opportunity was missed to maintain a contaminant free intake for the reservoir which would have diluted the existing contamination and provided a better quality supply to both Chigwell WTW and Chingford WTW. A decision supported by reliable odour monitoring would have aided the decision about remedial raw water management.

7.9. The raw supply to both Chingford WTW and Chigwell WTW could not be changed away from either the William Girling or the King George V reservoirs. The supply to Chingford WTW remained a blend of approximately 70:30 respectively and for Chigwell WTW the bulk supply was left as being solely from William Girling reservoir. The reason for Thames Water supplying Essex and Suffolk Water entirely from the William Girling reservoir was because the levels of water in King George V storage reservoir were already low due to maintenance activities on the embankment. The embankment works therefore proved to be a contributory factor to the event duration as they had the effect of removing an alternative supply to Chigwell WTW. As the William Girling reservoir receives its entire supply from the River Lee it consequentially had a higher concentration of the contaminants and this was confirmed later by analysis. However, had the source of the contaminants been known, this fact would have been obvious and Thames Water could have, and should have, changed the bulk supply to Essex and Suffolk Water to being entirely from King George V reservoir.

7.10. The Inspectorate is critical that there was no alternative arrangement for water which is exported to another company and also that there was no bulk supply agreement with quality monitoring to prevent this situation from arising contractually. At the time an unusual odour was noted in a sample taken from William Girling so the company were aware that the bulk supply was unsuitable therefore the decision was for reasons of quantity (level in the King George V reservoir) rather than quality.

7.11. The concentration of both contaminants on 11 February in King George V reservoir was approximately one-third of that in William Girling, the proportional difference to the volume of intake from the New River to that of the River Lee. Thames Water changed the bulk supply for Essex and Suffolk and incrementally changed the supply for Chingford WTW to 70% from the King George V Reservoir on 17 February and reopened

the New River intake only after it was aware, through analysis, of the relative contaminant levels.

8. Final Water Management

8.1. In this event Coppermills WTW became the main focus for Thames Water because the area supplied by this works was receiving twice the rate of consumer contacts compared with the area supplied by Chingford WTW. Chigwell WTW was managed by Essex and Suffolk Water but it received a bulk supply of water from Thames Water and should therefore have been an equal focus of attention and information.

8.2. There are two treatment processes in use at Coppermills WTW designed to control pesticides, but also capable of dealing with taste and odours and these are ozone and granular activated carbon (GAC) installed within slow sand filters. The process diagrams can be seen in Appendix III.

8.3. In October 2009, Thames Water refurbished the plant installing new dielectrics. However, due to operating problems, the ozone plant was not operating between October 2009 and February 2010. Ozone dosing at Coppermills WTW was re-instated on 10 February in response to the event, but as discussed earlier, this was because the company was considering the cause at that time might be algal.

8.4. Following re-introduction and assessment, ozone concentrations were incrementally increased during the event from 1.5mg/l to 3.75mg/l in response to emerging information.

8.5. The company carried out a number of checks at the treatment works including filtration, GAC and disinfection, as well as organising site audits by its own scientists. The company found no treatment deficiencies or network activities that might have been contributory to the event.

8.6. Essex and Suffolk Water also examined slow sand filters and network activities and found nothing abnormal other than the raw water resulting in a contact to Thames Water.

8.7. Thames Water sampled at a number of locations including retrospectively on retained samples and both compounds were identified in treated water from Coppermills WTW. Sample results in Coppermills WTW treated water contained concentrations of 2-EMD ranging from 0.124µg/l to 0.156µg/l and of 2-EDD ranging from 0.016µg/l to 0.026µg/l between 15 and 19 February 2010. Chingford South WTW contained a result of 2-EMD of 0.037µg/l and 2-EDD of 0.0005µg/l on 18 February. Chigwell WTW contained a result of 2-EMD of 0.018µg/l and 2-EDD of 0.0005µg/l on 25 February as the single result. Sampling at the works and in distribution continued and showed concentrations declining over time following the remedial action in relation to intakes described above.

8.8. The quantity and quality of the data, together with the inherent variability of the analytical methodology and sampling and also the low concentrations of 2-EMD and 2-EDD observed, all make extrapolation of the effectiveness of their removal by the water treatment processes problematical. However, there would appear to have been minimal removal at Coppermills WTW and only some removal at Chingford and Chigwell WTW. These observations confirm that no particular treatment

process is favourable for removal of these chemicals. The three treatment works included between them, all conventional processes, ozone, coagulation, and both rapid gravity filters and slow sand filters with GAC. This observation is consistent with the scientific literature

8.9. Thames Water took samples at four treated water service reservoirs and the earliest of these samples was from 22 February at Woodford Forest Service Reservoir. The maximum value measured was 0.146µg/l 2-EMD and 0.015µg/l 2-EDD on this day. Thereafter the values reduced in all reservoirs. The Inspectorate has noted that Thames Water did not sample at Stewardstone service reservoir until 11 March 2010 which is not consistent with a timely event response.

8.10. Sampling was carried out at consumer taps between 6 February and 16 March. The maximum values found were 0.186µg/l 2-EMD and 0.022 µg/l 2-EDD on 18/19 February 2010. This was one week after the River Lee intake closure and coincides with the peak number of consumer contacts. After this date the levels reduced although they remained above the odour threshold of 0.1µg/l for 2-EMD until 9 March and for 2-EDD on 25 February 2010. Again this coincides with the decline in consumer contacts.

8.11. There was no sampling undertaken by Essex and Suffolk for these compounds at consumer taps.

9. Health Protection Agency Liaison

9.1. Thames Water held an initial meeting with the local Health Protection Unit (HPU) of the Health Protection Agency on 9 February 2010 and then a follow up meeting took place on 10 February 2010 Notes of these meetings were not provided to the Inspectorate by Thames Water and the company is reminded that all information in respect of an event must be included in the company's final event reports. The meetings were held at a point in time before Thames Water had determined the cause as raw water matter, (Essex and Suffolk where still being supplied with the contaminated bulk supply). At this stage the company advised there was a problem with the chloramination process and HPA advice was given on this basis. It was also reported at this time that about 10% of consumers were reporting symptoms of diarrhoea, headache and skin rash. The HPA advised that there was no increased level of potentially water related illness in the population of the affected area; however, the Director of the North East/North Central London HPU was aware of a large outbreak of norovirus, (a group of single-stranded RNA viruses that cause acute gastro-intestinal illness lasting 2-3 days, self limiting and often transmitted by hand to hand contact, surfaces and the faecal-oral route), affecting the catchment of Whipps Cross Hospital. It was considered that the norovirus outbreak was not related to water and it was noted that disinfection was operating effectively for virus removal.

9.2. Essex and Suffolk Water notified the HPU on 11 February and sought independent medical advice on 13 February 2010 with their contracted advisor who also had also attended the HPU meeting on 10 February 2010. Their advice was to monitor the situation in close liaison with the Health Protection Agency.

9.3. Thames Water became aware of the two chemicals, namely 2-EMD and 2-EDD on 15 February through the mutual support network and sought toxicological advice on that day. The company identified both chemicals in samples on 16 February 2010 and due to this new information called a meeting with the HPA. The meeting held over two days (17 and 18 February) included Essex and Suffolk Water, the Chemical Hazard and Poisons Division, (CHaPD), Health Protection Agency (HPA) and on the 18 February the Inspectorate was in attendance.. CHaPD provided written advice on 18 February 2010 which stated that *assuming the laboratory analysis was suitably quality controlled then the reported concentrations are several orders of magnitude lower than the levels expected to cause health effects in humans.*

9.4. Results from Coppermills WTW s confirmed concentrations of 2-EDD of 0.024µg/l and 2-EMD of 0.143µg/l in drinking water, above the 0.01µg/l taste and odour threshold., therefore it was concluded that these levels may lead to consumer taste and odour complaints.

9.5. Following the Wem incident there were two health studies carried out and published in 1996 and 1998 respectively. The first study investigated whether exposure to tap water contaminated with 2-EMD and 2-EDD was associated with an increase in self reported symptoms between those who noticed an unusual taste and odour and those who did not.

The second study looked at bias in self reported symptoms to an emergency helpline. In the first study by S. E. Fowle[10] et al, 62% of subjects, (867 of 1398) in the study group had noticed the taste and odour. Among those who had not noticed any unusual taste and odour, there was no association between drinking the water and reporting individual symptoms, only between increasing dose and nausea. Among those who had noticed the unusual taste and odour, there was both an association and a dose response between the water and the reporting of diarrhoea, nausea, headache, stomach pains, skin irritation and itchy eyes. In the second study by David L. Fone[9] et al, 106 complainants to an emergency helpline were sent a questionnaire asking about symptoms following consumption of tap water during the incident in 1994. 89 complainants responded of which only 45 were in fact exposed to the contaminated water. The study found no difference in rates of self reporting of symptoms between those exposed and those who were not. This suggests that the 'worried well' used the helpline regardless of whether they were exposed. The findings from these studies have been taken into account when assessing the response of consumers during the 2010 event.

10. Consumer Perceptions

10.1. From 3 January to 21 March, the total number of consumer contacts to Thames Water during the event was 1114 and 104 of these mentioned illness (total population of affected area was 2 million). After excluding repeat contacts, 848 of the contacts were unique and 12% of these referred to illness. In the area supplied by Essex and Suffolk Water the contacts occurred between 3 February and 11 March and there were 97 in total, of which 7 (7%) mentioned illness. It is possible that the difference in reporting rates reflects the higher concentrations measured in water supplied from Coppermills WTW compared to Chigwell WTW as this would be consistent with the above mentioned published findings. The peak consumer response in terms of number of unique contacts occurred between 15 and 19 February 2010.

10.2. Essex and Suffolk Water's report describes how their water quality department liaised with their communications teams and call centre to ensure that the information being given out to consumers was up to date and accurate. Written guidance was issued to call centre staff on 15 February. On 19 February 2010 Thames Water updated their customer centre with public health information including the names of the chemicals identified, the source (River Lee) and the advice given by the Health Protection Agency. Further updates occurred over subsequent days.

10.3. It is not uncommon for the first indication of a problem to be contacts from consumers. In the 1994 Wem incident the first customer contact was recorded at 07:50 hours, multiple contacts (20) were received by 09.40 hours and within 80 minutes the treatment works had been shut down. However the situation in the 2010 event was not directly comparable because the scale of the works in the Wem incident was relatively small (served 30,000 consumers). Looking at the Essex and Suffolk Water situation, the population was an order of magnitude greater (460,701 consumers). The first consumer contact to the company was received on 3 February 2010 but it was only three days later that it became evident that there were multiple contacts (on 6 February 2010 there were three contacts) and by the time Essex and Suffolk Water called Thames Water there had been 31 contacts recorded. After taking into account the larger scale and complexity (multiple zones) the response of consumers in the Essex and Sufffolk supply area is comparable to that recorded for the 1994 Wem incident. In the case of consumers in the Thames Water supply area there were 166 contacts received upto and including 8 February. Although the absolute number is four times greater than experienced by Essex and Suffolk Water, the contacts came from 42 different zones compared to just eight zones for Essex and Suffolk Water. The question arises therefore as to whether it requires five times the number of consumer contacts to be received before an event can be recognised across an area which comprises five times as many zones. The findings from the 2010 event would imply that the scale and complexity of a supply area is a rate limiting factor in respect of speed of event recognition. A

confounding factor in establishing retrospectively the exact start of the event in the 2010 event was the Norovirus outbreak in the community centred on Whipps Cross and also the retained effluent sample which was a pooled sample representing a four week period of time. Using just the Essex and Suffolk Water consumer data would identify the start of the event as the beginning of February and this is not inconsistent with the Thames Water consumer data which showed a noticeable increase in reporting towards the end of January into the beginning of February. This suggests that it was only in late January, rather than December, when the chemicals reached or exceeded the threshold taste and odour concentration in tap water sufficient to evoke a consumer response. In summary the operational consequences of the change in the raw water management regime to accommodate maintenance of the King George V reservoir appear to have been critical to raising the concentration of contaminants in the raw water to a level sufficient to impact on tap water quality and hence consumers.

10.4. The 2010 event reinforces the value of tracking consumer responses once an event has been recognised and facts illustrate that Thames Water did not perform well in this regard. Essex and Suffolk Water tracked six consumers by call back on 12 March, (and attempted but failed to contact another ten consumers) and this strategy proved successful in determining that residual post event concerns had been resolved. Thames Water tracked 11 consumers (a 1% sample compared to the 6% sample of Essex and Suffolk Water). Overall therefore Thames Water did not sufficiently determine that consumer concerns were resolved and this lack of follow through is reflected in the company's report which did not consider such matters. However the company did write to all consumers who had contacted them during the event and this letter was sent on 26 March 2010.

10.5. There were 16 consumers from the area supplied by Thames Water who made direct contact with the Inspectorate (2% of unique contacts in response to the taste and odour event) and the equivalent numbers (3) were received from Essex and Suffolk Water's consumers. The first contact from a consumer in the Thames Water area was received by the Inspectorate on the 10 February 2010 and the last on 5 March 2010. The first contact to the Inspectorate from a consumer of Essex and Suffolk Water was on 18 February 2010 and the last was some months later on 28 June 2010. The peak for consumer contacts to the Inspectorate occurred between 19 February and 23 February (typically 3 or 4 a day). The number reporting illness complaints represented 12.5% of the total (exactly in proportion to the illness reporting to the companies).

10.6. The first contact to the Inspectorate, who was a customer of Thames Water, reported a strange taste and odour in tap water to the company from mid-January onwards before contacting the Inspectorate. The consumer expressed a lack of trust in the company. *It was said the company was very reluctant to admit initially that there was a problem*. This was a recurrent theme in the subsequent 15 contacts to the Inspectorate; the time taken to acknowledge there was a problem was crucial to consumer perception, as was the lack of any statement from an independent health advisory body about the risk posed by the

chemicals found. The relatively low key media coverage caused some consumers to believe that there had been “a cover up”. These perceptions are a direct reflection of the uncertainty as to cause within Thames Water and this can be tracked exactly by the experience of the first consumer to contact the Inspectorate. He was told firstly that there was a problem with the chloramination process and then by 18 February he was being told about the presence of the odoriferous chemical contaminants. His experience independently verifies the information being given out by the company at various points in time but it also illustrates the fragility of consumer confidence in the face of a protracted event where information changes over time. For the majority of consumers their concerns dissipated when their supply returned to normal however for a minority the event resulted in a more significant erosion of confidence in drinking water safety.

10.7. The Inspectorate directly sought the views of all those consumers who had contacted the two companies during the event using a standard event questionnaire. This group of consumers is not a representative sample of the population potentially affected instead it comprises those consumers who had been sufficiently motivated to call their water company in response to the event. It is of interest to note that about 4% of those who completed the questionnaire stated that they did not notice anything different about the water supply. All had stopped using the water for drinking, cooking or washing or a combination thereof and all heard about the event through the media. Almost two thirds noticed the problem in February with the remainder noticing it first in January. Three-quarters stated they were given advice by the company as a consequence of making the phone call, the rest did not recall receiving any advice. Some 3% mentioned that they had been offered an alternative water supply by Thames Water, compared to none of the respondents from the area served by Essex and Suffolk Water. (Full questionnaire data is provided in Appendix VIII)

10.8. The Inspectorate visited and interviewed twelve consumers, six from each company. At around the time of the event all of these consumers had noticed a change to the taste and odour of their water and whilst descriptions varied (including “onions”, “decaying fish”, “yoghurt” and in one case describing the smell as “effluent”) all found the quality of the water at this time to be unpleasant and unacceptable. In general the consumers all turned to using bottled water as an alternative, although one consumer initially continued to drink the water after passage through a filter, but this reportedly made no difference to the taste and odour. Two of the consumers reported developing skin rashes and another consumer who continued to use the water (boiled and in hot drinks) later suffered a bout of diarrhoea, for which she sought medical advice and tests. Largely the interviews verified and followed a similar pattern to the responses given by the wider group in the questionnaires.

10.9. In summary, the Inspectorate’s own investigation obtained reliable evidence that consumers rejected the water for drinking, cooking and washing (domestic purposes) on grounds that it tasted or smelt objectionable and therefore the investigating inspectors concluded that

both water companies supplied water unfit for human consumption during the course of the event.

11. Media Reporting

11.1. There was significant media interest in this event primarily focussed on Thames Water. Coverage included BBC Radio 4, BBC London News online, BBC London News (TV), the BBC Web site, (Appendix IX), The Evening Standard, ENDS Report and a number of local London newspapers. The first of these appeared on 16 February in the form of a report on BBC London News at 18:30 hrs. The BBC followed up with an article on 26 February 2010. Only two newspaper articles mentioned Essex and Suffolk Water. The first report was an article in the Waltham Forest Guardian on 16 February and the second article appeared in the Barking and Dagenham Post on 24 February.

11.2. The first press statement by Thames Water was made on 19 February 2010 following identification of the chemicals. This named the chemicals and included the advice of the HPA as the basis for the company's opinion that there was no reason to believe that there was a significant risk to public health. Subsequent press releases occurred on 24 and 26 February and 02 March 2010. Essex and Suffolk Water responded directly to each press statement and article.

11.3. Both companies liaised with the Inspectorate in relation to media and press interest throughout the event, although initially Thames Water's press office had to be prompted of the need to do so by a contact by the Inspectorate on 15 February 2010.

12. Liaison with Stakeholders

12.1. The Inspectorate was notified of the event on 9 February 2010. A multi disciplinary incident management team was convened by Thames Water between 3 and 10 February 2010; however the company failed to accurately document when their incident management procedures were evoked therefore it is questionable as to whether notification was timely, not least because 252 consumer contacts were received by the company between 3 January and 8 February 2010. The company has since recognised the need to improve procedures in this area.

12.2. The Environment Agency was informed by both companies on 11 February 2010 via their Incident Hotline when it was known that the cause was associated with contamination of raw water. Ongoing liaison occurred after this date.

12.3. Thames Water was contacted by Essex and Suffolk Water on 11 February. No prior contact was made with Essex and Suffolk Water and both companies have acknowledged that there was no formal agreement in place between them regarding communication or raw water bulk supply quality.

12.4. Thames Water requested assistance on 11 February 2010 from the industry's laboratory mutual aid group to obtain information concerning the source of the taste and odour. The group responded with advice about 2-EDD and 2-EMD, spectra and standards. The Inspectorate commends and highlights this action as being significant in management and resolution of the event thereafter.

12.5. Consumer Council for Water was notified on 10 February and the relevant Local authorities (Environmental Health Departments) were notified between 10 and 16 February by Thames Water and on the 11 February by Essex and Suffolk Water.

12.6. Information on contact made with the Health Protection Agency is given elsewhere in this report.

12.7. Toxicological advice was requested by Thames Water from NCET-WRc on 15, 16 and 17 February regarding both 2-EDD and 2-EMD. Essex and Suffolk Water did not independently seek this advice which was shared with them by Thames Water.

13. Lessons Learnt

13.1. Both companies have reviewed the event, drawn conclusions and taken actions in response to their internal findings. Thames Water intends to review discharge agreements with trade effluent dischargers. It also intends to review risk assessments and share this work with Essex and Suffolk Water. The Inspectorate endorses this approach, particularly the learning point regarding sharing and transparency between companies.

13.2. Both companies intend to review taste and odour methodology and monitoring at water and sewage works as appropriate

13.3. The companies intend to formalise all bulk supply agreements in relation to communications and quality.

13.4. Thames Water has made changes to its handling of consumer contacts to ensure that patterns can be identified earlier and actions are taken to record calls about quality concerns.

13.5. The Inspectorate is pleased to note that findings from the event are to be shared with the wider industry at a workshop for Health and Local authorities.

13.6. Other technical actions cover analytical and treatment methodology for the identification and removal of the causative chemicals.

14. Contraventions of the Water Supply (Water Quality) Regulations

14.1. The water supplied from Coppermills WTW and Chingford South WTW by Thames Water contravened the Water Supply (Water Quality) Regulations 2000 (as amended) by virtue of the presence of 2-EDD and 2-EMD which led to the rejection of the water for drinking, cooking or washing by 369 consumers responding to a questionnaire issued by the Inspectorate. The odour threshold for both chemicals is 0.01µg/l and there were 39 samples exceeding this level for 2-EDD and 207 samples exceeded this threshold for 2-EMD. Out of all the laboratory tests for taste or odour which were carried out, none were positive.

14.2. There is no specific standard for these chemicals in the Water Supply (Water Quality) Regulations but schedule 1 part 2 national requirements sets a standard for both taste and odour as "acceptable to consumers and no abnormal change". At least 369 consumers rejected the water for drinking or washing or cooking (or a combination thereof) based on objectionable taste and odour. Six of these provided witness statements to this effect. Accordingly Thames Water Utilities Ltd breached the taste and odour standard and supplied water that was not wholesome as defined in Regulation 4(1) and these contraventions were not trivial

14.3. The water supplied from Chigwell Works by Essex and Suffolk Water (Northumbrian Water Limited) contravened the Water Supply (Water Quality) Regulations 2000 (as amended) by virtue of the presence of 2-EDD and 2-EMD, which led to the rejection of the water for drinking, cooking or washing by 43 consumers responding to a questionnaire issued by the Inspectorate and six provided witness statements to this effect.

14.4. There is no specific standard for these chemicals in the Water Supply (Water Quality) Regulations but schedule 1 part 2 national requirements sets a standard for both taste and odour as "acceptable to consumers and no abnormal change". . A total of 84 samples were taken from consumer taps between 3 February and 19 March 2010. and 15 were associated with a positive odour (maximum 19 DN). Accordingly Essex and Suffolk Water (Northumbrian Water Limited) breached the taste and odour standard and supplied water that was not wholesome as defined in Regulation 4(1) and these contraventions were not trivial.

15. Notification

15.1. Thames Water notified the North East and North Central London Health Protection Unit on 9 February 2010. Essex Health Protection Unit was notified on 17 February 2010. Thames Water notified three Local Authorities (Tower Hamlets Council, Newham Council and Hackney Council) on 10 February 2010. Two Local Authorities were notified on 16 February 2010 (Waltham Forest Council and Islington Council) and a further two had messages left for them on 16 February with a follow up contact on 17 February 2010 (Epping Forest Council and Redbridge Council). The Consumer Council for Water were notified on 10 February 2010.

15.2. Some of the notifications were significantly later than others therefore Thames Water did not meet fully the requirements of Section 35(8) of the Water Supply (Water Quality) Regulations 2000 (as amended).

15.3. Thames Water notified the Inspectorate on 9 February 2010 and provided relevant reports by the agreed dates however the Company did not meet fully the notification and reporting requirements of Section 7 of the Water Undertakers (Information) Direction 2004. A water supplier must notify the drinking water quality regulator of the occurrence of any event which has caused or, in the opinion of the supplier, is likely to cause, significant concern to persons to whom water is supplied and this must be given as soon as possible after the event or matter has come to the supplier's attention. The company was aware of a deterioration in quality of the water and took responsive actions at a point in time well before it made the notification.

15.4. Essex and Suffolk Water notified the North East and North Central London Health Protection Unit on 11 February 2010. The company also notified the London Borough of Barking and Dagenham, London Borough of Redbridge and the London Borough of Havering on the same day. Therefore the company met the requirements of Section 35(6) of the Water Supply (Water Quality) Regulations 2000 (as amended). Despite the notification being two days after that of Thames Water, Essex and Suffolk Water notified the authorities as soon as they became aware of unusual taste and odour reports from consumers.

15.5. Essex and Suffolk Water contacted the Inspectorate on 11 February 2010 and provided associated reports by the agreed dates and therefore met the notification and reporting requirements of Section 7 of the Water Undertakers (Information) Direction 2004 for the same reason as specified in the preceding paragraph.

16. Water unfit for human consumption

16.1. Water may be regarded as being unfit for human consumption if either, when drunk it would be likely to, or did in fact, cause injury to the consumer or, where by reason of its appearance or smell, it was of such quality that it would cause a reasonable consumer of firm character to refuse to drink it or use it in the preparation of food. The supply of water unfit for human consumption is an offence under Section 70 of the Water Industry Act 1991.

16.2. Evidence exists that water was rejected by 369 consumers of Thames Water Utilities Ltd and by 43 consumers of Essex and Suffolk Water (Northumbrian Water Limited) for drinking or washing or cooking, or a combination thereof, based on objectionable taste and odour. Twelve consumers gave statements to this effect, (six from each company).

16.3. Based on the aforementioned evidence that water unfit for human consumption may have been supplied during this event the Inspectorate considered proceeding with a prosecution under Section 70 of the Water Industry Act 1991. Statements were taken from relevant staff of both companies. An interview under caution was carried out with a directing mind of each company. As outlined in this report both companies have taken number of actions to prevent a recurrence and will be taking further actions, including sharing the learning with the industry as a whole and the Consumer Council for Water and other stakeholders such as local authorities. After careful examination of all available information, including similar historical events worldwide and advice received from the Health Protection Agency that neither chemical at the levels found posed a potential danger to human health, the Chief Inspector of Drinking Water concluded that proceeding with a prosecution would not be in the public interest. Each company has admitted the offence of supplying water unfit for human consumption during this event and each has been formally cautioned. These cautions have been lodged as a record of the actions that each company has committed to undertake to prevent a recurrence of this incident. The caution record will be taken into account should at any time in the future a similar event occur. A copy of the Inspectorate's Enforcement Policy is available on its website.

16.4. Correspondence relating to this report should be addressed in the first instance to Marcus.rink@defra.gsi.gov.uk

17. References

1 The Water Supply (Water Quality) Regulations 2000

2 The Water Industry Act 1991

3 The River Severn Pollution Incident of April 1994 and its impact on public water supplies. K. J. Ives, D. Hammerton & R. F. Packham
Report for Severn Trent Water Ltd. 11 August 1994

4 The determination of taste and odour in drinking waters (2010)
Methods for the Examination of Waters and Associated Materials
Standing Committee of Analysts
Published by the Environment Agency

5 Factors causing off-taste in waters, and methods and practices for the removal of off-taste and its causes
Final Report to the Department of the Environment, Transport and the Regions
DETR/DWI 5008/1
NOVEMBER 2001

6 Letting the nose lead the way. Malodorous components in drinking water
G. Preti, T. S. Gittelman, P. B. Staudite & P. Luitwiler
Analytical Chemistry Vol 65, No. 15, Aug 1, 1993 PP 699 – 702

7 Identification of 1,3-Dioxanes and 1,3-Dioxolanes as Malodorous Compounds at Trace Levels in River Water, Groundwater, and Tap Water
J. Romero et al
Environmental Science and Technology. Vol 32, No 2. 1998 PP 206 – 216

8 An acute taste and odour episode solved by olfactory GC-MS
A. Bruchet, C. Hochereau and C. Campos
Water Science & Technology. Vol 55 No 5 PP 223-230 2007

9 The Worcester water incident, UK: bias in self reported symptoms to the emergency helpline
D. L. Fone. C. E. Constantine, B McCloskey
J Epidemiol & Community Health 1998; 52: 526 – 527

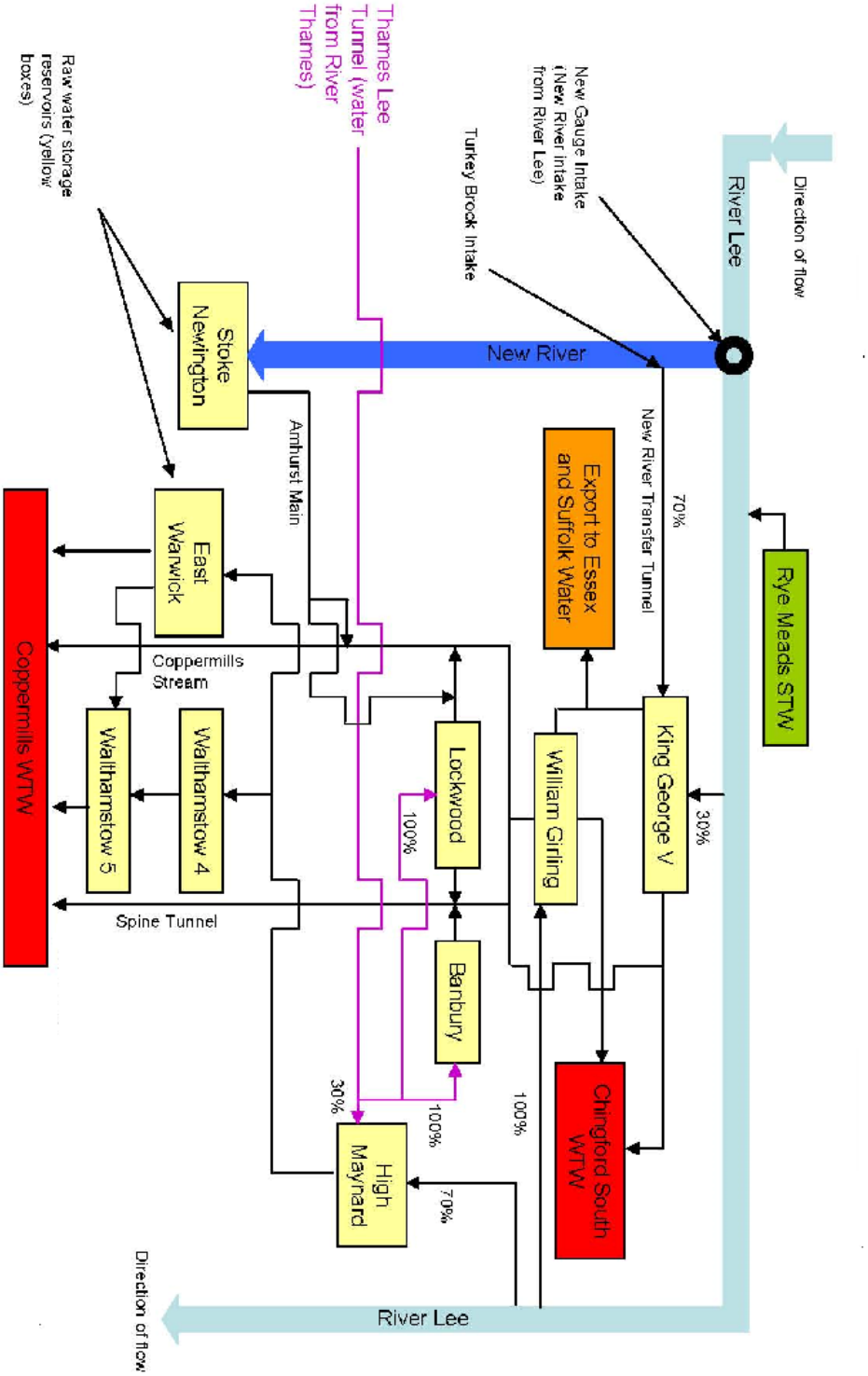
10 An epidemiological study after a water contamination incident near Worcester, England in April 1994
S. E. Fowle, C. E. Constantine, D. Fone, B McCloskey
J Epidemiol & Community Health 1996; 50: 18-23

11 The Upper Lee Catchment Abstraction Management Strategy
Final Strategy Document June 2006
Published by the Environment Agency

12 The London Catchment Abstraction Management Strategy
Final Strategy Document June 2006
Published by the Environment Agency

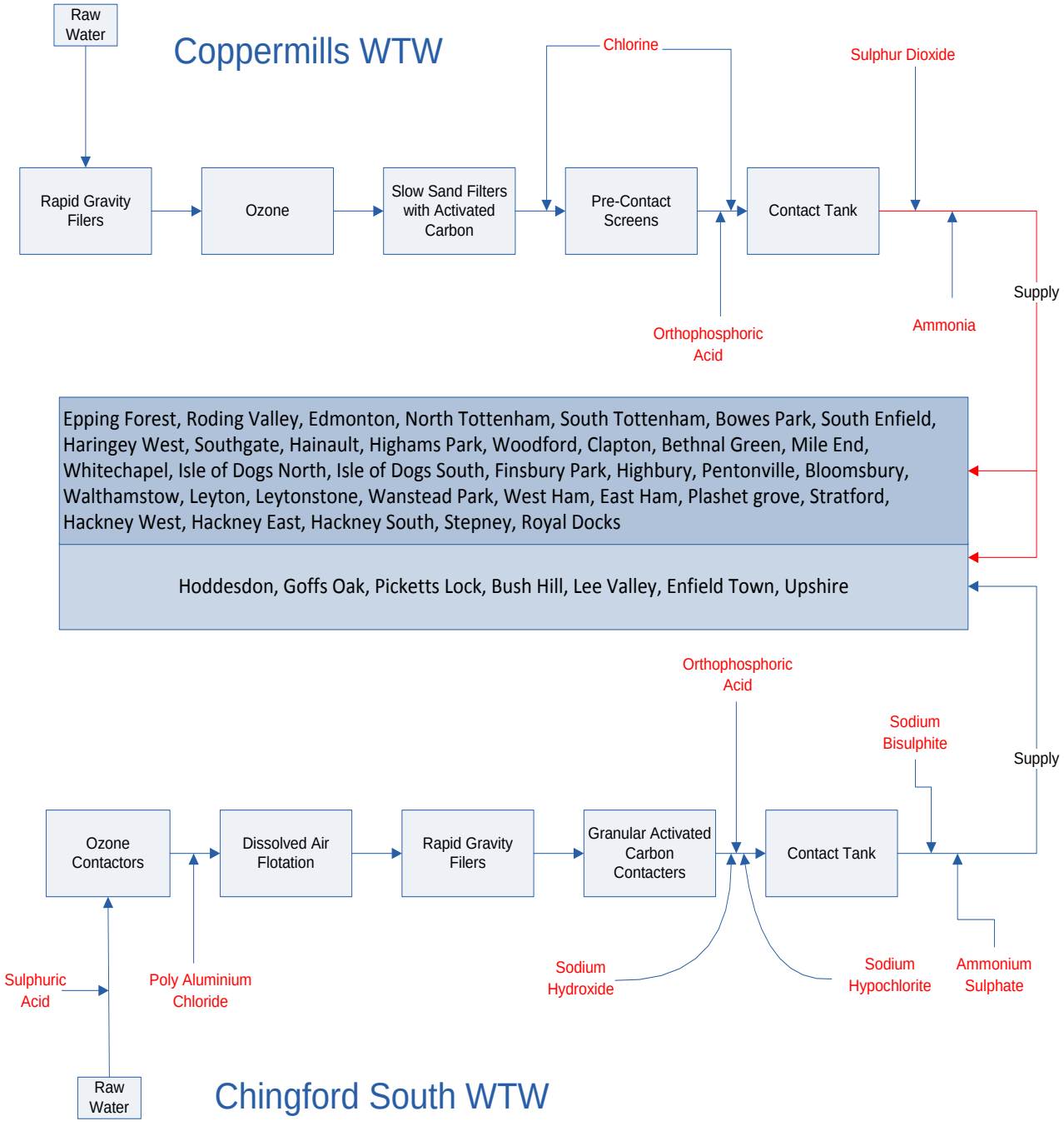
13 UKWIR's Database on Chemical Toxicity, Environmental Fate and Water Treatment
UK Water Industry Research Limited, 1 Queen Anne's Gate, London, SW1H 9BT

Appendix I: Simplified Schematic of the Raw Water Supply Arrangements

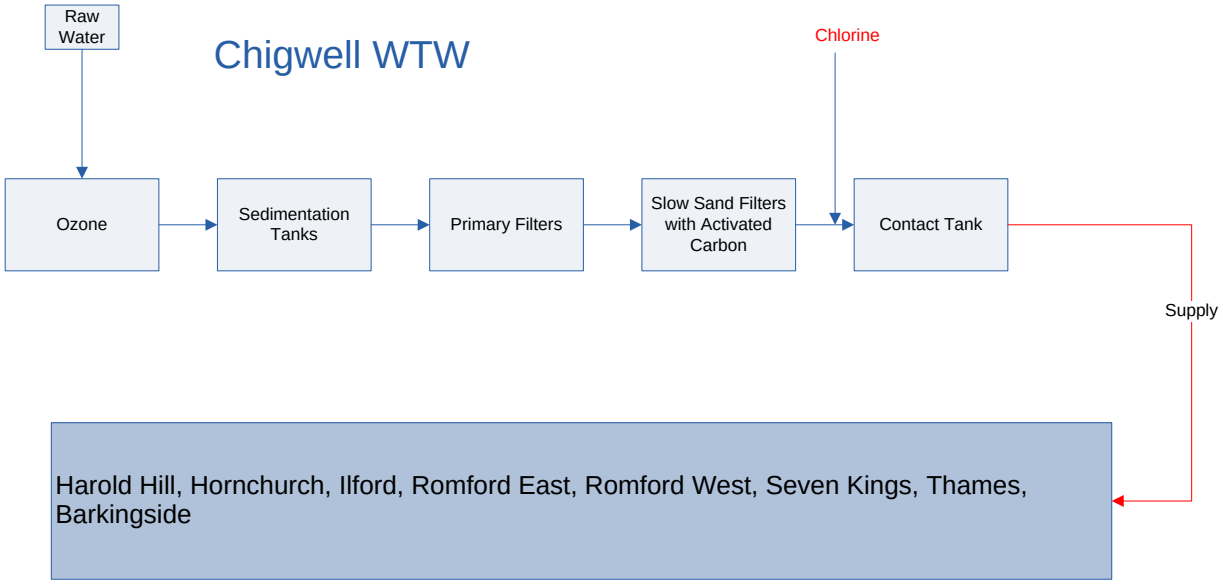


Appendix II:

A: Water Treatment and Supply (Thames Water)

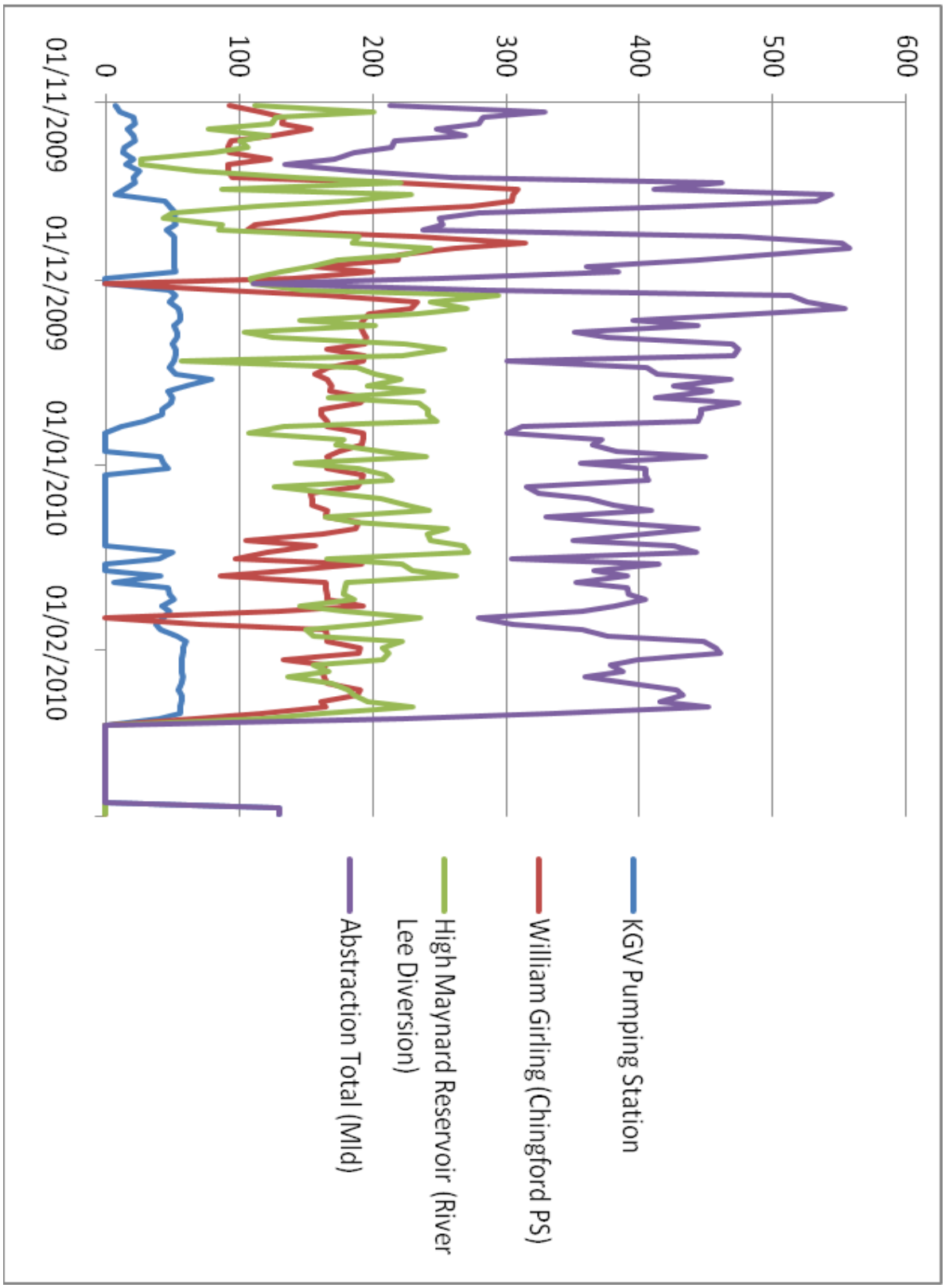


B: Water Treatment and Supply (Essex and Suffolk Water)

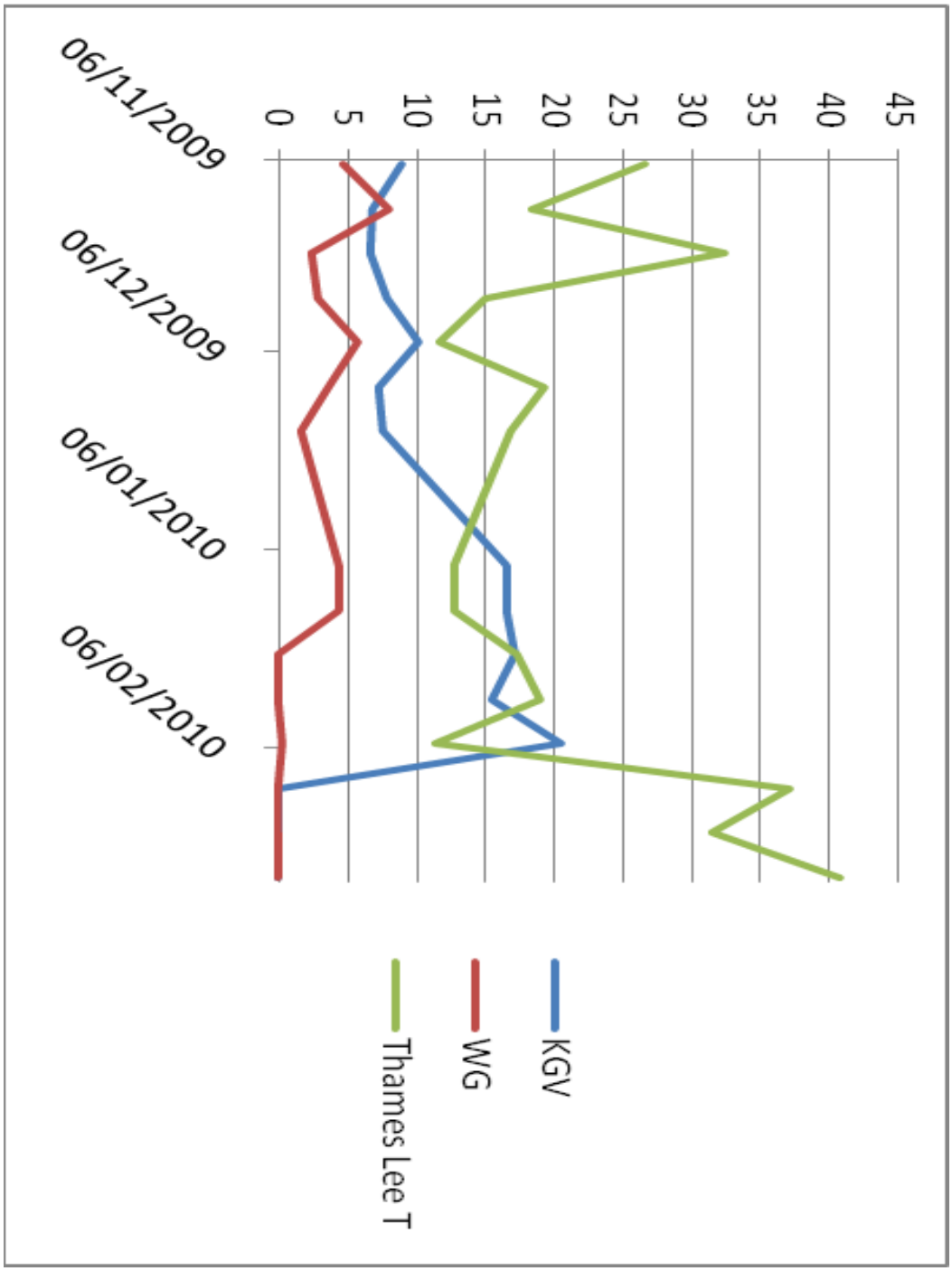


Appendix III

A: Abstraction from the River Lee to King George V, William Girling and High Maynard Reservoirs, (ML/day)



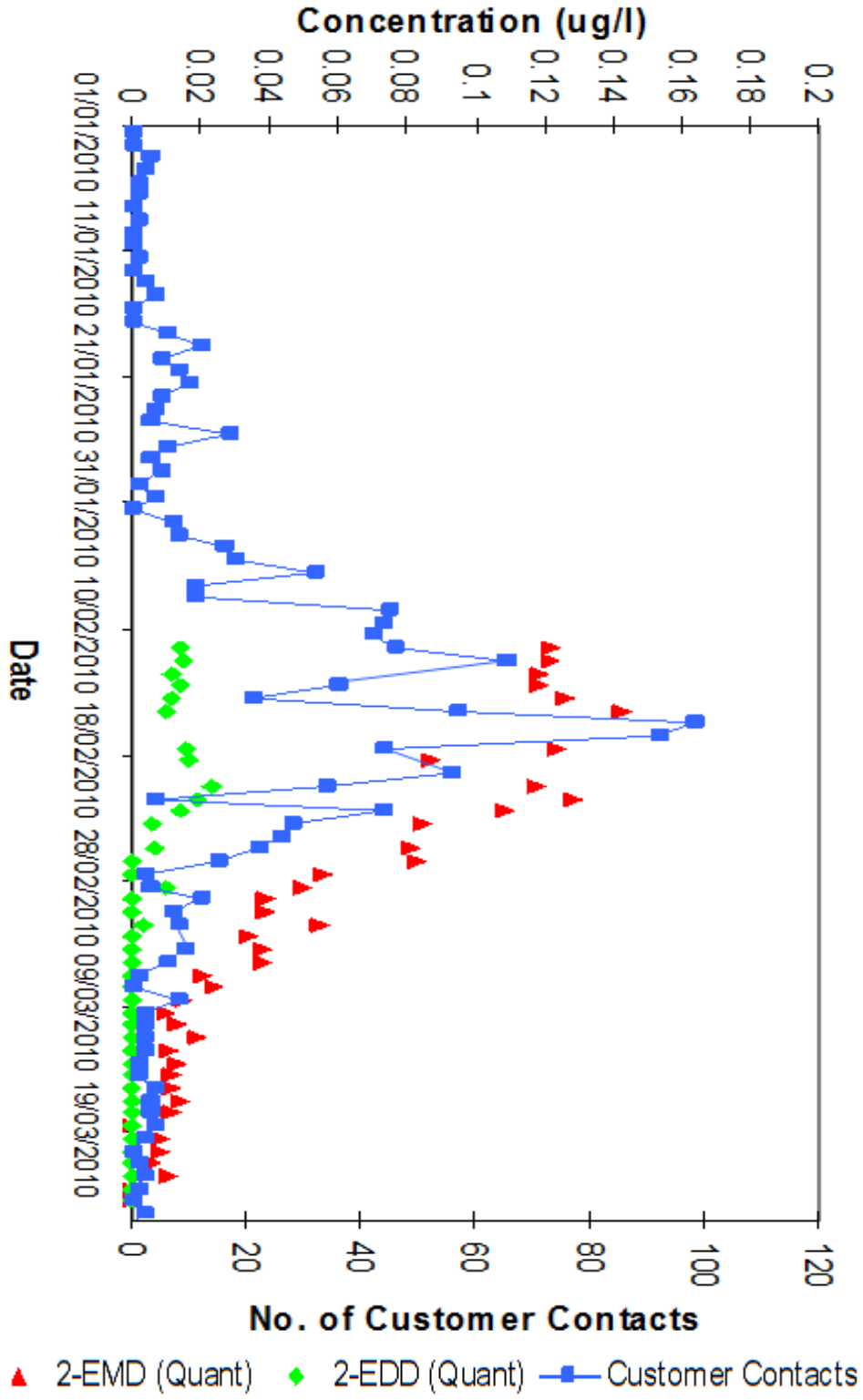
B: Percentage contribution of the raw water supply from King George V, William Girling and the Thames Lee Tunnel to Coppermills WTW



Appendix IV

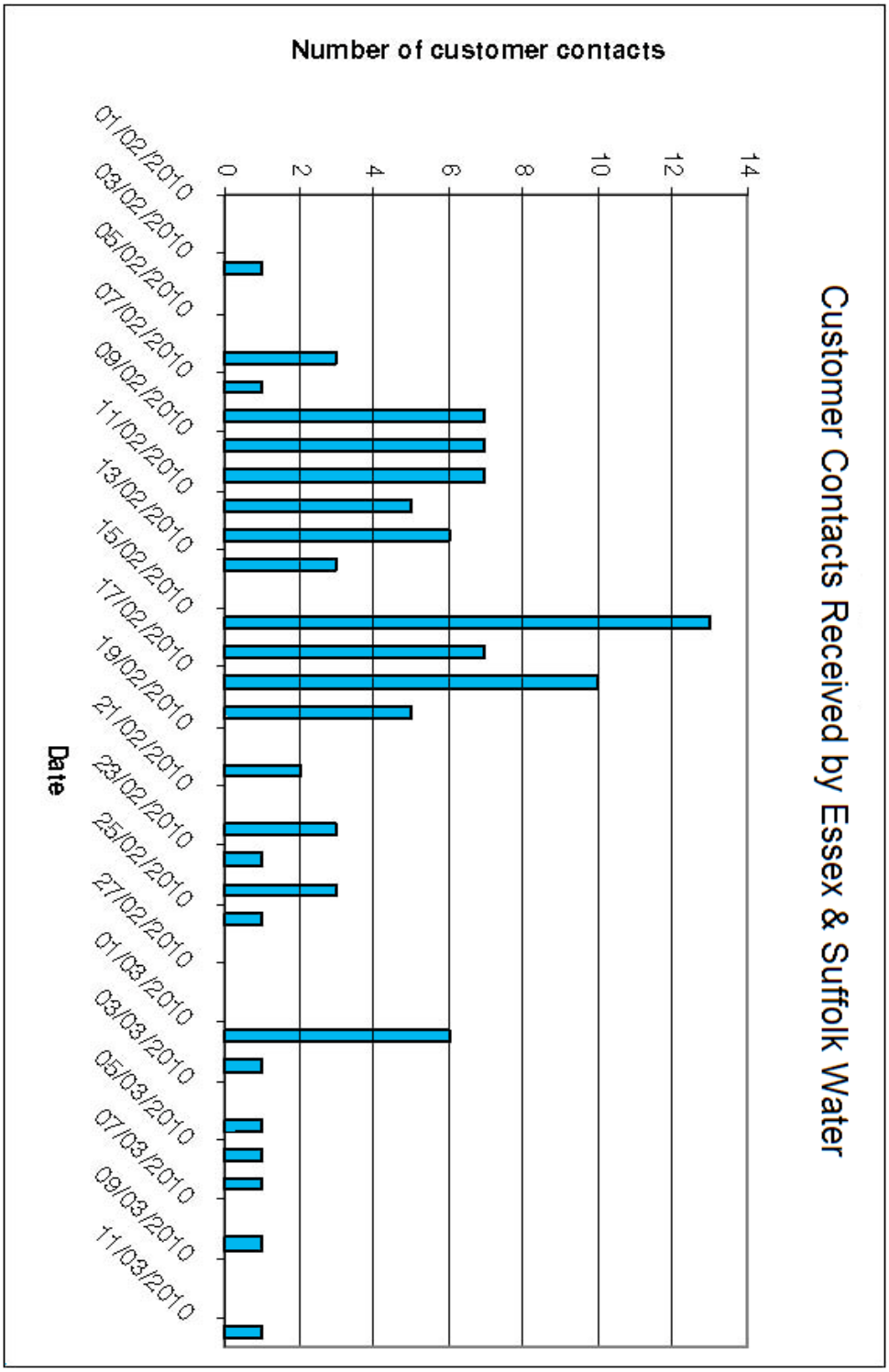
A: Comparison of the total number of contacts received with concentrations of 2-EMD and 2-EDD encountered at a zonal sampling point (Thames Water Woodford Depot).

Graph provided by Thames Water.



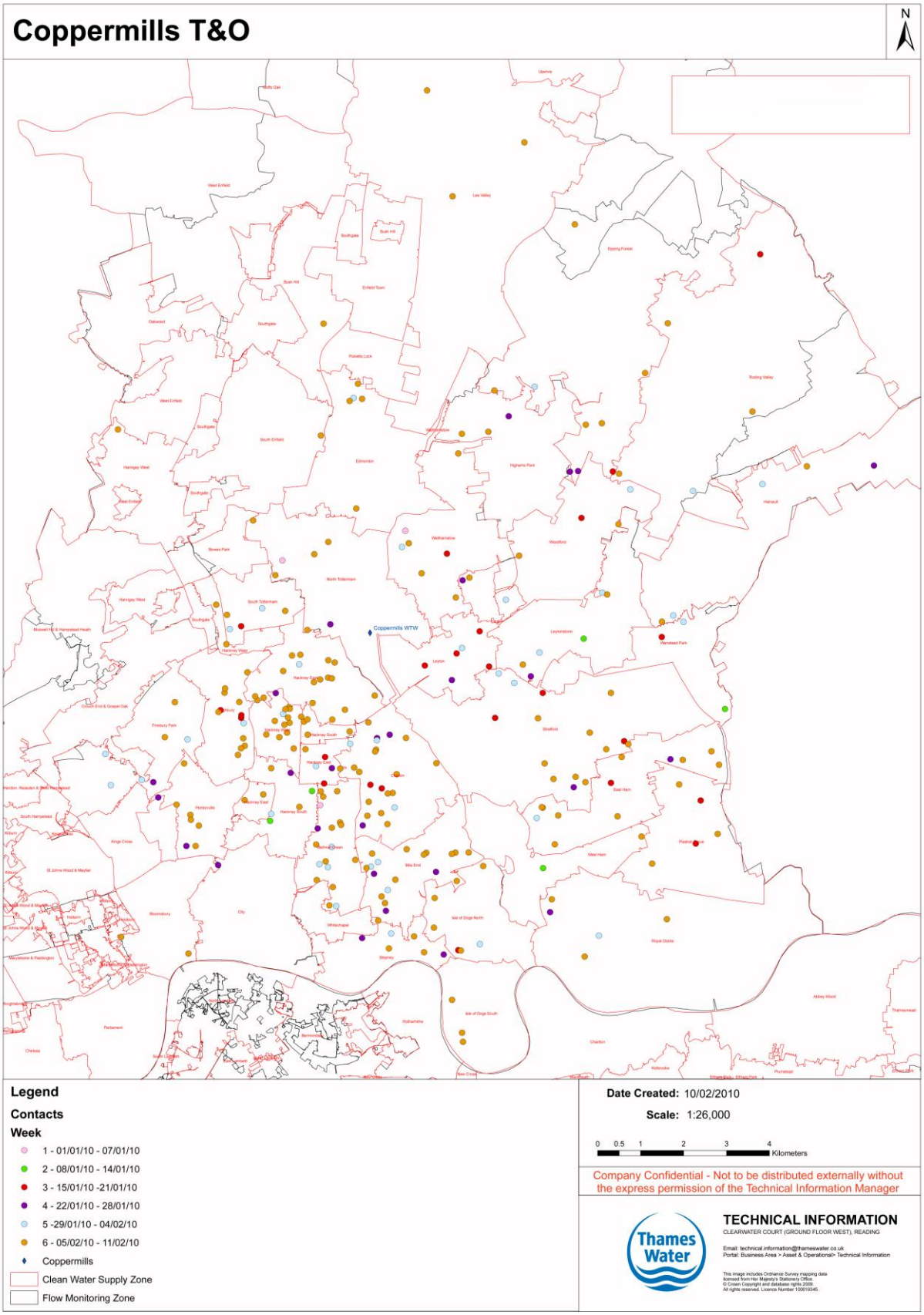
B: Contacts received by Essex and Suffolk water during the event

Graph derived from Essex and Suffolk Water data

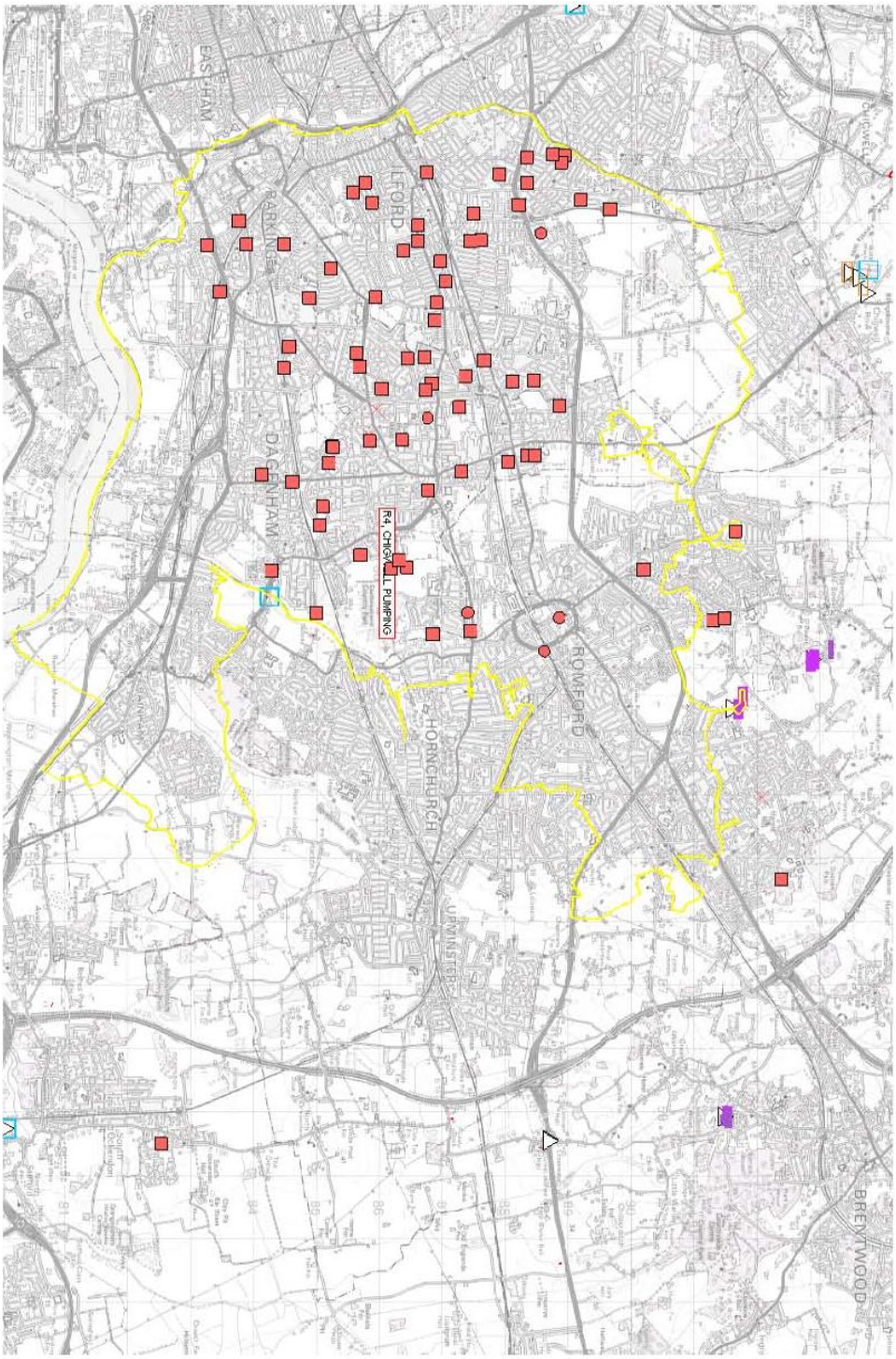


Appendix V:

A: Consumer contact distribution map for Thames Water



B: Consumer contact distribution map for Essex and Suffolk Water



Appendix VI:

A: Method synopsis of 2-EMD/2-EDD

Supplied by Thames Water Laboratory

Each 500ml sample is acidified with sulphuric acid to pH2 and ascorbic acid added to remove any residual chlorine. The sample is then spiked with D5 Chlorobenzene (at 200 ng/l), which is used as a surrogate standard.

A sample is extracted with 20 ml of dichloromethane, by shaking for 4 minutes at 190 rpm on a linear flat bed shaker, the dichloromethane layer is removed and the extraction repeated with a 10ml aliquot of dichloromethane.

The extracts are dried with anhydrous sodium sulphate, and then combined. The combined extract is then concentrated using a combination of a water bath and nitrogen gas, until this extract volume is reduced to 200 µl.

With each batch of samples a procedural blank, a set of calibration standards (10, 50, 100 & 200 ng/l), and an AQC are also analysed.

Samples are run on an Agilent 7890A GC coupled to an Agilent 5975C MS. Samples introduction was, via an automated sampler, into a cool on-column injector. A 1m length of 0.53mm id deactivated fused silica pre-column was connected to a 30m x 0.25mm id x 0.25 µm film thickness DB-5ms capillary column with a constant flow rate of 1ml/min of Helium.

GC Conditions:

Initial temperature: 35 °C; hold for 4.0 minutes,
Temperature Ramp 1: 10 °C/min to 80 °C,
Temperature Ramp 2: 50 °C/min to 300 °C; hold for 10.0 minutes.

Injection volume: 2 µl

Mass spectral detection is carried out in selected ion monitoring (SIM) mode with the following ion used for each compound.

Compound	Quantitative ion (m/z)	Qual Ion 1 (m/z)	Qual Ion 2 (m/z)	Qual Ion 3 (m/z)
D5 Chlorobenzene	117	119		
2-EMD	87	59	72	115
2-EDD	115	56	69	143

MS Interface temperature: 310 °C.

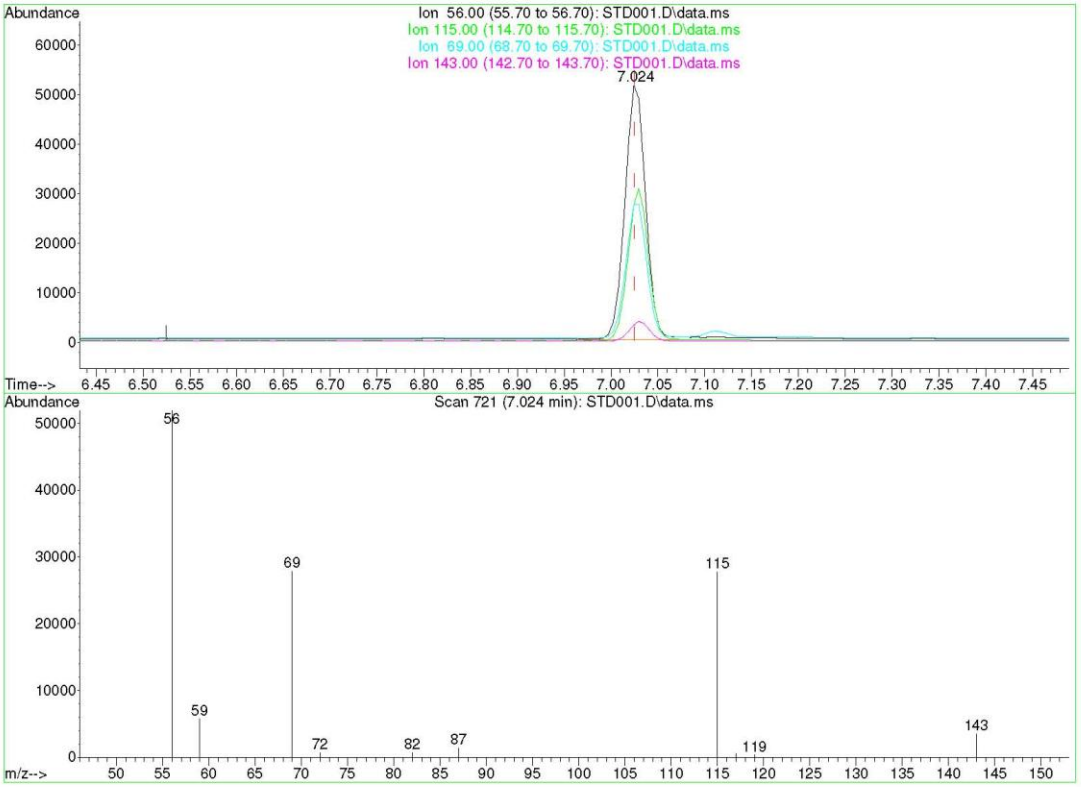
B: Mass Spectra for 2-EDD

(Actual 18 Feb 2010 produced by Thames Water Laboratory)

Quantitation Report (Qedit)

Data Path : D:\2EDD\
Data File : STD001.D
Acq On : 18 Feb 2010 11:21
Operator : JCF
Sample : Cal 200
Misc :
ALS Vial : 50 Sample Multiplier: 1

Quant Time: Feb 19 11:59:46 2010
Quant Method : C:\MSDCHEM\1\METHODS\2EDD.M
Quant Title : 2EDD&2EMD
QLast Update : Fri Feb 19 11:59:30 2010
Response via : Initial Calibration



TIC: STD001.D\data.ms

(3) 2EDD

7.024min (-0.001) 0.00ng/l m

response 79933

Ion	Exp%	Act%
56.00	100	100
115.00	53.50	59.11
69.00	53.60	53.37
143.00	6.70	7.33

2EDD.M Fri Feb 19 13:33:25 2010 Page: 1

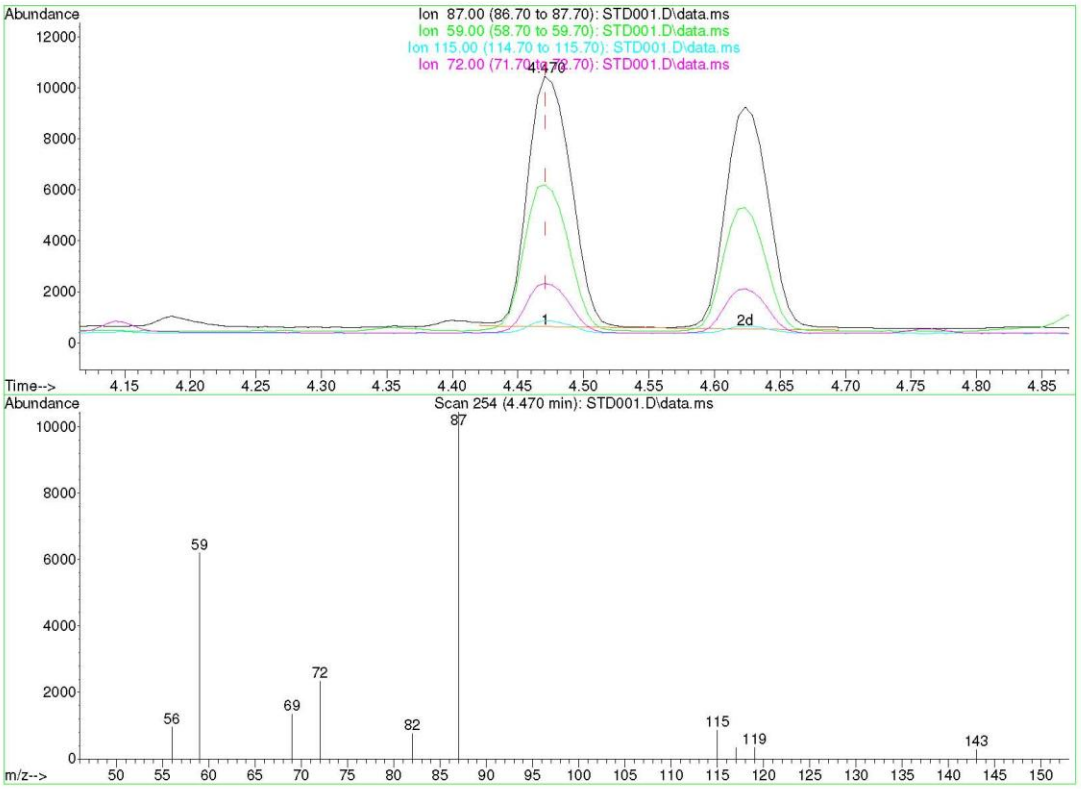
C: Mass Spectra for 2-EMD

(Actual 18 Feb 2010 produced by Thames Water Laboratory)

Quantitation Report (Qedit)

Data Path : D:\2EDD\
Data File : STD001.D
Acq On : 18 Feb 2010 11:21
Operator : JCF
Sample : Cal 200
Misc :
ALS Vial : 50 Sample Multiplier: 1

Quant Time: Feb 19 11:59:46 2010
Quant Method : C:\MSDCHEM\1\METHODS\2EDD.M
Quant Title : 2EDD&2EMD
QLast Update : Fri Feb 19 11:59:30 2010
Response via : Initial Calibration



TIC: STD001.D\data.ms

(2) 2EMD

4.470min (-0.001) 0.00ng/l m

response 42564

Ion	Exp%	Act%
87.00	100	100
59.00	59.40	65.68
115.00	8.20	8.99
72.00	22.30	22.98

2EDD.M Fri Feb 19 13:33:13 2010 Page: 1

Appendix VII: Technical details of 2-EDD & 2-EMD

Information reproduced with the kind permission of UKWIR[12]

A: 2-Ethyl-5,5-dimethyl-1,3-dioxane (2-EDD)

Synopsis

2-Ethyl-5,5-dimethyl-1,3-dioxane (2-EDD) has been identified in waste products from a resin factory. It has been involved in several incidents involving contamination of drinking water and caused major taste and odour problems. However, an epidemiological study conducted after one of these incidents failed to demonstrate any adverse health effects as a result of the chemical contamination, although adverse symptoms were associated with the unpleasant taste or odour of the tap water. 2-EDD has the ability to pass through sewage treatment and was not removed by coagulation, flocculation or clarification during drinking water treatment. The use of granular activated carbon (GAC) reduced the concentration of the contaminant and powdered activated carbon (PAC) was rapid and effective in removing 2-EDD. There were no data on the toxicity of 2-EDD, although it is likely to cause odour problems at significantly lower levels than those considered to be of risk to human health. It is extremely odorous and an operational SNARL of 0.01 µg/l (10 ng/l) is suggested based on odour, although some sensitive individuals may be able to detect odour as low as 0.005 µg/l (5 ng/l).

Occurrences

In January 1992, a commercial hazardous waste management facility, located 28 miles upstream of a water treatment plant accepted six tanker loads (about 30 000 gallons; 113 562 litres) of wastewater from a resin coatings manufacturer in New Jersey, USA. The water contained substantial concentrations of various by-products of the resin-manufacturing process. One of these by-products proved to be a very potent odour-causing agent that had a bitter taste. Because this material was not removed by treatment at the waste management facility or at the sewer plant to which the treated wastewater was discharged, the sewer plant and the creek were subsequently contaminated with the odour-causing agent (1). Odour comparisons, smell chromatography and GC/MS analyses showed that 2-EDD was the predominant odour-causing agent in the waste associated with the incident (1). Estimates of 2-EDD concentrations during the height of the incident, based on comparisons of water samples with measured concentrations of the synthetic 2-EDD are provided in the table below:

Location	Concentration (µg/l)
Wastewater from the resin coating manufacturer	950
Effluent from a sewer plant	10
Water from the west branch of the creek (approximately 300 feet downstream of the sewerage plant)	5
Water from the abstraction point	0.04
Finished drinking water	0.02

A similar incident occurred in the UK in April 1994. On 11th April 1994, a mixture of organic chemicals was discharged into a sewer, passed through Wem sewage treatment works and entered the River Severn via two tributaries. Four days later in Worcester (about 120 km down river from Wem), water consumers complained of an unpleasant taste and odour. Analysis of a sample from Wem (taken on 13 April) showed a mixture of 7 organics and 2-EDD was detected at a level of 1300 mg/l. By 17 April, levels of 2-EDD had fallen to analytically undetectable concentrations. The highest concentration measured in treated water was 0.13 µg/l (2).

In an investigation of taste and odour episodes involving Barcelona's drinking water supply between 1993 and 1995, 2-EDD was detected in wastewater from a resin plant and in groundwater samples (distance 0-40 km). The concentration of 2-EDD found in wastewater was 3673 µg/l and, in groundwater samples, ranged between below the level of detection to 7.07 µg/l (mean concentration: 0.95 µg/l) (7).

In 2010 in the UK, following a series of consumer taste and odour complaints, 2-EDD was detected in a drinking water supply at a concentration range of 0.03-0.2 µg/l (WRc data).

Uses
No data were located at time of update. However, 2-EDD has been identified as a by-product of the resin manufacturing process (type of resin not reported).

Human toxicity
No specific health effects are known for this chemical. However, an epidemiology study was performed to assess the health effects of the Worcester incident that occurred in 1994 (10). This study found that 62% of people questioned noted an unusual taste or odour in the water and that a dose-response relationship existed between the amount of water consumed and the presence of a variety of symptoms (diarrhoea, nausea, headache, stomach pains, skin irritation and itchy eyes) (10). However, the study concluded that the symptoms presented were associated with the unpleasant taste or odour of the tap water rather than the chemical contamination (10).

Emergencies and SNARLs

2-EDD is extremely odorous with a variety of odour thresholds being reported between 0.01-0.02 µg/l, although sensitive individuals may be able to detect odour as low as 0.005 µg/l. A WRc taste threshold of 0.02 µg/l has also been reported. An operational SNARL of 0.01 µg/l (10 ng/l) is recommended in order to avoid odour effects.

Taste and odour properties
Based on the literature, the odour threshold for 2-EDD in water appears to be 0.01 µg/l (1). The odour has been described as walnutty, latex paint, varnish, chlorinous, earthy, musty, creeky/decaying vegetation, nutty, sewage, fishy/algae, marshy/sulphurous, rotten, methanol/piney, sweet, chemical (4).

In a study conducted in 1997 (5) using a sniff port on a gas chromatograph the EDD peak was described as tutti-frutti (Italian for 'all fruits', but implying sweet, fruity confectionery). The study included Flavour Profile Analyses which produced descriptors such as fruity, apple, menthol, sweet, burnt-sweet, solvent-sweet and sickening-sweet and suggested an odour threshold concentration of 0.005 to 0.01 µg/l. At levels close to the threshold concentration the odour was described using the more pleasant sweet terms, but less pleasant descriptors were applied to slightly more concentrated solutions.

WRc Data:
Tests were carried out on solutions of 2-EDD (distilled and pure by GC analysis) dissolved in still mineral water. Odour tests were done at 40°C and taste tests at 25°C. The test panels consisted of ten assessors but in each case one member failed to produce consistent results and therefore the following information summary is based on the results of the other nine assessors.

The minimum concentrations detected were odour at 6 ng/l and taste at 16 ng/l and all assessors detected both an odour and taste in the 100 ng/l samples. The median threshold concentrations were calculated as 17 ng/l for odour and 22 ng/l for taste.

The descriptors were very varied, but is was noted that the odour was more objectionable at the lower concentrations. During the preparation of the test solutions the odour of significantly more concentrated solutions was perceived as minty and menthol. These observations are in

agreement with those made when testing the odour of atmospheric samples (6). The odour was described as chemical/paint, chemical, sweet, stale, acetate, musty, effluent, plastic, yeast, estery, car-polish, perfumed, cowsheds, paint, rotting, fruit, plasticine and dishwater. The taste was described as metallic, musty, chemical, plastic, stale, acetate, fruity, sweet, rotting vegetables, cowsheds, drains, salty, burning, plasticine, vinegar, estery, car-polish, bitter, rotting apples and mouldy.

Removal during (drinking water) treatment
Coagulation, flocculation and clarification do not appear to remove 2-EDD. However, the use of Granular Activated Carbon (GAC) and Powdered Activated Carbon (PAC) are effective in removing 2-EDD (2).

B: 2-Ethyl-4-methyl-1,3-dioxolane (2-EMD)

Synopsis

2-Ethyl-4-methyl-1,3-dioxolane (2-EMD) has been identified in waste products from a resin factory. It has been involved in several incidents involving contamination of drinking water and major taste and odour problems. However, 2-EMD was not considered to be the odourous source, and an epidemiological study conducted after one of these incidents failed to demonstrate any adverse health effects as a result of the chemical contamination. Coagulation, flocculation and clarification do not appear to remove 2-EMD. However, the use of Granular Activated Carbon (GAC) and Powdered Activated Carbon (PAC) are effective in removing 2-EMD. No data were located on the toxicity of 2-EMD, but based on a structurally similar compound, it is likely to be of low acute oral toxicity to experimental animals. Instead, it is likely to cause odour problems at much lower levels than those considered to be of risk to health in the short-term. Odour threshold values reported in the literature vary considerably from as low as 0.005 to 380 µg/l, the odour most often being described as 'sweet'. A tentative 24-hour health-based SNARL of 1400 µg/l is proposed. Given the variation in threshold values it is difficult to propose an operational SNARL based on odour. It will be important to monitor taste and odour should 2-EMD contaminate water sources or supply.

Occurrences

Cocheo *et al.* (1) reported that 2-EMD was found in the effluent from the sewage treatment plant of a fibreglass and resin manufacturing company (levels not reported) as a by-product of the formation of propionaldehyde. Since that time, 2-EMD has been detected as a by-product present in waste from resin manufacturing plants and has been involved in a number of pollution incidents (2, 6, 7).

2-EMD was detected in a pollution incident on the River Severn in April 1994. On 11th April 1994, a mixture of organic chemicals was discharged into a sewer, passed through Wem sewage treatment works and entered the River Severn via two tributaries. Four days later in Worcester (about 120 km down river from Wem) water consumers complained of an unpleasant taste and odour. Analysis of a sample from Wem (taken on 13 April) showed a mixture of 7 organics and 2-EMD was detected at 350 mg/l. By 17 April levels of 2-EMD had fallen to analytically undetectable concentrations. The highest concentration measured in treated water was 0.02 µg/l (2). However, 2-EMD was not thought to be the source of odour. Instead, the compound causing the taste and odour problems was identified as 2-ethyl-5,5-dimethyl-1,3-dioxane (2-EDD) (2). A Toxicity Datasheet is available for 2-Ethyl-5,5-dimethyl-1,3-dioxane.

In a taste and odour incident along the Ohio river in the USA in 1989, 2-EMD was detected in a discharge from a sewage treatment plant (levels not reported). Like the Worcester incident, taste and odour effects were detected downstream (as far as 137 miles). Due to its hydrophilic nature, 2-EMD was not sufficiently removed by the wastewater treatment plant using activated sludge treatment nor by drinking water treatment facilities downstream (6).

In an investigation of groundwater contamination involving Barcelona's water supply, 2-EMD was detected in wastewater from a resin plant and in groundwater samples (distance 0-40 km). The concentration of 2-EMD found in waste water was 585 µg/l and in groundwater samples, ranged between below the level of detection to 30.6 µg/l (mean concentration: 4.02 µg/l) (7).

Uses

No data on the use of 2-EMD were located at time of update. However, it has been identified as a by-product of the resin manufacturing process (type of resin not stated).

Human toxicity

No specific health effects are available for this chemical. However, an epidemiology study was performed to assess the health effects of the Worcester incident that occurred in 1994 (11). This study found that 62% of people questioned noted an unusual taste or odour in the

water and that a dose-response relationship existed between the amount of water consumed and the presence of symptoms (diarrhoea, nausea, headache, stomach pains, skin irritation and itchy eyes) (11). However, the study concluded that the symptoms presented were associated with the unpleasant taste or odour of the tap water rather than the chemical contamination (11).

Emergencies and SNARLs

2-EDD is extremely odorous with a variety of odour thresholds being reported between 0.01-0.02 µg/l, although sensitive individuals may be able to detect odour as low as 0.005 µg/l. A WRc taste threshold of 0.02 µg/l has also been reported. An operational SNARL of 0.01 µg/l (10 ng/l) is recommended in order to avoid odour effects

Taste and odour properties

The odour threshold of 2-EMD was found to be 380 µg/l at room temperature and 360 µg/l at 60°C based on a panel size of 8 (5). The range of odour thresholds detected were 140-1390 µg/l and 70-810 µg/l at room temperature and 60°C, respectively. The odour was described as 'terpene', 'sweet' or 'spicy'.

A recent abstract reported in the proceedings of a conference (6) has reached different conclusions and reported a much lower odour threshold. From Flavour Profile Analyses using a trained panel the odour threshold concentration was estimated to be 0.005 to 0.01 µg/l, with descriptors being 'sweet' (at threshold concentration) and, at higher concentrations, 'solvent sweet', 'sickly sweet', 'toluene' and 'medicinal'. Less experienced panellists used the descriptors 'solvent', 'toluene', 'phenolic', 'sweet', 'solvent sweet' and 'sickening sweet'. From the method of preparation it must be assumed that the material tested was a mixture of the four stereoisomers.

Appendix VIII: Customer Questionnaire Responses to DWI

1. Did you notice anything different about your water supply around February 2010?	Essex & Suffolk Water		Thames Water	
	No'	%	No'	%
Yes	46	96	394	98
No	2	4	7	2
Total	**48**		**401**	
2. When did you first notice that there was something different about your drinking water?				
		%		%
Dec 2010	2	7	15	6
Jan-10	7	24	87	32
Feb-10	20	69	163	61
Mar-10	0	0	3	1
Total	**29**		**268**	
3. Did you notice the difference by:				
		%		%
Smell	1	2	15	4
Taste	8	17	59	15
Smell & Taste	32	68	263	67
Appearance	1	2	0	0
All three	5	11	54	14
Other	0	0	4	1
Total	**15**		391	
5. Did the change in the water supply cause you to stop using it for any of the following:				
		%		%
Drinking	26	60	213	58
Cooking	0	0	1	0.3
Drinking & Cooking	13	30	114	31
Drinking & Washing	0	0	8	2
Cooking & Washing	0	0	1	0.3
Drinking, Cooking & Washing	2	5	15	4
Cooking, Washing, Laundry	1	2.5	0	0
Drinking, Cooking, Washing, Laundry	1	2.5	12	3
Other combination	0	0	5	1.3
Total	**43**		**369**	
6. Approximately how long did the problem continue?				
		%		%
1 day	0	0	2	1
2-7 days	7	5	19	5
8-30 days	30	70	199	55
>30 days	11	26	145	40
Total	**43**		**365**	

7. Did you receive any advice from your water company?				
		%		%
Contact in advance	0	0	0	0
Contacted after problem	0	0	7	2
Only when I contacted Company	32	73	303	78
No advice	12	27	78	20
Total	**44**		**388**	
9. Did the Water Company offer you an alternative supply of water?				
Bottled	0	0	5	1
Tanker or Bowser	0	0	0	0
Other	0	0	8	2
No	45	100	379	97
Total	**45**		**392**	
10. Did you take a sample of the water, if so, what happened to it?				
		%		%
Still have it	0	0	6	2
Gave to Water Company	0	0	6	2
Gave to Env Health	1	2	1	0
Threw Away	2	4	27	7
Other	1	2	9	2
Didn't take Samples	41	91	341	87
Total	**45**		**390**	
11. Did the Water Company take a sample from your property?				
		%		%
Yes Got results	3	7	24	6
Yes didn't get results	1	2	4	1
No	41	91	358	93
Total	**45**		**386**	
12. Did you hear about the problem in the local or national media?				
Radio Only	0	0	5	2
TV Only	11	46	118	44
Newspaper Only	3	13	59	22
Radio & TV	2	8	14	5
Radio &Newspaper	0	0	2	1
TV & Newspaper	6	25	49	18
Radio, TV, & Newspaper	1	4	13	5
Other	1	4	6	2
None	0	0	0	0
Total	**24**		**266**	

Appendix IX: BBC Website reports of event
Reproduced from the BBC Website
http://news.bbc.co.uk/1/hi/england/london/8517463.stm and
http://news.bbc.co.uk/1/hi/england/london/8539286.stm

Tuesday, 16 February 2010

Thames investigate 'smelly water' in Walthamstow


Since the start of February 300 people have complained

Reports of foul smelling drinking water are being investigated after hundreds of complaints were made by residents in Walthamstow, north-east London .

Thames Water has stopped taking supplies from the River Lea and is now extracting water from the River Thames while they consider the issues.

Water tests have been carried out but so far nothing abnormal has been found.

Since the start of February, 300 of the 1.8m customers served by the supply in Walthamstow have reported the problem.

Bob Collington, Director of Operational Management for Thames Water, said: "Early indications suggest the problem could be due to a change in environmental conditions in the River Lee, which is the normal source of water for our Walthamstow works.

"We've spoken to the Health Protection Agency for the area and our drinking water regulator, the Drinking Water Inspectorate, and we can confirm that they are supportive of the steps we're taking.

"As well as carrying out extra testing at our own laboratories, we've also sent samples to labs at other water companies and to independent labs, but so far nothing abnormal has been identified."

Thames Water supplies water to over eight million customers across London and the Thames Valley.

Friday, 26 February 2010

Chemicals caused smelly tap water in north-east London


Since the start of February 800 people have complained

Foul smelling drinking water reported by residents of east and north London was caused by a chemical used in glues and manufacturing, it has emerged.

Since the start of February 800 people have complained about the smell, caused by a contamination of the River Lea.

Now Thames Water has said the smell was caused by the chemicals 2-EDD and 2-EMD, present at harmless levels.

At its height there were 30 billionths of a gram of the chemicals in each litre of water.

A Thames Water spokesman said the chemical had a "low smell threshold", meaning some people could detect it even at very low levels.

He said: "Our most recent tests indicate that minute traces of these substances in water going to customers in north-east London have significantly reduced and are now almost undetectable.

'We're really sorry'

"Although 800 of the two-million customers served by our Walthamstow works have reported an unusual smell in their water since the start of February, this has never been a health concern.

"We're really sorry to all those who've been affected."

The Drinking Water Inspectorate has begun an investigation.

A spokeswoman confirmed that if the water was found to be unfit for consumption or inadequately treated Thames Water could face fines of thousands of pounds.

She said: "When ongoing investigations are complete the inspectorate will independently assess all the findings and then report on the cause and the lessons learnt.

"Consumers experiencing ongoing taste and odour problems should contact their water company in the first instance."