Friends of the Earth Australia Chlorine Disinfection Report

Grampians Wimmera Mallee Case Study
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Image Source: http://inhabitat.com/researchers-announce-new-way-to-creating-drinking-water-from-air/

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Formatting Issues: Some graph formatting may be lost due to conversion of Open Office Files to PDF. Friends of the Earth apologises these discrepencies.

Glossary

CHBr2Cl	Dibromochloroform
CHBr3	Bromoform
CHCl2Br	Dichlorobromoform/Bromodichloromethane
CHCl3	Chloroform
DBA	Dibromoacetic Acid
DBP	Disinfection Byproduct
DCA	Dichloroacetic Acid
DOC	Dissolved Organic Carbon Content
EPA	Environment Protection Authority
FoE	Friends of the Earth
GWMWater	Grampians Wimmera Mallee Water
HAA	Haloacetic Acid
IARC	International Agency For Research On Cancer
MCC	Maximum Contaminant Level
mg/L	Parts Per Million
NDMA	N-Nitrosodimethylamine
NHMRC	National Health and Medical Research Council
NOM	Natural Organic Matter
NTP	National Toxicology Program
TCA	Trichloroacetic Acid
THM	Trihalomethanes
TTHM	Total Trihalomethanes
ug/L	Parts Per Billion
WHO	World Health Organisation
WMP	Wimmera Mallee Pipeline

Key Findings

1. Drought caused widespread increases in Trihalomethanes in numerous town water supplies in the Grampians Wimmera Region between 2005-2009, in many cases well above World Health Organisation and Australian Drinking Water Guidelines.

2. The increases in Trihalomethanes were also associated with increased levels of salts remaining in water held in town storages.

3. A flush of “fresher” water after the drought (between October 2008 – October 2009) and connection of the Wimmera Mallee Pipeline initially saw better quality water arrive at towns that had suffered large from amounts of THM's during the drought.

4. Sharp decreases of Trihalomethanes occurred in several communities receiving water from the pipeline. Average decreases were 47%. Bromoform and Dibromochloromethane were significantly reduced, however chloroform eventually increased an average of 3 times in the communities studied.

5. In terms of Haloacetic Acids, all 9 communities saw decreases in formation of Bromochloroacetic Acid and Dibromoacetic Acid. All communities in this case study saw increases in exposure to Dichloroacetic Acid and all observed significant increases in the production of Trichloroacetic Acid (between 146 and 4000%) after pipeline water was supplied to their towns. These increases could also be attributed to the January 2011 floods.

6. Six communities in this case study saw increases (by between 43 and 130%) in Total Haloacetic acid exposure after receiving “fresh water” from the pipeline - an increase over 9 communities of 38.9%.

7. Seven communities were declared regulated in February 2012, highlighting the fact that new pipeline water has not led to a positive outcome in these communities.

8. Significant impacts on Grampians Wimmera source water at Lake Bellfield between 2005-11 was caused by fire, drought and flood. These circumstances were beyond the control of GWMWater, yet could signify similar events unfolding in the future, potentially caused by climate change. These water quality issues were the worst recorded for GWMWater.

9. Between 2007 and 2009 Lake Bolac and Willaura were receiving drinking water with levels of Chlorite 1.5 to 2 times above the Australian Drinking Water Guideline level of 0.8mg/L.

10. For the communities studied in this case study, the primary concerns according to World Health Organisation Guidelines appear to be in descending order, Bromodichloromethane, Dibromochloromethane, Bromoform, Dichloroacetic Acid, Trichloroacetic Acid.

11. The communities with the most breaches according to World Health Organisation Guidelines and Australian Drinking Water Guidelines were: Jung (258 breaches), Minyip (231 breaches), Wycheproof (223 breaches), Beulah (221 breaches), Woomelang (217 breaches), Donald (212 breaches), Murtoa (190 breaches), Warracknabeal (181 breaches), Rupanyup (171 breaches), Quambatook (92 breaches), Lake Bolac (69 breaches), Willaura 65 breaches.

Background

In late May 2013, Friends of the Earth received an 858 page Freedom of Information request from Grampians Wimmera Mallee Water (GWMWater).

The original request dated April 10 2013 said:

"I require details of all water quality testing results (including tap water tests) conducted by GWM Water or contractors employed by GWM Water regarding results recorded between the dates 1/1/05 to 10/4/13 for Chlorine Disinfection By-products and aluminium. I also require any test results for N-nitrosodimethylamine (NDMA). I require the sample results, the location of the sample results and the dates that the samples were taken.

Disinfection By-products would include;

- *Chlorine based/Chloramination based disinfection by-product chemicals.*
- *Trihalomethanes [Trichloromethane (Chloroform), Dibromochloromethane, Tribromomethane (Bromoform), Bromodichloromethane etc].*
- *Dichloroacetic Acid, Trichloroacetic Acid, Chloroacetic Acid, Chloral Hydrate etc"*

Almost all of the information originally requested was granted, except for information pertaining to NDMA, probably indicating that GWMWater do not test for this chemical.

After assessing the information it was decided to focus on ten communities that appeared to be having the most concerns regarding the quality of their drinking water. Most results supplied in the Freedom of Information request were not included for the year 2012, probably as a result of these water supplies being designated as being Regulated and as such not suitable for drinking water. Information sourced from GWMWater also only included chlorite information for Lake Bolac and Willaura between the years 2007-9.

The communities appearing to have the most concerns regarding drinking water quality between 2005-12 included:

Beulah, Donald, Jung, Minyip, Murtoa, Quambatook, Rupanyup, Warracknabeal, Woomelang and Wycheproof. Lake Bolac and Willaura were also included in terms of high levels of chlorite detected in those supplies.

From the information supplied by GWMWater it would appear that many of these communities have been drinking substandard water in terms of chlorine disinfection by-products for periods of time, extending over some years for some communities. It is also highly likely that there would be many other communities across Australia facing similar problems with their water supplies, particularly in times of drought and when chlorine is used as a disinfectant.

Friends of the Earth was aware that there had been issues regarding Trihalomethanes, however problems concerning Haloacetic Acids reveal that this class of chemical has since the *"Millenium Drought"* been of major concern in many communities including communities supplied by 'new' pipeline water.

An explantation concerning high THM levels from GWMWater – email to Friends of the Earth June

14 2013

"GWMWater experience a severe shortage of water across its entire region during 2009 as a result of ongoing drought conditions, during this time the capacity of GWMWater's headwork reservoirs got as low as 2.5%. During this period the only means of transferring water from the headwork reservoirs to these towns was through the existing channel infrastructure, however, this method of transfer incurred large loses due to seepage and evaporation. Therefore, GWMWater was unable to supply many of the towns in the region with water to supplement what remained in their town storages. As a result the water contained in town storage became more saline, the increase in the salinity of the water directly impacted on the concentration of disinfection by products produced.

During this time GWMWater was working towards completing the Wimmera Mallee Pipeline (WMP), the pipeline system was designed to reduce the amount of water lost to evaporation and seepage and made transferring water from the headwork to the town storages much more efficient. It is the connection of the WMP to the new town storages and the subsequent supply of "fresh" water which directly impacted the salinity, and therefore, the disinfection by product concentrations. The treatment processes were unchanged."

Note that this response does not take into account high levels of Haloacetic Acids detected in communities after the drought, supplied with freshwater via the newly commissioned Wimmera Mallee pipeline. (Quality of this water was greatly diminished by the January 2011 floods).

The Wimmera Mallee Pipeline consists of seven supply zones connected during a staggered time period. Many Mallee towns received a flush of freshwater after the pipeline was connected to their communities. At least eight communities in this study, received this water and results in changes in the characteristics of the disinfection byproducts detected was in most cases quite dramatic. The changes usually meant an immediate reduction of trihalomethanes, with a gradual increase of haloacetic acids, probably caused by an increase in dissolved organic carbon concentration in the fresh water.

Similar issues have been observed in Victorian and South Australia: *"In all three scenarios natural organic matter or dissolved organic carbon concentration (DOC) and bromide had the greatest impact on DBP formation...Under drought conditions DBP formation was dependant mainly on bromide concentration while under flood conditions, DBP formation could be directly related to DOC concentration."* (1)

The Grampians suffered widespread flooding in January 2011 with disastrous impacts on water quality at Lake Bellfield. The floods caused water quality problems including significantly increased levels of colour and turbidity. Boil Water Notices were immediately issued for Beulah (18 Feb 2011), Donald (15 Jan 2011), Jung (7 Feb 2011), Minyip (3 Feb 2011), Rupanyup (3 Feb 2011), Woomelang (18 Feb 2011), Wycheproof (15 Jan 2011). Coagulating devices were also installed in these communities as a means of reducing turbidity. All of these supplies were then declared to be Regulated on February 27 2012. Regulated water supplies, means that the water is not treated and not suitable for drinking or food preparation.

The water quality problems at Lake Bellfield were reportedly the worst on record. Lake Bellfield, located on the eastern slopes of the Grampians, supplies water to 26 towns (12,000 connections). 50% of the Grampians National Park was burnt in January 2006, including all of the Lake Bellfield catchment. The intensity of fire scorched a large amount of vegetation and left soils exposed to erosion. Very high rainfall occurred in January 2011 leading to 200 landslips in the Grampians National Park. These events led to excessive turbidity and colour problems at Lake Bellfield and problems for downstream communities. Towns with Water Treatment Plants could adequately cope with the excessive turbidity, however for 19 towns and 10,000 residents and rural customers where Water Treatment Plants were not present (including seven towns in this case study), aesthetic problems meant that the water was largely undrinkable. This also means that perhaps a large percentage of the population would not have been drinking the water after January 2011.

It should be pointed out that most of the water quality data used in this report applies to drinking water prior to these water supplies being both issued with Boil Water Notices and being Regulated. Boiling Water can reduce levels of some THM's however it may not be effective against DBP's which do not evaporate easily.

Of the 9* communities reviewed in this study which received "fresh water" after the commissioning of the new pipeline, all saw reductions of total Trihalomethanes of between 13 to 98% (averaging 47.3%), with subsequent large drops in the formation of Bromoform and Dibromochloromethane. Seven communities saw Bromoform levels reduce by 99% (averaging a reduction of 96.3% across 9 communities), with Dibromochloromethane reducing by an average of 91.2%). One community saw a tiny increase in formation of Bromodichloromethane and all observed increases in formation of chloroform by an average of 315%. [*Quambatook and Lake Bolac/Willaura not included in this breakdown).

In terms of Haloacetic Acids, all 9 communities saw falls in formation of Bromochloroacetic Acid and Dibromoacetic Acid. Seven communities saw decreased levels of Bromodichloroacetic acid. All communities saw increases in exposure to dichloroacetic acid (between 57 and 363%) and all observed significant increases in the production of trichloroacetic acid (between 146 and 4000%) after pipeline water was supplied to their towns. Six communities saw increases (by between 43 and 130%) in Total Haloacetic acid exposure after receiving "fresh water" from the pipeline - an increase over 9 communities of 38.9%.

Wimmera Mallee Pipeline Announcement April 2010 (Source: GWMWater)

The Wimmera Mallee Pipeline Project is the best thing for 100 years

The Wimmera Mallee Pipeline Project (WMPP) is the largest water infrastructure project in Australia, replacing 18,000 kilometres of inefficient earthen channel with 9,159 kilometres of pressurized pipeline and associated structures.

Construction of this great engineering feat commenced in November 2006 with the last pipe being laid in April 2010 - well ahead of the ten year timeframe originally proposed and within the $688 million project budget.

Thursday 15 April 2010 saw the Horsham Soundshell come alive with celebrations for the official opening of the Wimmera Mallee Pipeline.

Federal and State parlimentarians joined GWMWater's then Chairman Barry Clugston to lower the 'Piping It' flag and raise the 'Piped It' flag with a crowd of more than 1,100 interested community members cheering them on. The flag ceremony symbolised the completion of all pipes laid and officially opened the Wimmera Mallee Pipeline.

Thanks to the pipeline project, made possible by project partners including the Australian and Victorian governments, 36 towns and our 7,000 rural customers are now receiving a high quality and reliable water supply.

Water restriction levels for these customers were eased from Stage 4 to Stage 1 in October 2009 and subsequently moved to Permanent Water Saving Rules in October 2010 as a result of the improved water security that the project has delivered. (2)

Towns in Case Study in Relation Seven Supply Systems for Wimmera Mallee Pipeline

Town	Population	Wimmera Mallee Pipeline System	Source Water	Approximate Date of Change in Water Quality	Boil Water Notice Issued	Coagulation Commenced	Water Supply Regulated
Beulah	200	System 2 Woomelang	Grampians Headworks	Feb 09	18 Feb 2011	19 Sep 11	27 Feb 2012
Donald	1363	System 4 Wycheproof	Grampians Headworks	Oct 09	15 Jan 2011	8 Jul 11	27 Feb 2012
Jung	87	System 2 Woomelang	Grampians Headworks	Dec 08	7 Feb 2011	20 Sep 11	27 Feb 2012
Lake Bolac /Willaura	540	n/a	**Mt William Creek, Stony Creek, Mason Creek**	N/a			
Minyip	435	System 3 Birchip	Grampians Headworks	May 09	3 Feb 2011	21 Sep 11	27 Feb 2012
Murtoa	840	System 2 Woomelang	Grampians Headworks	Oct 08			
Quambatook	280	System 5 Culgoa	Murray River Pipeline				
Rupanyup	373	System 3 Birchip	Grampians Headworks	May 09	3 Feb 2011	13 July 11	27 Feb 2012
Warrackna beal	2490	System 2 Woomelang	Grampians Headworks	Nov 08			
Woomelang	193	System 2 Woomelang	Grampians Headworks	Apr 09	18 Feb 2011	21 Sep 11	27 Feb 2012
Wycheproof	686	System 4 Wycheproof	Grampians Headworks	Dec 09	15 Jan 2011	20 Sep 11	27 Feb 2012

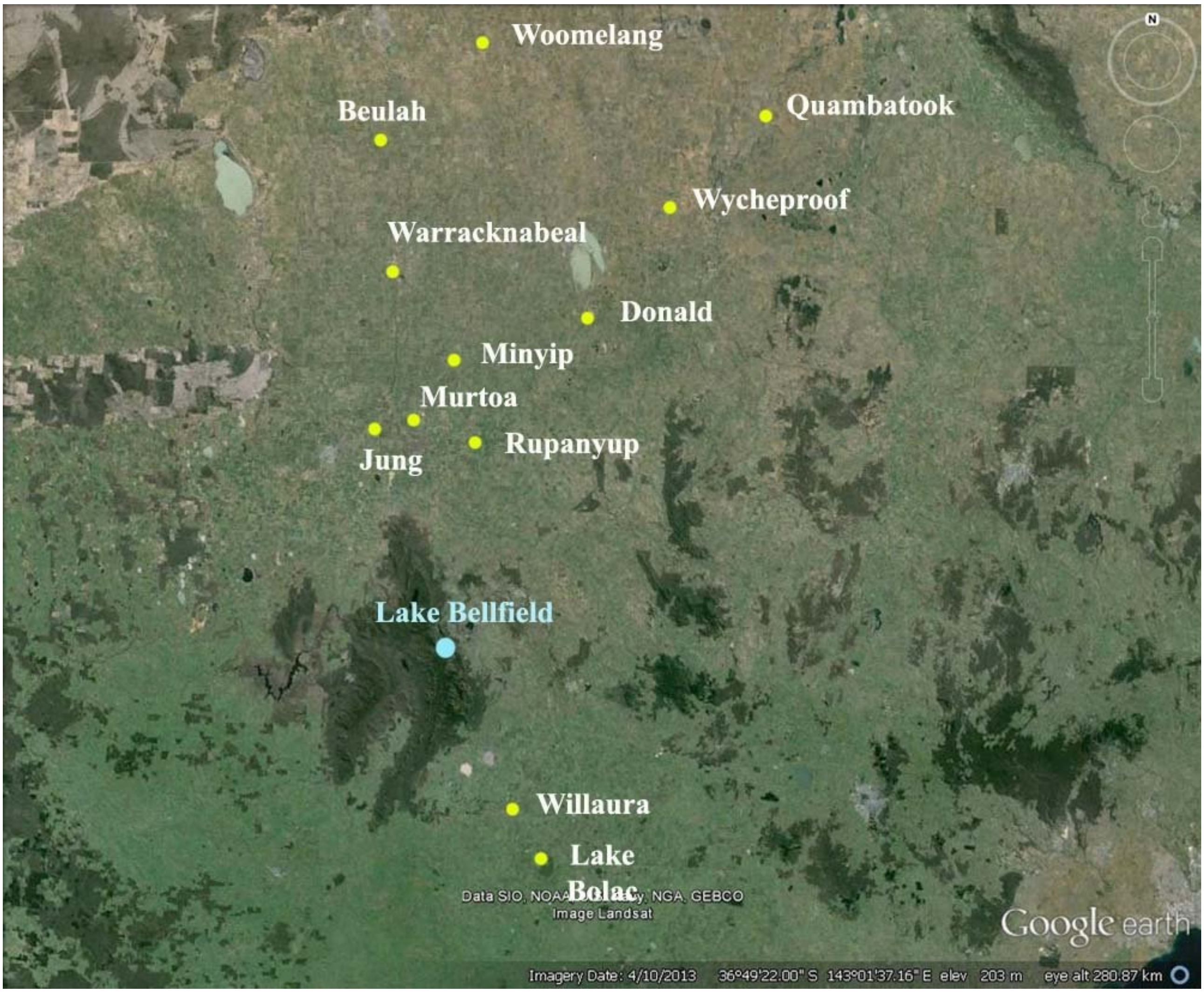
Note that despite being supplied with drinking water from the Wimmera Mallee Pipeline, seven communities in this case study had their water supplies declared as being regulated only 2-3 years after receiving the flush of new water supplied through the pipeline. Beulah, Donald, Jung, Minyip, Rupunyap, Woomelang and Wycheproof all had disinfection as the only means of treatment, meaning that these communities were exposed to high turbidity and poor coloured water after the January 2011 floods. As a result, the water was undrinkable. It is also understood that many Mallee residents rely on water tanks for drinking water.

Lake Bellfield Problems

Located on the eastern side of the Grampians, have suffered from a litany of problems since 2006.

January 2006 bushfires, burnt a large portion of the catchment. This in turn led to high erosion potential, as much of the vegetation was burnt, leaving soils exposed. Floods five years later in January 2011, resulted in hundreds of landslips throughout the Grampians National Park. Huge amounts of soil ended up being deposited in Lake Bellfield, increasing turbidity and colour of the source water. This water was then passed through the system and communities with no Water Treatment Plants suffered a sharp decline in aesthetic water quality. These natural events were beyond the control of GWMWater and highlight how vulnerable water authorities can be to extremes in weather.

Map of Region



Lake Bellfield is the main source of water for towns supplied by the Wimmera Mallee Pipeline. It was affected by the 2006 Mt Lubra bushfires and floods of January 2011. All the towns on this map are supplied by water from Lake Bellfield, excluding Willaura, Lake Bolac and Quambatook.

Climate change predictions for South East Australia show that the region will suffer from longer droughts and more intense short term rainfall events. With the severe climatic events that have occurred in the Grampians since 2005 one could comment that these events are already having a negative influence on the quality and security of water supplies in the region.

It could also be argued that unless impacts of climate change are addressed huge infrastructure projects such as the Wimmera Mallee Pipeline Project may not achieve improved water quality improvements, particularly if source water continues to be heavily impacted by land use changes such as flooding and fires.

What are Disinfection By-Products?

Chlorine was initially added to drinking water as a means of killing disease causing bacteria including cholera, typhoid, dysentery etc which were responsible for the deaths of millions of people. Its use as a water disinfectant was '*perfected'* in the United States in the 1930's.

Chlorine however does have its own 'problems', such as those related to Disinfection By-Products (DBP's). DBP's were first discovered in 1974 when Dutch Scientist, Johannes Rook, found that chloroform was formed when chlorine reacted with organic molecules in drinking water. Chlorine also reacts with fulvic, humic and amino acids in water as well as bromide and iodide ions. Saline water has the potential to produce of high levels brominated DBP's because of levels of bromide usually in salty water which when chlorinated will produce [cause] a variety of Brominated Disinfection Byproducts to be formed in drinking water. Since 1974 over 600 DBP's identified and some have been linked with cancers, adverse birth outcomes and birth defects. If detected, water authorities need to conduct regular air scouring, flushing of the reticulation system and powder activated carbon dosing.

The most commonly detected DBP's are Trihalomethanes (THM's) and Haloacetic Acids. THM's can be present in water as a result of chlorination and to a lesser extent chloramination. Regulated THM's include chloroform, bromodichloromethane, dibromochloromethane and bromoform. In the United States, the EPA limits the total concentration of the four chief constituents (chloroform, bromoform, bromodichloromethane, and dibromodichloromethane), referred to as total trihalomethanes (TTHM), to 80 parts per million in treated water. In Australian the limit is 250 parts per billion. The Australian limits have not been revisited by the National Health and Medical Research Council since 1996. No explanation is given to why Australian Guideline levels are three times higher than those in the United States.

"The Australian trihalomethanes (THM) guideline was developed in 1996 and has not been subject to review since that time. However, in recent years there has been conjecture about the use and significance of trihalomethanes (THM) as indicators for disinfection by-products and associated health implications. This has included debate about the nature of potential health risks and the appropriate guideline value.

The National Health and Medical Research Council's Water Quality Advisory Committee is currently considering their work program to 2015 and has identified disinfection-by products as an area for revision as part of this work" NHMRC Letter to Friends of the Earth 14 January 2013.

Haloacetic acids (HAA's) are also DBP's. 15 HAA's can be formed in the presence of chlorine, bromide and iodide. The most common HAA's are dichloroacetic acid and trichloroacetic acid. Other HAA's include: bromochloroacetic acid, bromodichloroacetic acid, dibromoacetic acid, monochloroacetic acid, monobromoacetic acid, bromoacetic acid and chloroacetic acid.

It is evident from the information supplied by Grampians Wimmera Mallee Water that they test for seven HAA's which appears to be unusual for a Victorian water authority. This indicates that the issue may have warranted special attention by the Victorian Health Department in the past. As a result the data provided by GWMWater is some of the most detailed monitoring data in regards to HAA that Friends of the Earth have been privy to.

Trihalomethanes

Classical trihalomethanes consist of chloroform ($CHCl_3$), dichlorobromoform ($CHCl_2Br$), dibromochloroform ($CHBr_2Cl$) and bromoform ($CHBr_3$).

Why and how are THMs formed?

"When chlorine is added to water with organic material, such as algae, river weeds, and decaying leaves, THMs are formed. Residual chlorine molecules react with this harmless organic material to form a group of chlorinated chemical compounds, THMs. They are tasteless and odorless, but harmful and potentially toxic. The quantity of byproducts formed is determined by several factors, such as the amount and type of organic material present in water, temperature, pH, chlorine dosage, contact time available for chlorine, and bromide concentration in the water. The organic matter in water mainly consists of a) humic substance, which is the organic portion of soil that remains after prolonged microbial decomposition formed by the decay of leaves, wood, and other vegetable matter; and b) fulvic acid, which is a water soluble substance of low molecular weight that is derived from humus". (3*)

"...Increase in bromide ion concentration increases total THM formation. Fractions of brominated THMs decrease with increasing NOM molecular size. Lower molecular weight NOM forms more brominated THMs than the corresponding higher molecular weight NOM. Increase of bromide to chlorine ratio decreases chloroform and increases brominated THMs. Increase in pH increases chloroform and decreases brominated THMs. This study demonstrates that the distribution of NOM and bromide ion can have important role on the distribution of THMs....distribution of lower and higher molecular weight NOM, can influence THM formation..."(18)

"What are the health effects of THMs? According to a University of Florida report, exposure to THMs may pose an increased risk of cancer. According to Rebekah Grossman, two THMs, chloroform and dibromochloromethane, are carcinogens; and another THM, bromodichloromethane, has been identified as a mutagen, which alters DNA. Mutagens are considered to affect the genetics of future generations in addition to being carcinogenic. A California study indicates that THMs may be responsible for reproductive problems and miscarriage. The study found a miscarriage rate of 15.7 percent for women who drank five or more glasses of cold water containing more than 0.075 mg/l TTHM, compared to a miscarriage rate of 9.5 percent for women with low TTHM exposure. In addition to these risks, TTHMs are linked to bladder cancer, heart, lungs, kidney, liver, and central nervous system damage." (3*)

According to the Australian Drinking Water Guideline *"The World Health Organization (WHO) has derived separate guideline values for each compound, but in doing so recognises that the compounds have similar toxicological action. The WHO guideline values for chloroform (0.2 mg/L) and bromodichloromethane (0.06 mg/L) were based on calculations that estimated additional lifetime risks of one fatal cancer per 100,000 people. The use of this approach is questionable because there is evidence that tumours do not occur at low concentrations.... The WHO guideline values for bromoform (0.1 mg/L) and dibromochloromethane (0.1 mg/L) were based on different studies and safety factors from those recommended by the NHMRC Standing Committee on Toxicity, although toxicological effects were similar."* (4)

It is also important to note that exposure to DBP's is not only through drinking water, but also showering, bathing, swimming or enhaling. Australian Guidelines do not necessarily take into account additional exposure through these routes.

"Although drinking water studies in laboratory animals might reflect human risks associated with oral exposure, they may not adequately represent risks from dermal or inhalation exposures. The latter exposures lack first-pass liver metabolism and may result in a relatively greater extrahepatic distribution of bromodichloromethane than from oral exposure alone. Indeed, blood levels of trihalomethanes including bromodichloromethane were four to five times higher in people who took 10-minute showers or bathed for 10 minutes than in people who drank one liter from the same tap water source in 10 minutes (Backer et al., 2000). Thus, evaluations of human risk to bromodichloromethane in tap water need to account for all potential routes of exposure, not just oral". (5*)

Bromodichloromethane/Dichlorobromoform

Bromodichloromethane 0.06mg/L (WHO) Guideline Level.

Bromodichloromethane is a Group 2B Possible carcinogen. The Australian Drinking Water Guidelines do not list Bromodichloromethane. Bromodichloromethane is a Trihalomethane. The trihalomethane guideline includes the sum of four different substances.

"The International Agency for Research on Cancer (IARC) has classified BDCM in Group 2B (possibly carcinogenic to humans). BDCM gave both positive and negative results in a variety of in vitro and in vivo genotoxicity assays. In an NTP bioassay, BDCM induced renal adenomas and adenocarcinomas in both sexes of rats and male mice, rare tumours of the large intestine (adenomatous polyps and adenocarcinomas) in both sexes of rats and hepatocellular adenomas and adenocarcinomas in female mice. Exposure to BDCM has also been linked to a possible increase in reproductive effects (increased risk for spontaneous abortion or stillbirth)." (6)

"Preliminary animal studies indicate that BDCM and other trihalomethanes that contain bromine may be more toxic than chlorinated trihalomethanes such as chloroform. For this reason, and based on the availability of scientific data for BDCM, a separate guideline was also developed for BDCM. BDCM is considered to be a probable carcinogen in humans, with sufficient evidence in animals and inadequate evidence in humans. Animal studies have shown tumours in the large intestine in rats. Among the four trihalomethanes commonly found in drinking water, BDCM appears to be the most potent rodent carcinogen, causing tumours at lower doses and at more target sites than the other three compounds. Exposure to BDCM at levels higher than the guideline value has also been linked to a possible increase in reproductive effects (increased risk for spontaneous abortion or stillbirth) above what can normally be expected. Further studies are required to confirm these effects." (7)

Chloroform

Chloroform 0.3mg/L (WHO) Guideline Level

Chloroform is considered to be a possible carcinogen in humans, based on limited evidence in experimental animals, and inadequate evidence in humans. Animal studies have shown links between exposure to specific trihalomethanes and liver tumours in mice and kidney tumours in both mice and rats; some studies in humans show data that are consistent with these findings. Human studies are suggesting a link between exposure to trihalomethanes and colorectal cancers. Human studies also suggest a link between reproductive effects and exposure to high levels of trihalomethanes. However, an increase in the concentration of trihalomethanes could not be linked to an increase in risk, suggesting the need for more studies. (7)

"In Australia, trihalomethanes are present in drinking water principally as the result of disinfection using chlorination or, to a much lesser extent, chloramination. Chlorine, which produces hypochlorous acid when added to water, can react with naturally occurring organic material, such as humic and fulvic acids, to produce trihalomethanes. The brominated trihalomethanes are produced by the oxidation of bromide present in water to form hypobromous acid, which can then react with organic matter in a similar way. High trihalomethane concentrations may indicate the presence of other chlorination by-products. Chloroform is produced commercially and is an important solvent. It is used in the manufacture of refrigerants, and as an ingredient in pharmaceutical and cosmetic preparations. Brominated trihalomethanes are also produced industrially, but less commonly than chloroform." (4)

"Sources of chloroform in the aquatic environment include paper bleaching with chlorine, chlorination of recreational (pool) water, cooling water and wastewater. Chloroform is present in drinking-water through direct contamination of the source and through formation from naturally occurring organic compounds during chlorination. The rate and degree of formation of chloroform during chlorination are a function primarily of the concentrations of chlorine and humic acid, temperature and pH. Levels vary seasonally, with concentrations generally being greater in summer than in winter (IPCS, 1994a)..." (10)

Bromoform & Dibromochloromethane

Bromoform 0.1mg/L (WHO) Guideline Level
Dibromochloromethane 0.1mg/L (WHO) Guideline Level

Bromoform is a chlorine disinfection byproduct and is classed one of the sum of 4 chemicals under Trihalomethanes. As such it is not given a seperate guideline under the ADWG.

According to the ADWG: *"The WHO guideline values for bromoform (0.1mg/L) and dibromochloromethane (0.1mg/L)were based on different studies and safety factors from those recommended by the NHMRC Standing Committee on Toxicity, although toxicological effects were similar. It is recommended that future reviews of the guidelines consider the various THM's individually, as data are emerging that suggest that different THMs have different toxic effects. Data were not sufficient at the time of this review to justify individual assessments."* (4)

"Some studies in animals indicate that exposure to high doses of bromoform or dibromochloromethane may also lead to liver and the kidney injury within a short period of time. Exposure to low levels of bromoform or dibromochloromethane do not appear to seriously affect the brain, liver, or kidneys. Other animal studies suggest that typical bromoform or dibromochloromethane exposures do not pose a high risk of affecting the chance of becoming pregnant or harming an unborn baby. However, studies in animals indicate that long-term intake of either bromoform or dibromochloromethane can cause liver and kidney cancer. Although cancer in humans cannot be definitely attributed to these chemicals, it is an effect of special concern, since many people are exposed to low levels of bromoform and dibromochloromethane in chlorinated drinking water.

The International Agency for Research on Cancer (IARC) concluded that bromoform and dibromochloromethane are not classifiable as to human carcinogenicity. The EPA classified *bromoform as a probable human carcinogen and dibromochloromethane as a possible human carcinogen....EPA recommends that drinking water levels for bromoform should not be more than 0.7 parts per million (ppm) for bromoform and 0.7 ppm for dibromochloromethane".* (8)

Also note that the Department of Health has allowed water authorities to exceed Australian Drinking Water Guidelines, in regards to the following DBP's, in some cases by 45% over the guideline levels set by the National Health and Medical Research Council in the ADWG's. (19)

Water Quality Reporting Standards – Chlorine Based Chemicals

GWMWater Water Quality Report 2011/12

Parameter	**Benchmark Compliance Standard**	**Examples Of Compliance Including Rounding#**
Chloroacetic Acid	Must not exceed 0.15mg/L	Results of 0.155 mg/L and greater are noncompliant, results of 0.154 mg/L and less are compliant.
Dichloroacetic Acid	Must not exceed 0.1mg/L	Results of 0.145 mg/L and greater are noncompliant, results of 0.144 mg/L and less are compliant.
Trichloroacetic Acid	Must not exceed 0.1mg/L	Results of 0.145 mg/L and greater are noncompliant, results of 0.144mg/L and less are compliant.
Trihalomethanes	Must not exceed 0.25mg/L	Results of 0.255 mg/L and greater are noncompliant, results of 0.254mg/L and less are compliant.

The Department of Health stipulates that results are deemed to be complaint with the Regulations at or below the benchmark standard when rounding of the value has been conducted.

Haloacetic Acids

Potential Health Effects From Long Term Exposure Above MCL
Increased risk of cancer (9)

There is no overall guideline for Haloacetic Acids in Australia, only singular guidelines for Chloroacetic Acid, Dichloroacetic Acid and Trichloracetic Acid. Other countries such as Canada 0.08mg/L and the United States 0.06mg/L have combined Haloacetic Guideline levels.

"HAAs are formed in drinking water when chlorine disinfectants used in water treatment react with organic matter (e.g., humic or fulvic acids) and inorganic matter (e.g., bromide ion) naturally present in the raw water (IPCS, 2000). HAAs are the second most frequently occurring DBPs, after THMs... HAA formation can be appreciable when drinking water is chlorinated under conditions of slightly acid pH (IPCS, 2000). Whereas THM formation increases with increasing pH, HAA formation decreases, hydrolysis likely being a significant factor (Krasner et al., 1989; Pourmoghaddas and Stevens, 1995). Despite the fact that HAAs and THMs have different pH dependencies, their formation appears to correlate strongly when treatment conditions are relatively uniform and when the water has a low bromide concentration (Singer, 1993)." (11)

"Australian Drinking Water Guideline
Based on health considerations, the concentrations of chloroacetic acids in drinking water should not exceed the following values:
Chloroacetic acid 0.15 mg/L
Dichloroacetic acid 0.1 mg/L
Trichloroacetic acid 0.1 m g/L

GENERAL DESCRIPTION
Chloroacetic acids are produced in drinking water as by-products of the reaction between chlorine and naturally occurring humic and fulvic acids. Concentrations reported overseas range up to 0.16 mg/L,and are typically about half the chloroform concentration.
The chloroacetic acids are used commercially as reagents or intermediates in the preparation of a wide variety of chemicals. Monochloroacetic acid can be used as a pre-emergent herbicide, dichloroacetic acid as an ingredient in some pharmaceutical products, and trichloroacetic acid as a herbicide, soil sterilant and antiseptic. (4)

Trichloroacetic Acid

Australian Drinking Water Guideline: 0.1mg/L
World Health Organisation Guideline: 0.2mg/L

"...Accordingly, this assessment concludes that there is suggestive evidence of carcinogenic potential for TCA. ... Because TCA is highly soluble in water, it is reasonable to assume that TCA can be absorbed and taken up into the blood via the inhalation route. Moreover, the drinking water studies demonstrate that TCA acts systemically rather than only at the site of first contact. In the absence of information to indicate otherwise, there is suggestive evidence of carcinogenic potential for TCA by all routes of exposure...In this case, although there are no epidemiologic studies that have evaluated the carcinogenicity in humans, the carcinogenicity of TCA has been evaluated in

several studies in both rats and mice. These studies are well-conducted studies showing evidence of increased incidence of tumors in both sexes of one species at multiple exposure levels. The data from these studies are adequate to support a quantitative cancer dose-response assessment. Considering these data and uncertainty associated with the suggestive nature of the tumorigenic response, EPA concluded that quantitative analyses may be useful for providing a sense of the magnitude of potential carcinogenic risk. Based on the weight of evidence, a dose-response assessment of the carcinogenicity of TCA is deemed appropriate. ...

There are no epidemiological studies of TCA carcinogenicity in humans. Most of the human health data for chlorinated acetic acids concern components of complex mixtures of water disinfectant byproducts. These complex mixtures of disinfectant byproducts have been associated with increased potential for bladder, rectal, and colon cancer in humans [reviewed by Boorman et al. (1999); Mills et al. (1998)]." (12)

Dichloroacetic Acid & Dibromoacetic Acid

Australian Drinking Water Guideline: 0.1mg/L
World Health Organisation Guideline: 0.05mg/L

Dichloroacetic Acid (DCA) is considered to be a probable carcinogen to humans, based on sufficient evidence in animals and inadequate evidence in humans. Animal studies have shown links between exposure to DCA and liver tumours in both mice and rats. A health-based target concentration of 0.01 mg/L can be calculated for DCA in drinking water... (Dibromoacetic Acid) DBA is considered to be probably carcinogenic in humans, based on sufficient evidence in animals and inadequate evidence in humans. Animal studies have shown links between exposure to DBA and tumours in several organs in both mice and rats. A health-based target concentration of 0.002 mg/L can be calculated for DBA in drinking water....

Some animal studies suggest a possible link between developmental effects (heart defects) and exposure to DCA or (Trichloroacetic Acid) TCA, whereas other studies fail to show a link. Animal studies also suggest a possible link between male reproductive effects (on sperm and sperm formation) and exposure to DCA or DBA, at levels significantly higher than those found in drinking water. Further studies are required to confirm these effects as well as their long-term significance to human health.

A single guideline for total haloacetic acids is established, based on the health effects of the individual haloacetic acids, and taking into consideration both treatment technology and the ability of treatment plants, particularly smaller ones, to achieve the guideline. The guideline is considered to be protective of health for all haloacetic acids, based on the ratio of haloacetic acids expected to be found in drinking water. The guideline value is primarily designed to be protective of the health effects of DCA, the haloacetic acid that would pose the most significant health concerns and is found at the highest levels in drinking water. (13)

"...DCA is classified in Group II (probably carcinogenic to humans), based on sufficient evidence in animals and inadequate evidence in humans. A health-based target concentration of 0.01 mg/L can be calculated for DCA in drinking water, based on liver tumours observed in both mice and rats. TCA is classified in Group III (possibly carcinogenic to humans), based on limited evidence of carcinogenicity in experimental animals and inadequate evidence in humans. A health-based target concentration of 0.3 mg/L can be calculated for TCA in drinking water. Although animal studies have shown a link between exposure to TCA and liver tumours in mice only, it is still uncertain

whether the mechanism causing these tumours is relevant to humans. ...DBA is classified in Group II (probably carcinogenic to humans), based on sufficient evidence in animals and inadequate evidence in humans. A health-based target concentration of 0.002 mg/L can be calculated for DBA in drinking water, based on tumours in several organs observed in both mice and rats." (14)

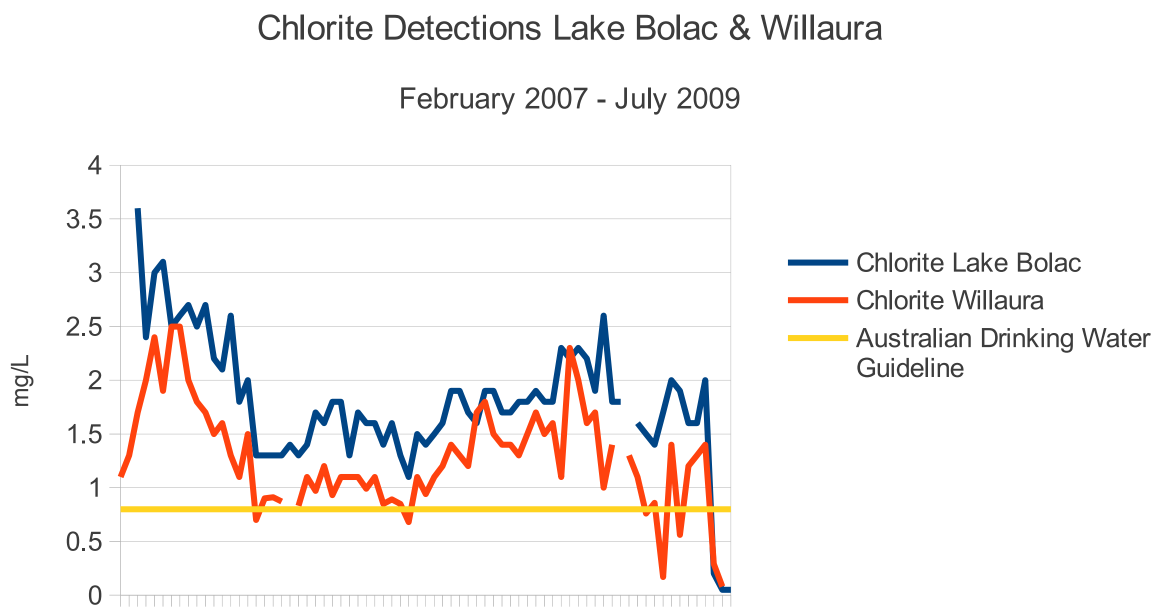
Bromochloroacetic Acid & Bromodichloroacetic Acid

The IARC class Bromochloroacetic Acid as possibly carcinogenic to humans (Group 2B).

"The results of a single toxicokinetic study show that bromochloroacetic acid is rapidly absorbed from the gastrointestinal tract, rapidly cleared from the blood, almost completely metabolized and minimally excreted in the urine and faeces. However, little information is available on tissue distribution, metabolism or primary excretion pathways. Limited mutagenicity and genotoxicity data give mixed results for monobromoacetic acid and generally positive results for bromochloroacetic acid. Because monobromoacetic acid and bromochloroacetic acid have not been tested in subchronic or chronic toxicity studies, the available data are considered inadequate to establish guideline values for these chemicals. Other data gaps for these chemicals include the absence of multigeneration reproductive toxicity studies, standard developmental toxicity studies and carcinogenicity studies." (17)

Chlorite

Australian Guideline: 0.8mg/L
WHO Guideline: 0.7mg/L



Average Chlorite Levels for Lake Bolac 2007-9: 1.7887mg/L (224% above ADWG)
Average Chlorite levels for Willaura 2007-9: 1.2876mg/L (161% above ADWG guideline)

"Chlorite occurs in drinking water when chlorine dioxide is used for purification purposes. The International Agency for Research on Cancer (IARC) has concluded that chlorite is not classifiable as carcinogenic to humans and is listed in the Group 3 category. Changes in red blood vessels due to oxidative stress are a major concern with excessive levels of Chlorite in drinking water. According to the US EPA, potential health problems for people drinking Chorite above safe drinking water guideline include: Anemia in infants and young children and nervous system effects." (15)

"Chlorine dioxide (chlorite) is rarely used as a disinfectant in Australian reticulated supplies. When used, the chlorite residual is generally maintained between 0.2mg/L and 0.4mg/L. It is particularly effective inthe control of manganese-reducing bacteria. Few data are available on chlorate levels in Australian water supplies....Chlorine dioxide, chlorite, and chlorate are all absorbed rapidly by the gastrointestinal tract into blood plasma and distributed to the major organs. All compounds appear to be rapidly metabolised. Chlorine dioxide has been shown to impair neurobehavioural and neurological development in rats exposed before birth. Experimental studies with rats and monkeys exposed to chlorine dioxide in drinking water have shown some evidence of thyroid toxicity; however, because of the studies' limitations, it is difficult to draw firm conclusions (WHO 2005) The primary concern with chlorite and chlorate is oxidative stress resulting in changes in red blood cells. This end point is seen in laboratory animals and, by analogy with chlorate, in humans exposed to high doses in poisoning incidents (WHO 2005)." (4)

"...Subchronic studies in animals (cats, mice, rats and monkeys) indicate that chlorite and chlorate cause haematological changes (osmotic fragility, oxidative stress, increase in mean corpuscular volume), stomach lesions and increased spleen and adrenal weights... Neurobehavioural effects (lowered auditory startle amplitude, decreased brain weight and decreased exploratory activity) are the most sensitive endpoints following oral exposure to chlorite..." (16)

References

(1) Source: 74th Annual Victorian Water Industry Engineers & Operators Conference Page No. 56Exhibition Centre – Bendigo, 6 to 8 September, 2011 IMPACT OF WATER QUALITY AND TREATMENT ON DISINFECTION BY-PRODUCT FORMATION Paper Presented by:David Cook
Authors: David Cook,Senior Research Officer-Water Treatment,Mary Drikas,Research Leader – WaterTreatment, Australian Water Quality Centre http://www.wioa.org.au/conference_papers/2011_vic/documents/David_Cook.pdf
(2) http://www.gwmwater.org.au/services/wimmera-mallee-pipeline
(3*) Potential Health Effects From Long Term Exposure Above MCL
Liver, kidney or central nervous system problems; increased risk of cancer
http://water.epa.gov/drink/contaminants/index.cfm
(4)Australian Drinking Water Guidelines – National Health and Medical Research Centre
(5*) NTP TECHNICAL REPORT ON THE TOXICOLOGY AND CARCINOGENESIS STUDIES OF BROMODICHLOROMETHANE (CAS NO. 75-27-4) IN MALE F344/N RATS AND FEMALE B6C3F1 MICE (DRINKING WATER STUDIES) NATIONAL TOXICOLOGY PROGRAM P.O. Box 12233 Research Triangle Park, NC 27709 February 2006. NTP TR 532
NIH Publication No. 06-4468. National Institutes of Health Public Health Service. U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES.
(6)http://www.who.int/water_sanitation_health/dwq/chemicals/trihalomethanes_summary_statement.pdf

(7) http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/trihalomethanes/guide-eng.php
(8)Agency for Toxic Substances & Disease Registry. Public Health Statement for Bromoform and Chlorodibromomethane http://www.atsdr.cdc.gov/phs/phs.asp?id=711&tid=128)
(9) http://water.epa.gov/drink/contaminants/index.cfm
(10)Trihalomethanes in Drinking Water. Background Document for Development of WHO Guidelines for Drinking Water Quality.
(11) http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/haloaceti/index-eng.php
(12) Ref: tmp/Trichloroacetic acid (TCA) CASRN 76-03-9 IRIS US EPA.htm
(13-14) Guidelines for Canadian Drinking Water Quality: Guideline Technical Document - Haloacetic Acids.
(15) http://water.epa.gov/drink/contaminants/index.cfm
(16) Source: *http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/chlorite-chlorate/index-eng.php#sec10_1*Guidelines for Canadian Drinking Water Quality.
(17)http://www.who.int/water_sanitation_health/dwq/chemicals/brominatedaceticacids.pdf
(18)Trihalomethanes in drinking water: Effect of natural organic matter distribution
Water SA Vol. 39 No. 1 January 2013
(19) GWMWater Water Quality Report 2011/12

Average Disinfection Byproduct Detections

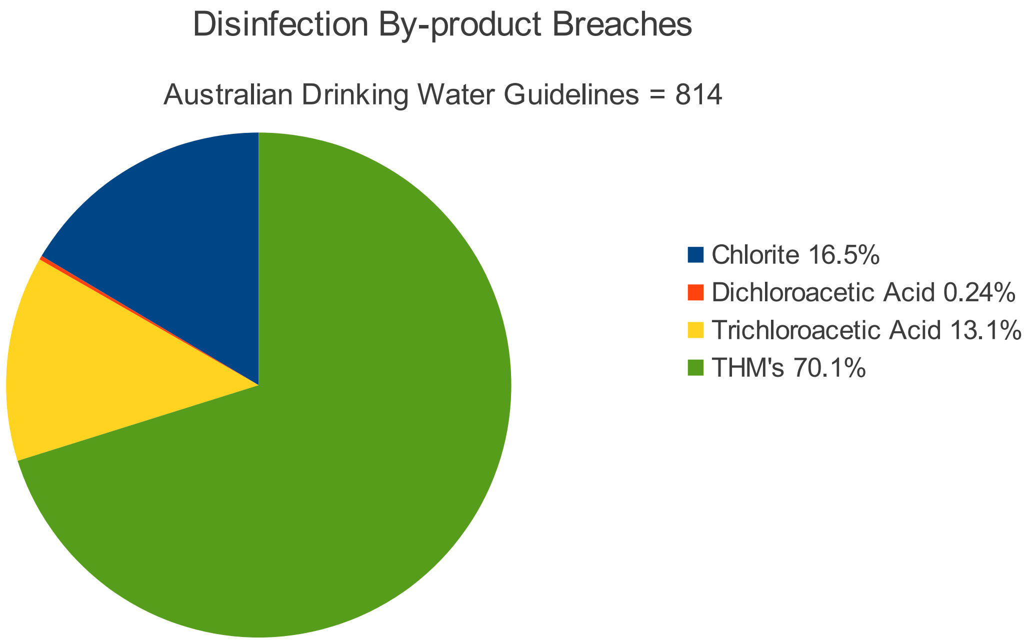
Average Total Haloacetic Acid Detections May 2005 – January 2012

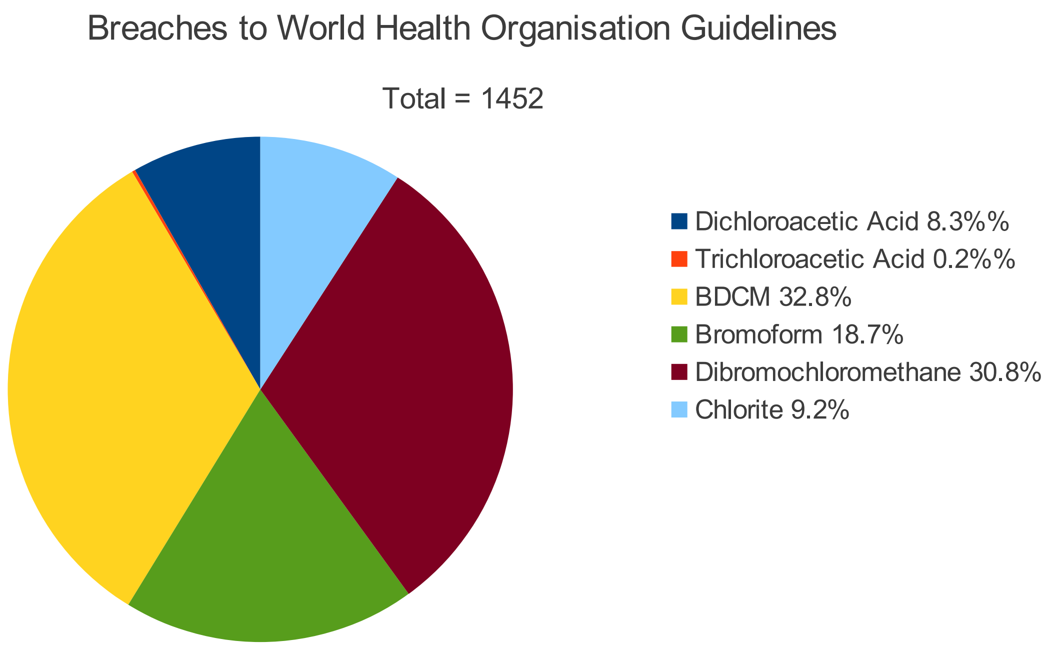
*US EPA Guideline Haloacetic Acids 0.08mg/L

	Bromoacetic Acid	Chloroacetic Acid	Bromochloro-acetic Acid	Bromodichloro-acetic Acid	Dibromoacetic Acid	Dichloroacetic Acid	Trichloroacetic Acid	Haloacetic Acids*
Beulah	0.0057	0.0051	0.0184	0.0388	0.0151	0.0333	0.0622	0.1738
Donald	0.0056	0.005	0.0123	0.0129	0.0233	0.0142	0.0245	0.0969
Jung	0.0055	0.005	0.0141	0.0208	0.0149	0.0311	0.0586	0.1502
Minyip	0.0054	0.005	0.0129	0.0176	0.017	0.0219	0.0511	0.131
Murtoa	0.0062	0.005	0.0158	0.0161	0.0216	0.0128	0.0126	0.0902
Quambatook	0.0052	0.0053	0.0149	0.0173	0.0069	0.0298	0.0313	0.1106
Rupanyup	0.0052	0.005	0.018	0.0207	0.0124	0.0348	0.0502	0.1462
Warracknabeal	0.0063	0.005	0.014	0.0153	0.0215	0.0122	0.011	0.0854
Woomelang	0.0052	0.0051	0.0186	0.0273	0.0126	0.0404	0.0646	0.1738
Wycheproof	0.0054	0.0051	0.0154	0.0197	0.0157	0.0196	0.038	0.1189

Average Total Trihalomethanes May 2005 – January 2012 (mg/L)

	Bromodichloro methane	Bromoform	Chloroform	Dibromochloro methane	Total THM's
Beulah	0.0765	0.0364	0.0935	0.0864	0.2913
Donald	0.0365	0.1042	0.0407	0.0826	0.2627
Jung	0.0669	0.0813	0.0843	0.097	0.3293
Minyip	0.0614	0.0678	0.0853	0.0989	0.3101
Murtoa	0.0439	0.0814	0.0814	0.0332	0.2455
Quambatook	0.0646	0.0058	0.1036	0.0436	0.2186
Rupanyup	0.0706	0.0162	0.0942	0.0658	0.2478
Warracknabeal	0.0354	0.0831	0.0288	0.0822	0.2307
Woomelang	0.0842	0.0244	0.1158	0.078	0.3013
Wycheproof	0.0633	0.0449	0.0823	0.0866	0.2764


Disinfection By-product Breaches
Australian Drinking Water Guidelines = 814
Chlorite 16.5%
Dichloroacetic Acid 0.24%
Trichloroacetic Acid 13.1%
THM's 70.1%


Breaches to World Health Organisation Guidelines
Total = 1452
Dichloroacetic Acid 8.3%%
Trichloroacetic Acid 0.2%%
BDCM 32.8%
Bromoform 18.7%
Dibromochloromethane 30.8%
Chlorite 9.2%

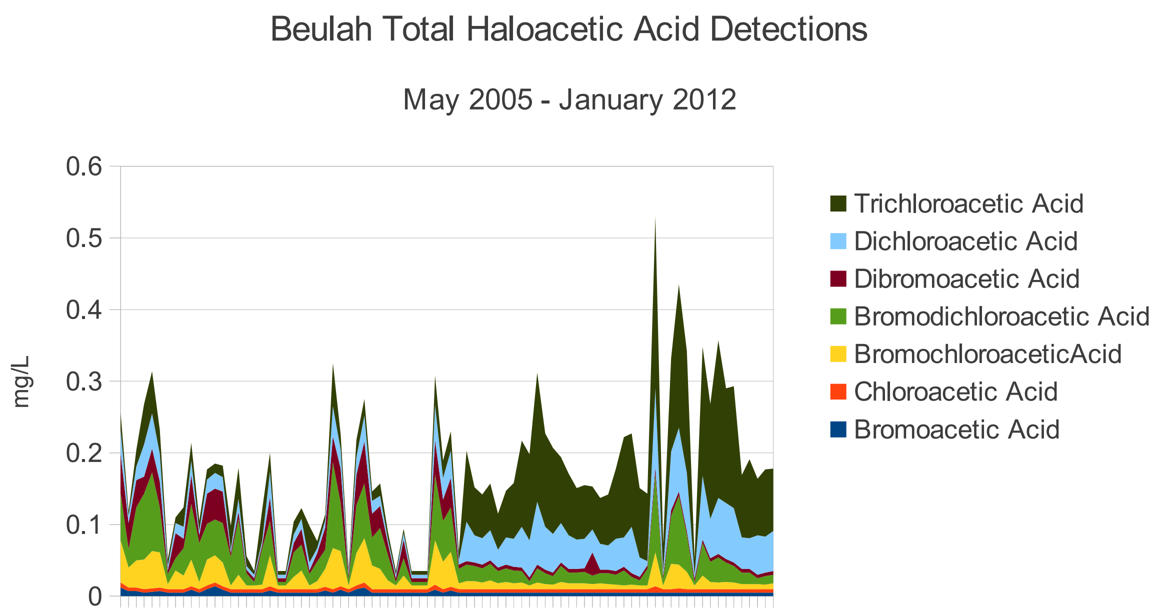
Beulah

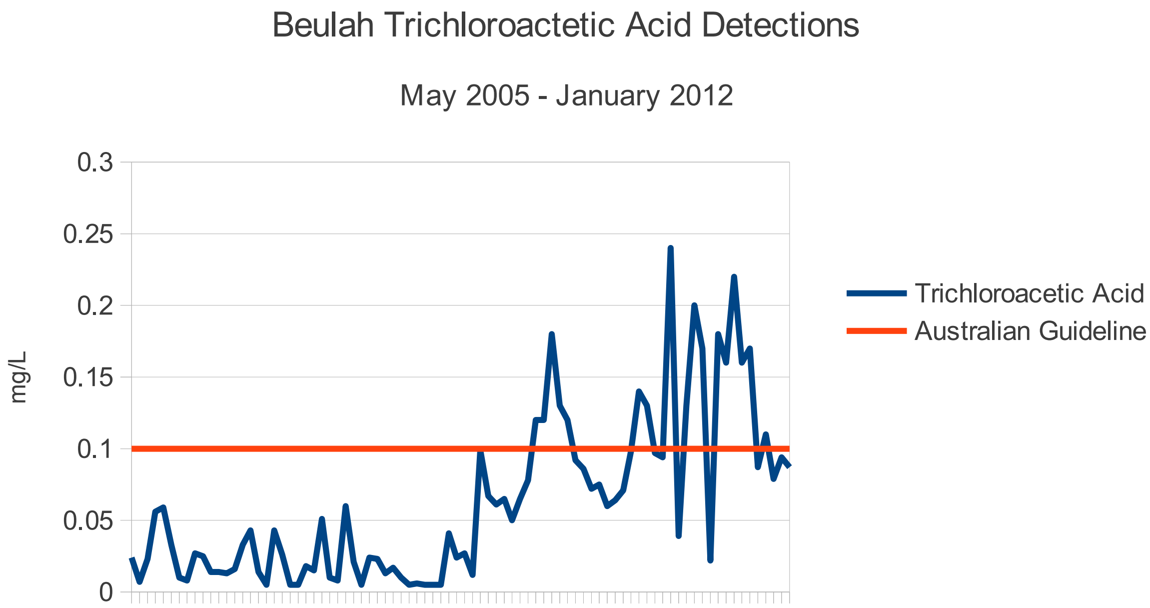
Beulah Average Haloacetic Acid Detections May 2005 – February 2012

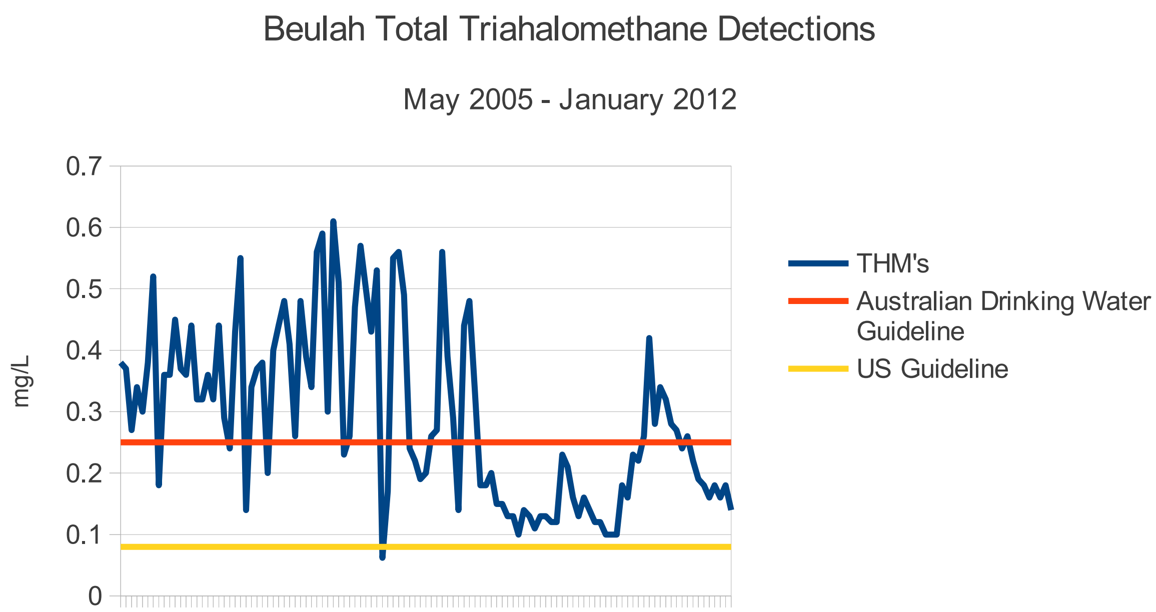
	Bromoacetic Acid	Chloroacetic Acid	Bromochloro-acetic Acid	Bromodichloro-acetic Acid	Dibromoacetic Acid	Dichloroacetic Acid	Trichloroacetic Acid	Haloacetic Acids*
1/5/05-3/2/09	0.0065	0.005	0.0259	0.0437	0.0239	0.0178	0.0206	0.1435
3/2/09-1/2/12	0.005	0.005	0.011	0.0245	0.006	0.0526	0.1124	0.2192

Beulah Average Total Trihalomethane Detections May 2005 – January 2012

	Bromodichloromethane	Bromoform	Chloroform	Dibromochloromethane	Total THM's
1/5/05 3/2/09	0.1042	0.0616	0.0625	0.1429	0.3694
3/2/09-1/2/12	0.0386	0.001	0.1399	0.0071	0.1856

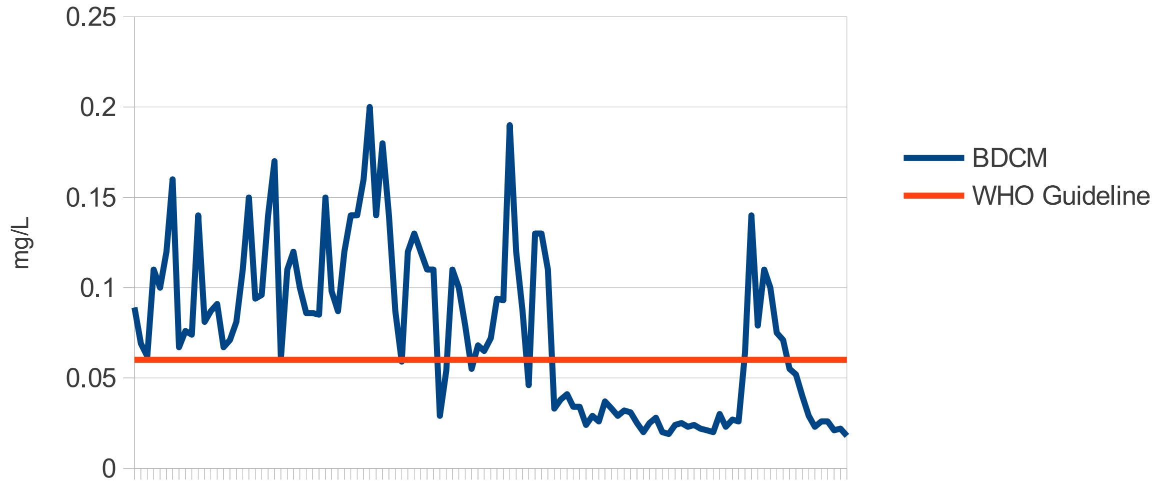



Beulah Trichloroactetic Acid Detections
May 2005 - January 2012
mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
Trichloroacetic Acid
Australian Guideline


Beulah Total Triahalomethane Detections
May 2005 - January 2012
mg/L
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
THM's
Australian Drinking Water Guideline
US Guideline

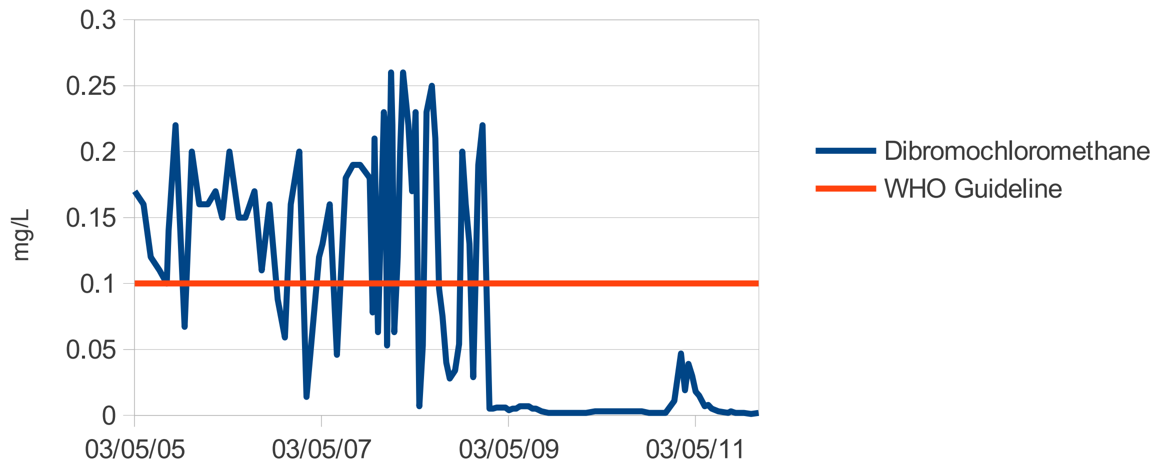
Beulah Bromodichloromethane Detections

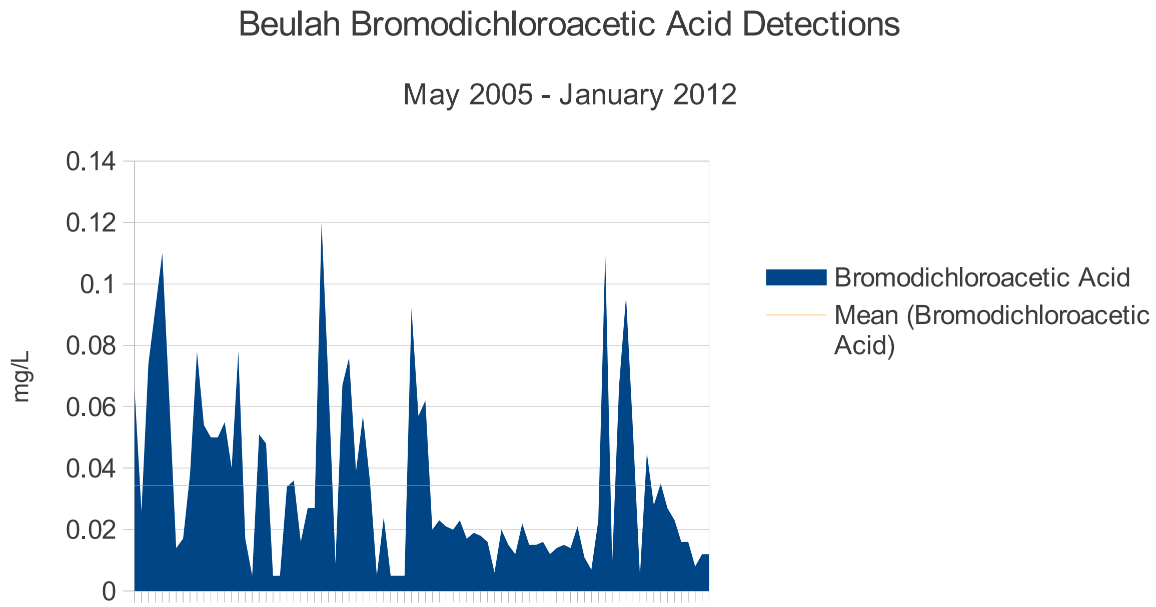
May 2005 - January 2012



Beulah Dibromochloromethane Detections

May 2005 - January 2012




Beulah Bromodichloroacetic Acid Detections
May 2005 - January 2012
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
mg/L
Bromodichloroacetic Acid
Mean (Bromodichloroacetic Acid)

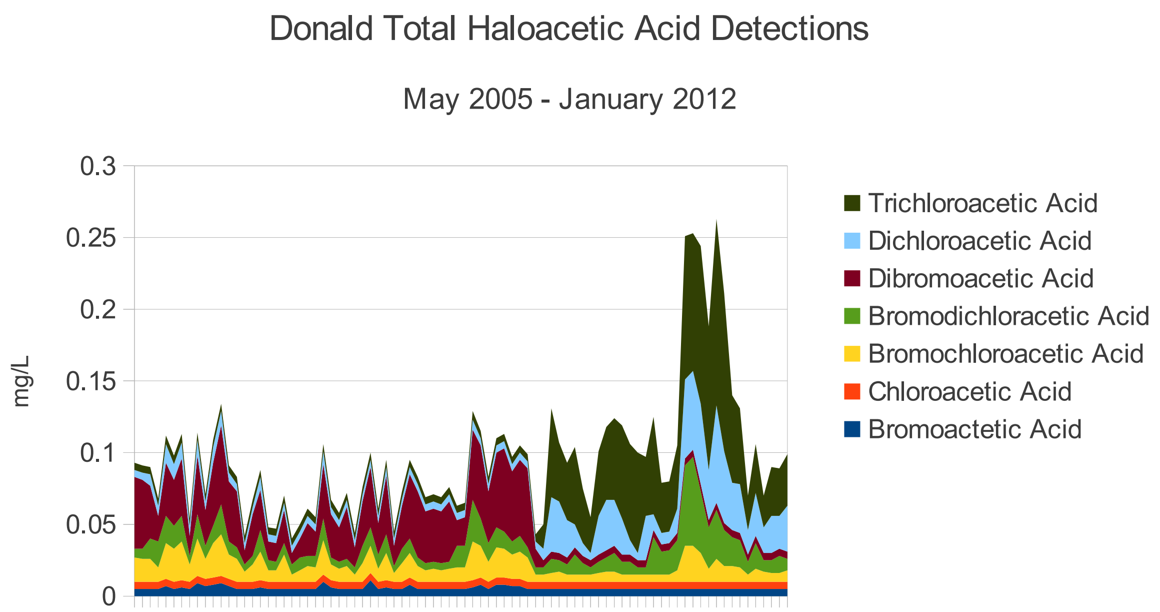
Donald

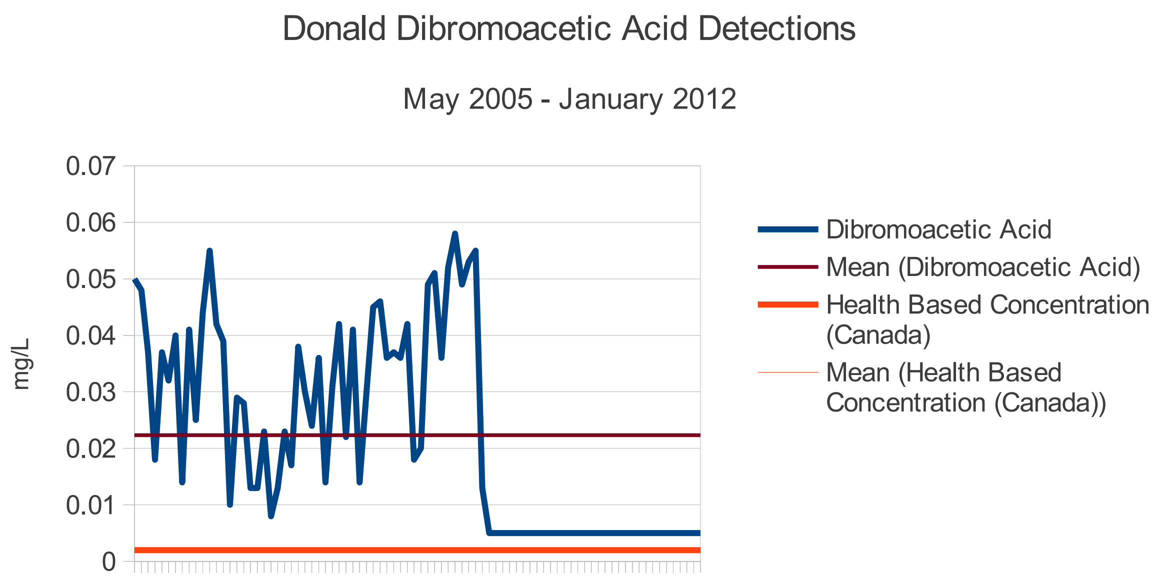
Donald Average Haloacetic Acid Detections May 2005 – February 2012

	Bromoacetic Acid	Chloroacetic Acid	Bromochloro-acetic Acid	Bromodichloro-acetic Acid	Dibromoacetic Acid	Dichloroacetic Acid	Trichloroacetic Acid	Haloacetic Acids*
1/5/05-8/10/09	0.0059	0.005	0.0147	0.0104	0.033	0.0061	0.005	0.0802
8/10/09-1/2/12	0.005	0.005	0.0087	0.0177	0.005	0.0283	0.058	0.1282

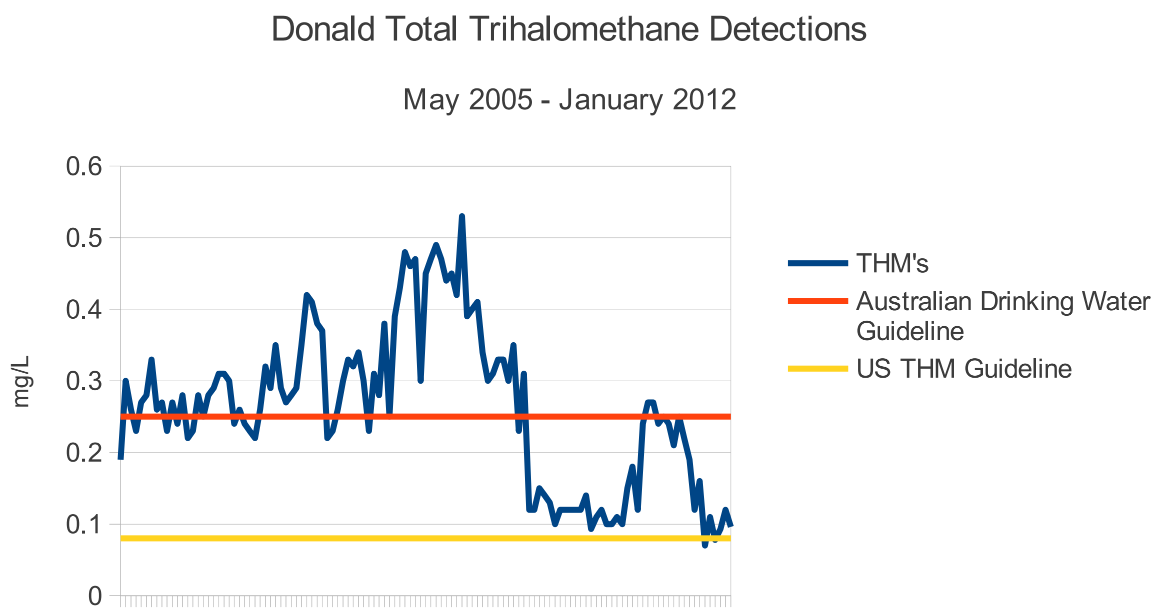
Donald Average Total Trihalomethane Detections May 2005 – January 2012

	Bromodichloromethane	Bromoform	Chloroform	Dibromochloromethane	Total THM's
1/5/05 3/2/09	0.0363	0.1565	0.009	0.1202	0.3209
3/2/09-1/2/12	0.0377	0.001	0.1059	0.0086	0.1515

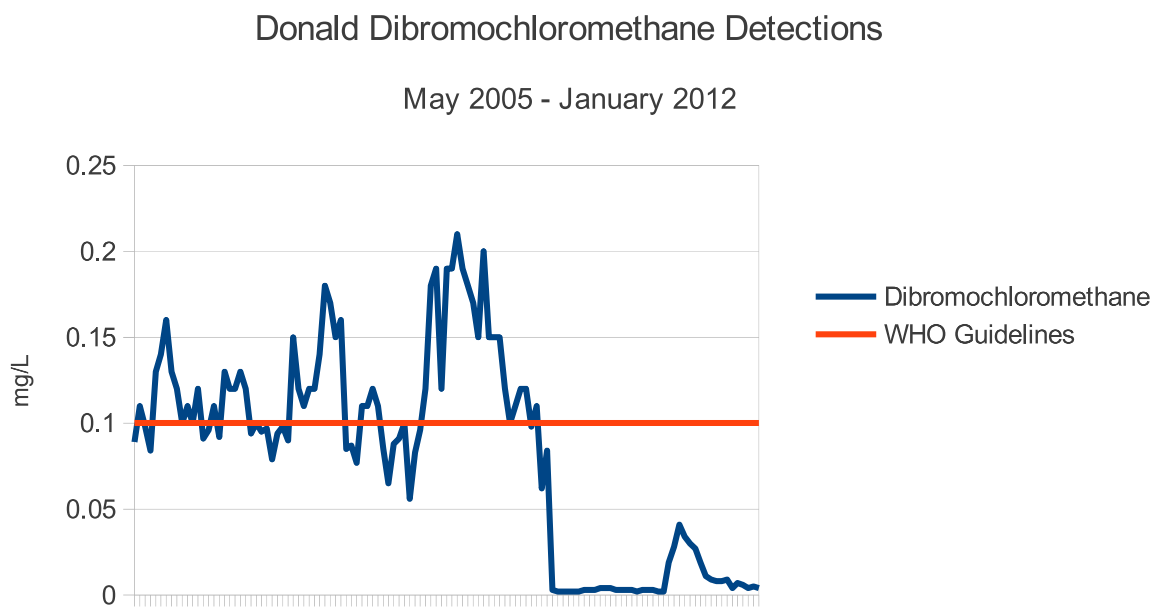


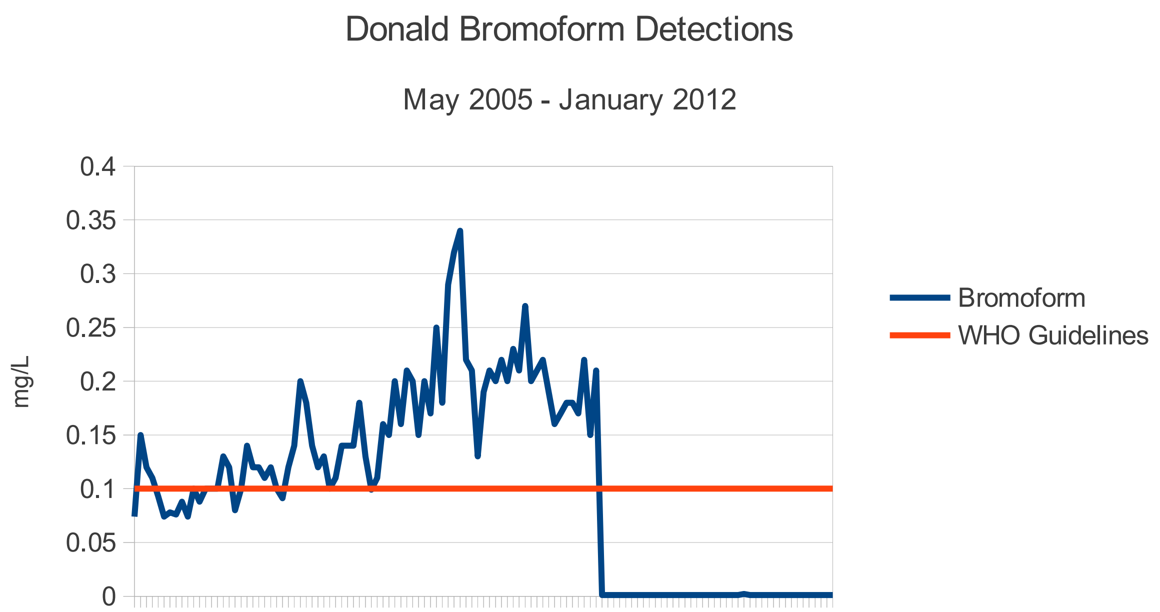


Donald Dibromoacetic Acid Detections
May 2005 - January 2012
mg/L
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Dibromoacetic Acid
Mean (Dibromoacetic Acid)
Health Based Concentration (Canada)
Mean (Health Based Concentration (Canada))



Donald Total Trihalomethane Detections
May 2005 - January 2012
mg/L
0.6
0.5
0.4
0.3
0.2
0.1
0
THM's
Australian Drinking Water Guideline
US THM Guideline


Donald Dibromochloromethane Detections
May 2005 - January 2012
0.25
0.2
0.15
0.1
0.05
0
mg/L
Dibromochloromethane
WHO Guidelines


Donald Bromoform Detections
May 2005 - January 2012
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
mg/L
Bromoform
WHO Guidelines

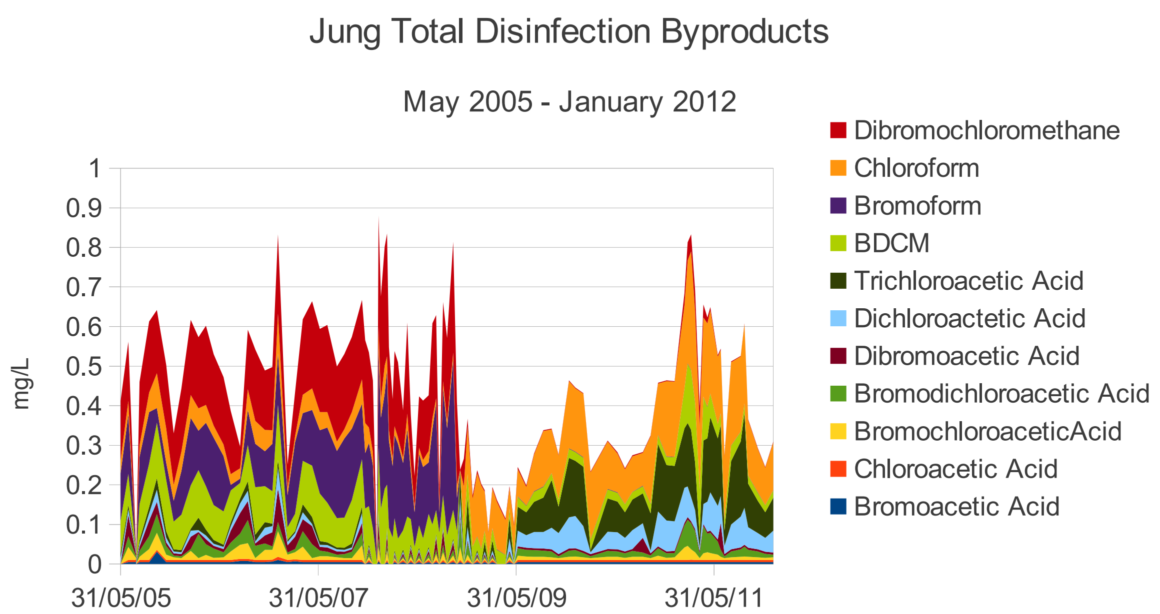
Jung

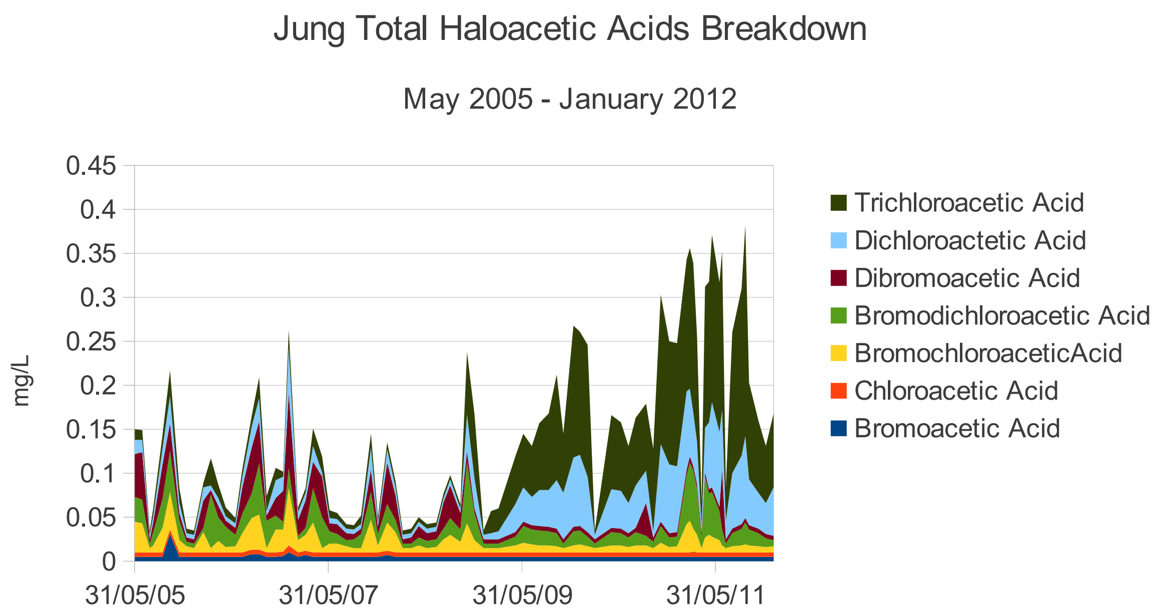
Jung Average Haloacetic Acid Detections May 2005 – February 2012

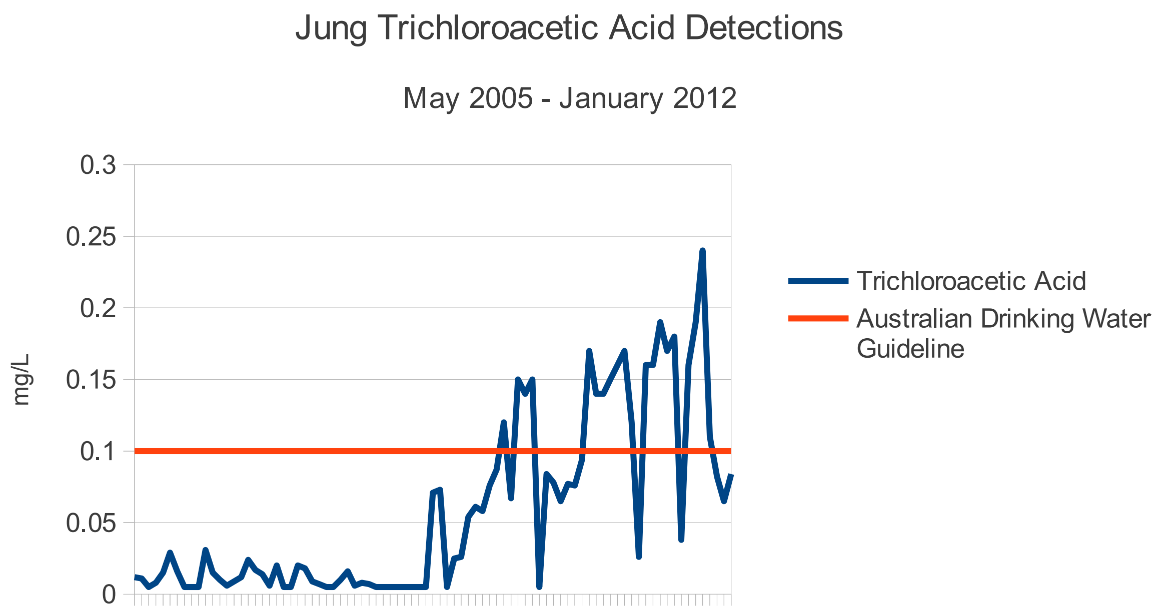
	Bromoacetic Acid	Chloroacetic Acid	Bromochloro-acetic Acid	Bromodichloro-acetic Acid	Dibromoacetic Acid	Dichloroacetic Acid	Trichloroacetic Acid	Haloacetic Acids*
1/5/05-23/10/08	0.006	0.005	0.0175	0.0193	0.0226	0.0113	0.0104	0.0921
23/10/08-1/2/12	0.005	0.005	0.0111	0.0229	0.0076	0.0517	0.1083	0.2119

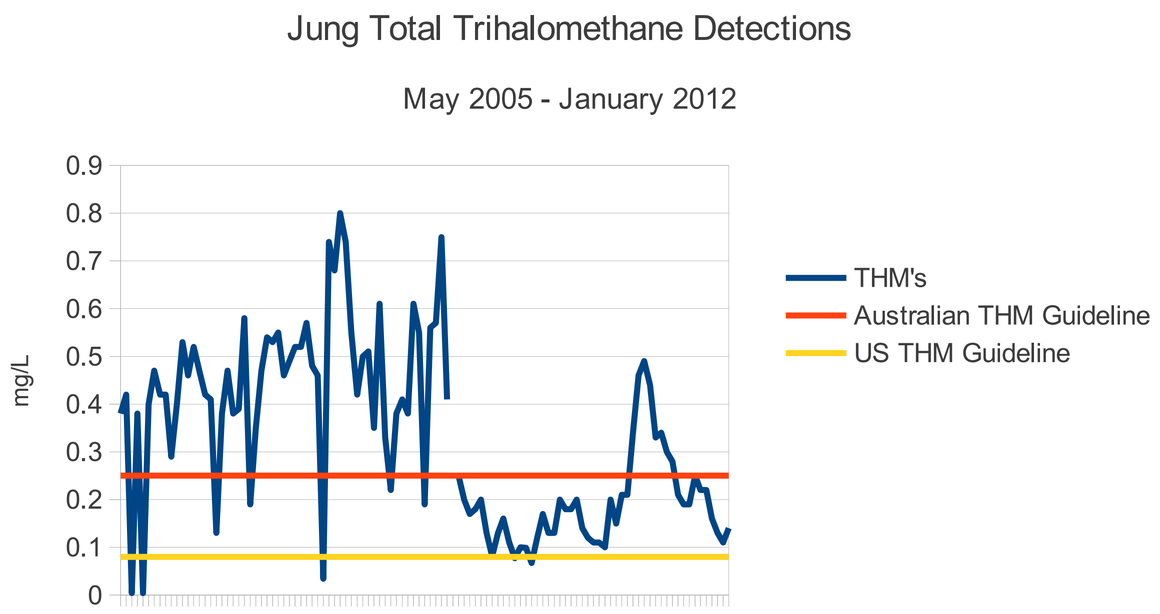
Jung Average Total Trihalomethane Detections May 2005 – January 2012

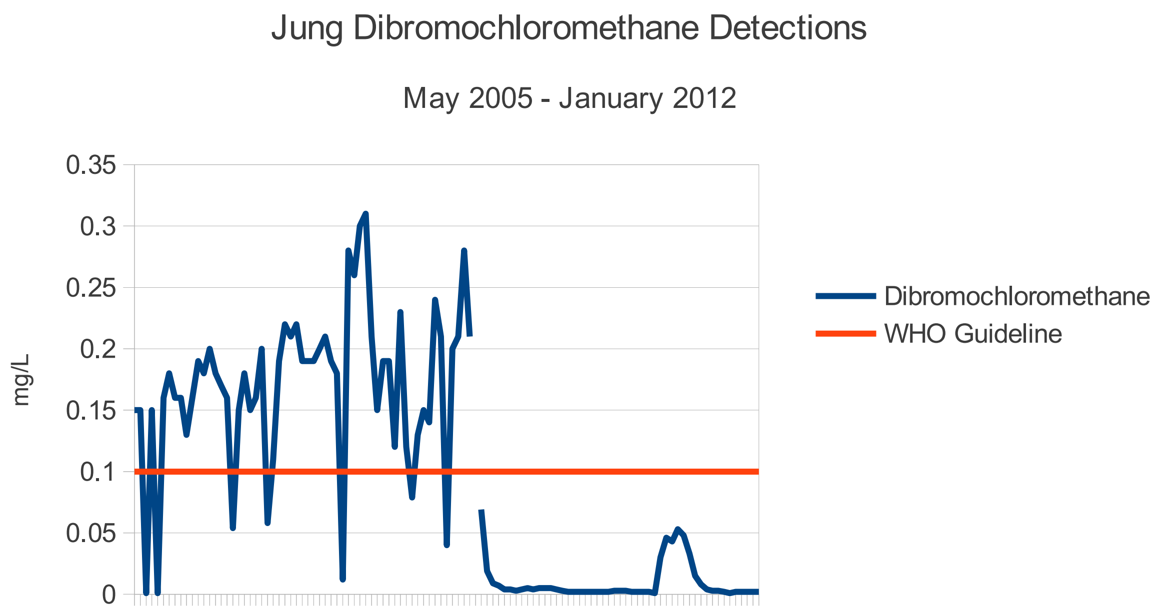
	Bromodichloromethane	Bromoform	Chloroform	Dibromochloromethane	Total THM's
1/5/05 23/10/08	0.0882	0.148	0.036	0.1694	0.4432
23/10/08-1/2/12	0.0421	0.001	0.145	0.0101	0.1961

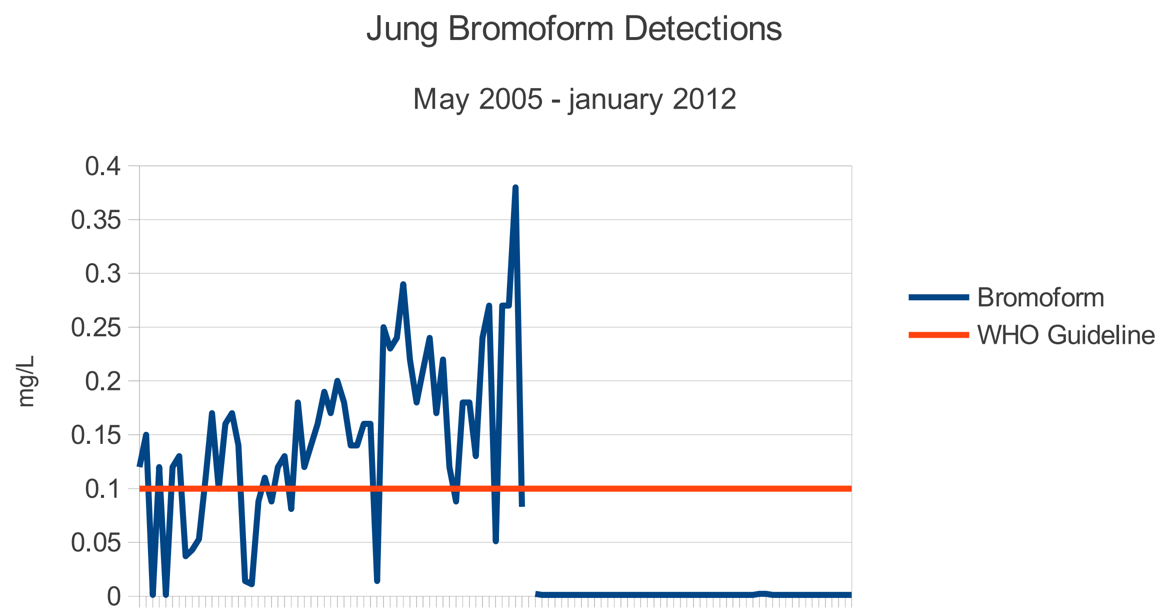


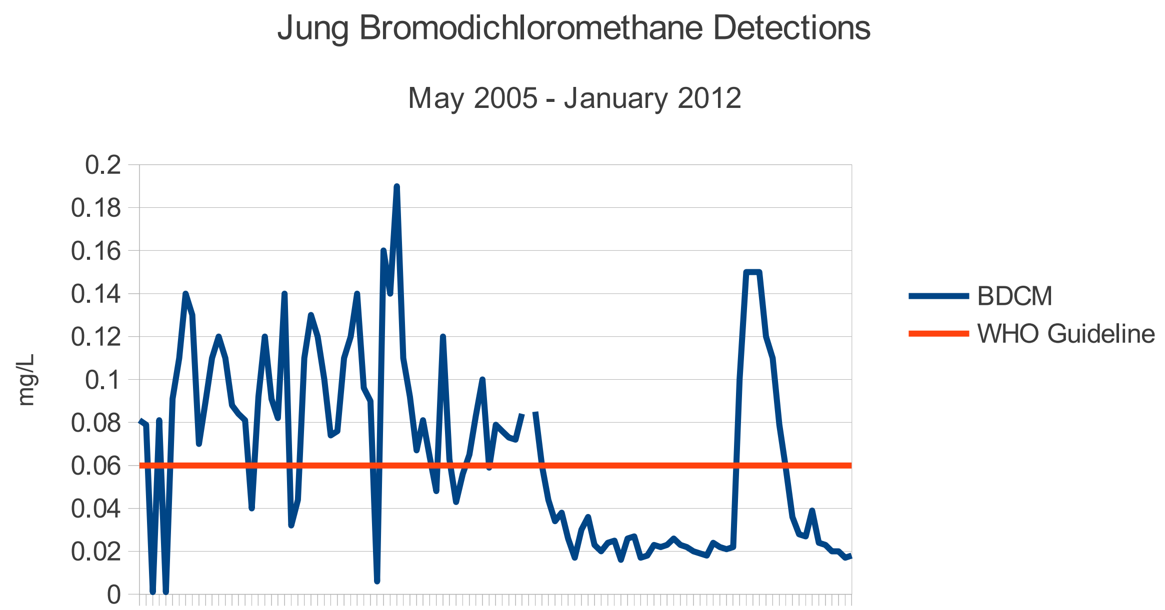

Jung Total Haloacetic Acids Breakdown
May 2005 - January 2012
mg/L
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
31/05/05
31/05/07
31/05/09
31/05/11
Trichloroacetic Acid
Dichloroactetic Acid
Dibromoacetic Acid
Bromodichloroacetic Acid
BromochloroaceticAcid
Chloroacetic Acid
Bromoacetic Acid


Jung Trichloroacetic Acid Detections
May 2005 - January 2012
mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
Trichloroacetic Acid
Australian Drinking Water Guideline


Jung Total Trihalomethane Detections
May 2005 - January 2012
mg/L
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
THM's
Australian THM Guideline
US THM Guideline


Jung Dibromochloromethane Detections
May 2005 - January 2012
mg/L
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Dibromochloromethane
WHO Guideline


Jung Bromoform Detections
May 2005 - january 2012
mg/L
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Bromoform
WHO Guideline


Jung Bromodichloromethane Detections
May 2005 - January 2012
mg/L
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
BDCM
WHO Guideline

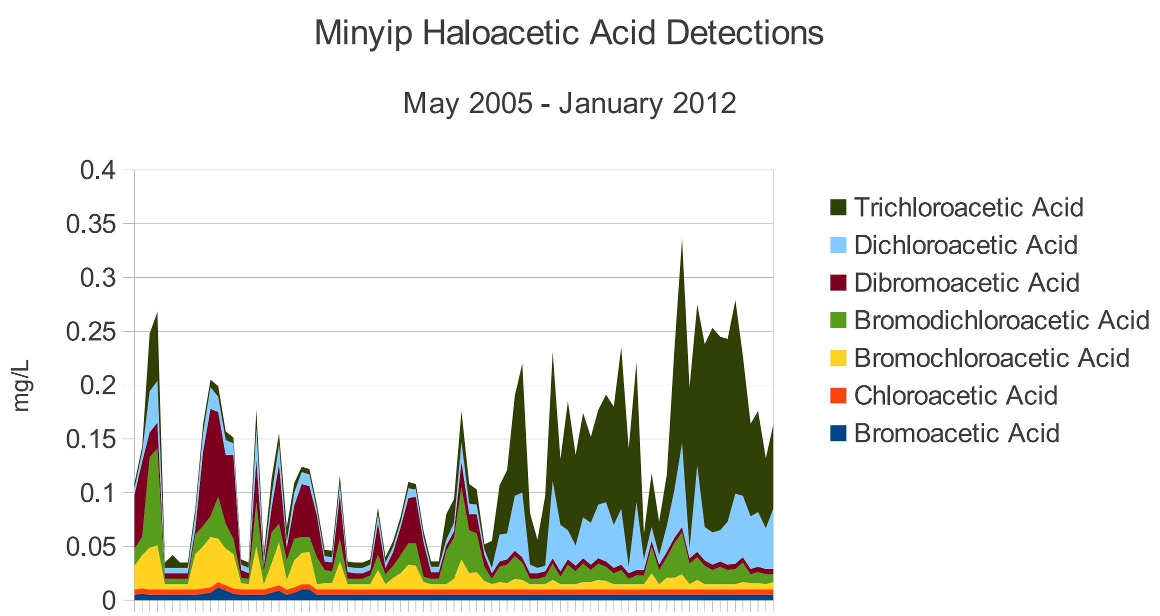
Minyip

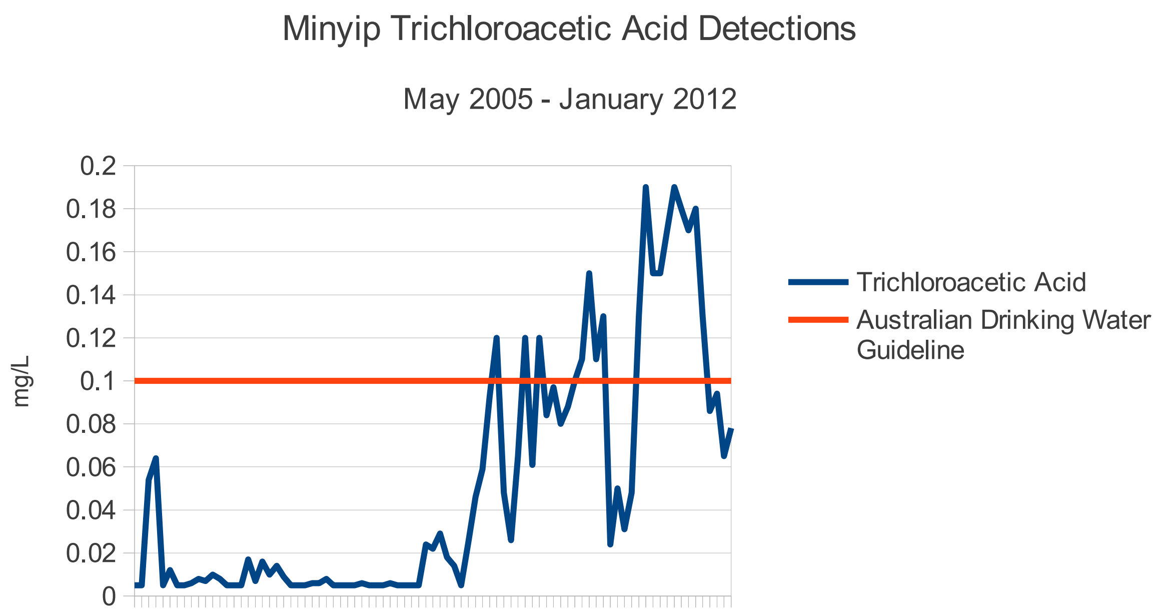
Minyip Average Haloacetic Acid Detections May 2005 – February 2012

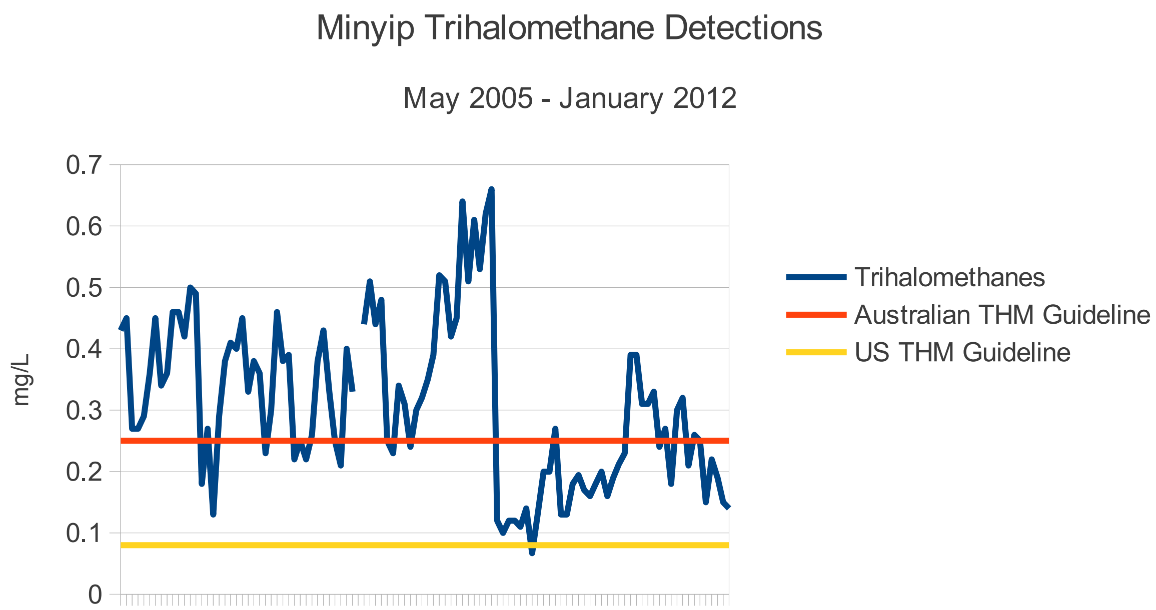
	Bromoacetic Acid	Chloroacetic Acid	Bromochloro-acetic Acid	Bromodichloro-acetic Acid	Dibromoacetic Acid	Dichloroacetic Acid	Trichloroacetic Acid	Haloacetic Acids*
1/5/05-22/4/09	0.0056	0.005	0.0179	0.0204	0.0267	0.0099	0.0105	0.0963
22/4/09 -1/2/12	0.005	0.005	0.0069	0.0114	0.005	0.0378	0.104	0.1786

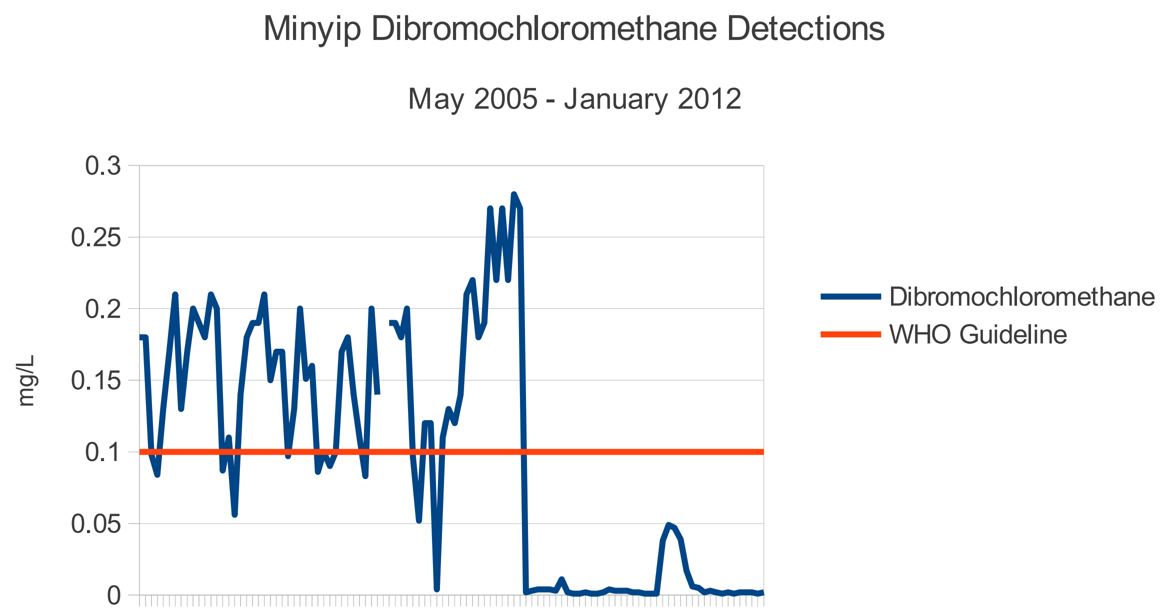
Minyip Average Total Trihalomethane Detections May 2005 – January 2012

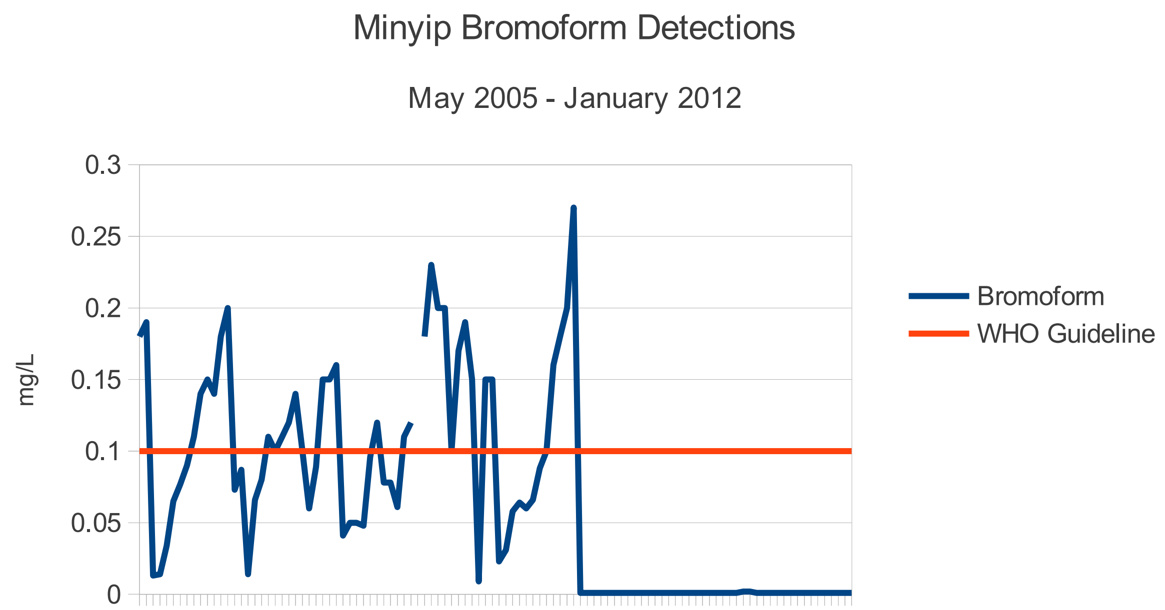
	Bromodichloromethane	Bromoform	Chloroform	Dibromochloromethane	Total THM's
1/5/05 22/4/09	0.0779	0.1105	0.0371	0.1579	0.3787
22/4/09-1/2/12	0.0364	0.001	0.1645	0.007	0.2081

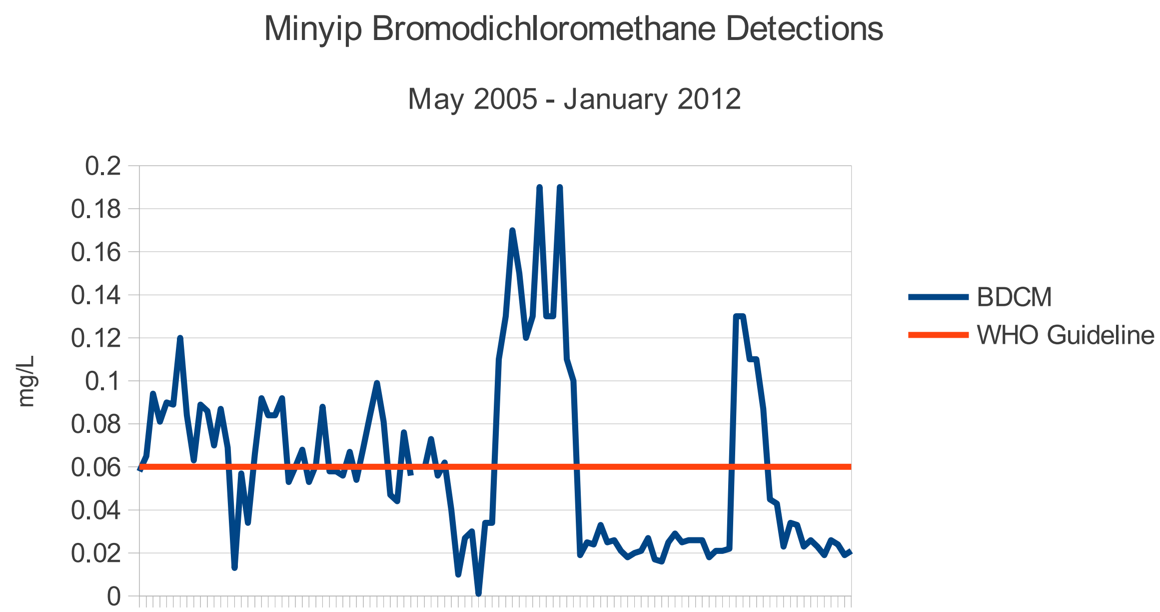



Minyip Trichloroacetic Acid Detections
May 2005 - January 2012
mg/L
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Trichloroacetic Acid
Australian Drinking Water Guideline


Minyip Trihalomethane Detections
May 2005 - January 2012
mg/L
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Trihalomethanes
Australian THM Guideline
US THM Guideline


Minyip Dibromochloromethane Detections
May 2005 - January 2012
0.3
0.25
0.2
0.15
0.1
0.05
0
mg/L
Dibromochloromethane
WHO Guideline


Minyip Bromoform Detections
May 2005 - January 2012
0.3
0.25
0.2
0.15
0.1
0.05
0
mg/L
Bromoform
WHO Guideline



Minyip Bromodichloromethane Detections
May 2005 - January 2012
mg/L
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
BDCM
WHO Guideline

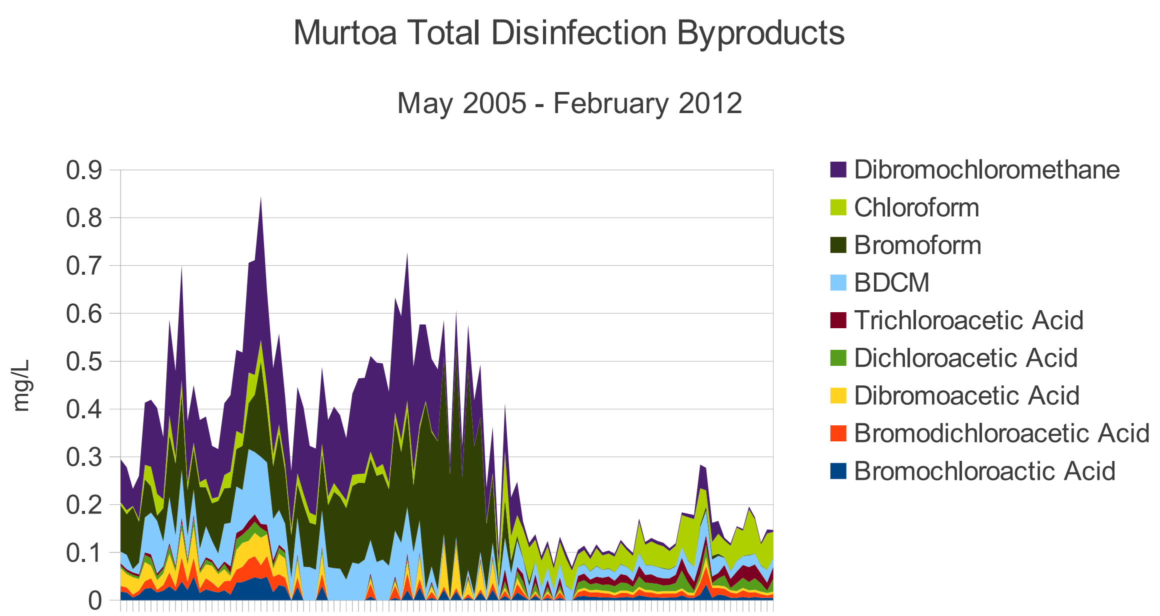
Murtoa

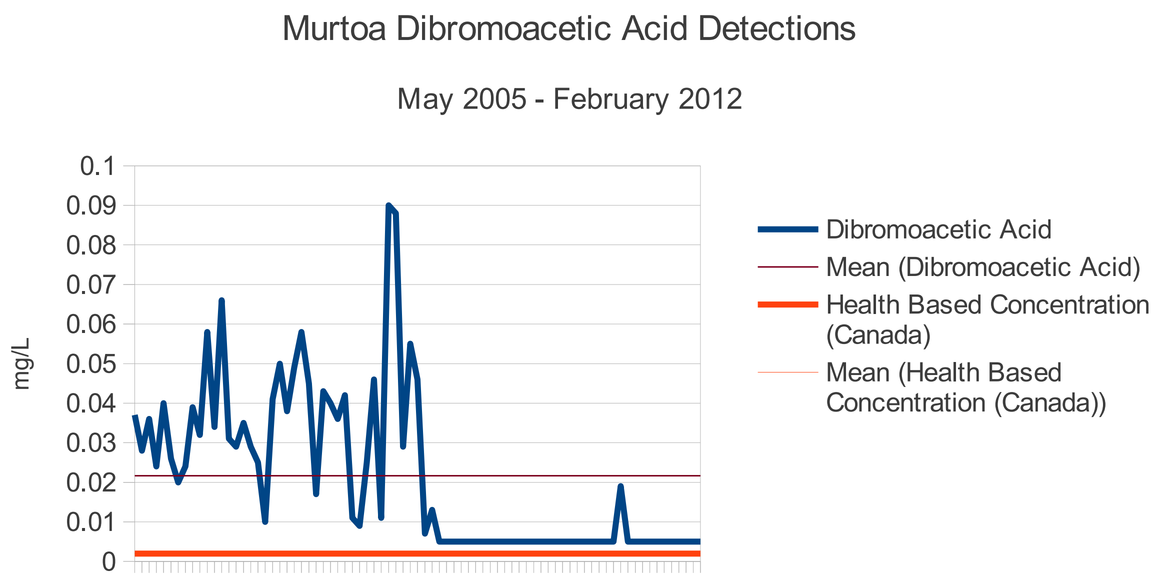
Murtoa Average Haloacetic Acid Detections May 2005 – February 2012

	Bromoacetic Acid	Chloroacetic Acid	Bromochloro-acetic Acid	Bromodichloro-acetic Acid	Dibromoacetic Acid	Dichloroacetic Acid	Trichloroacetic Acid	Haloacetic Acids*
1/5/05-21/12/08	0.0072	0.005	0.0228	0.0206	0.0353	0.0103	0.008	0.1091
21/12/08 -1/2/12	0.005	0.005	0.0076	0.0109	0.0055	0.0162	0.0189	0.0703

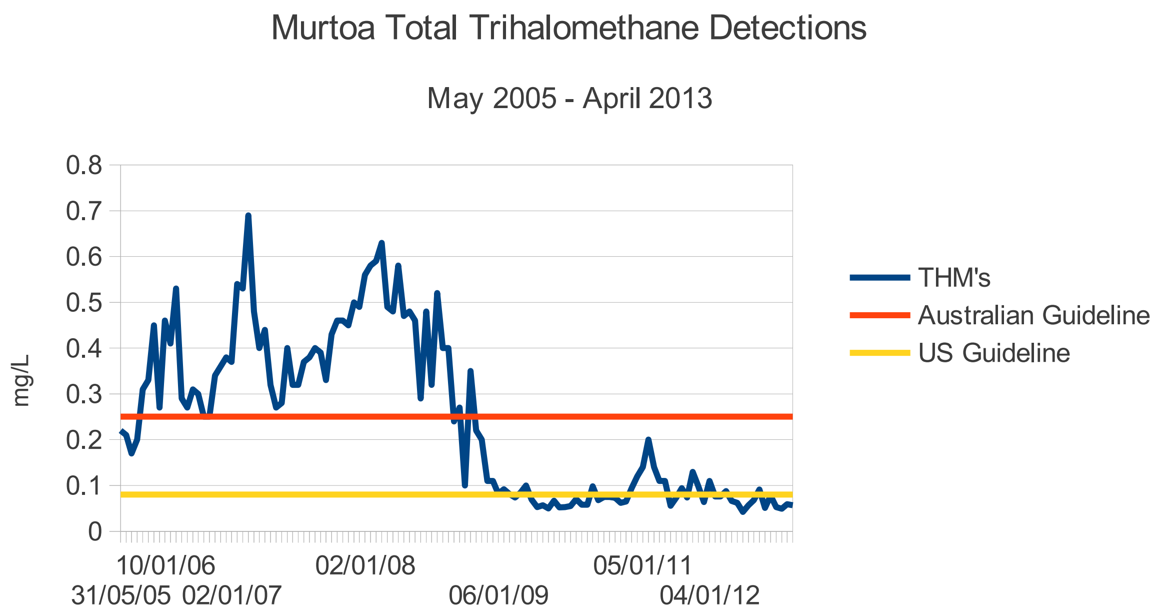
Murtoa Average Total Trihalomethane Detections May 2005 – January 2012

	Bromodichloromethane	Bromoform	Chloroform	Dibromochloromethane	Total THM's
1/5/05 21/12/08	0.0614	0.1449	0.0219	0.1471	0.3773
21/12/08-1/2/12	0.0222	0.0014	0.0483	0.0092	0.081

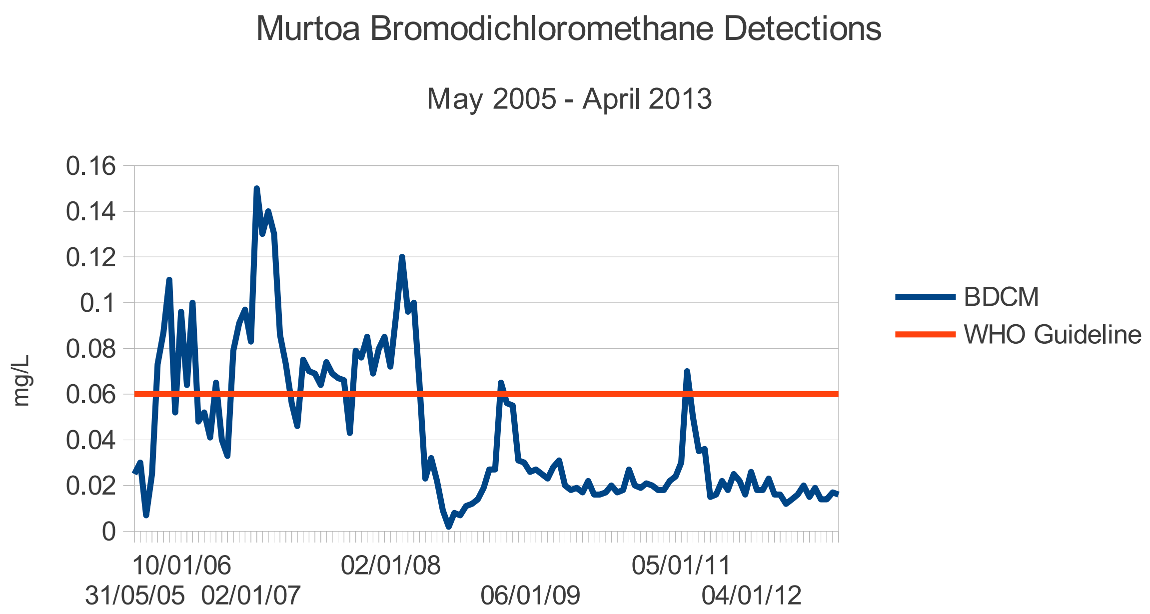


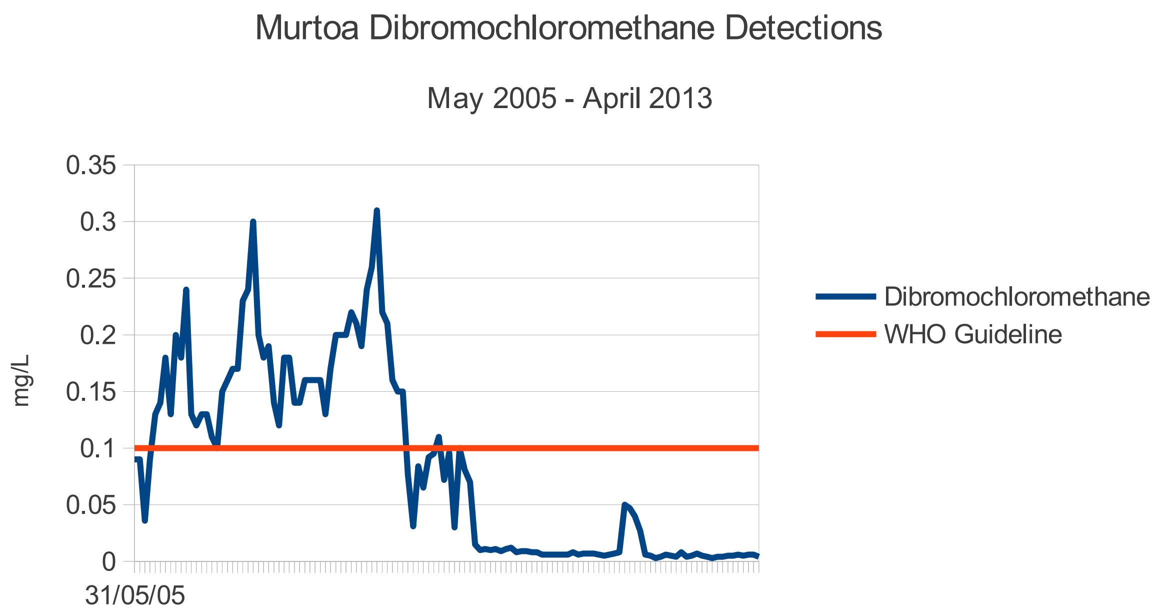


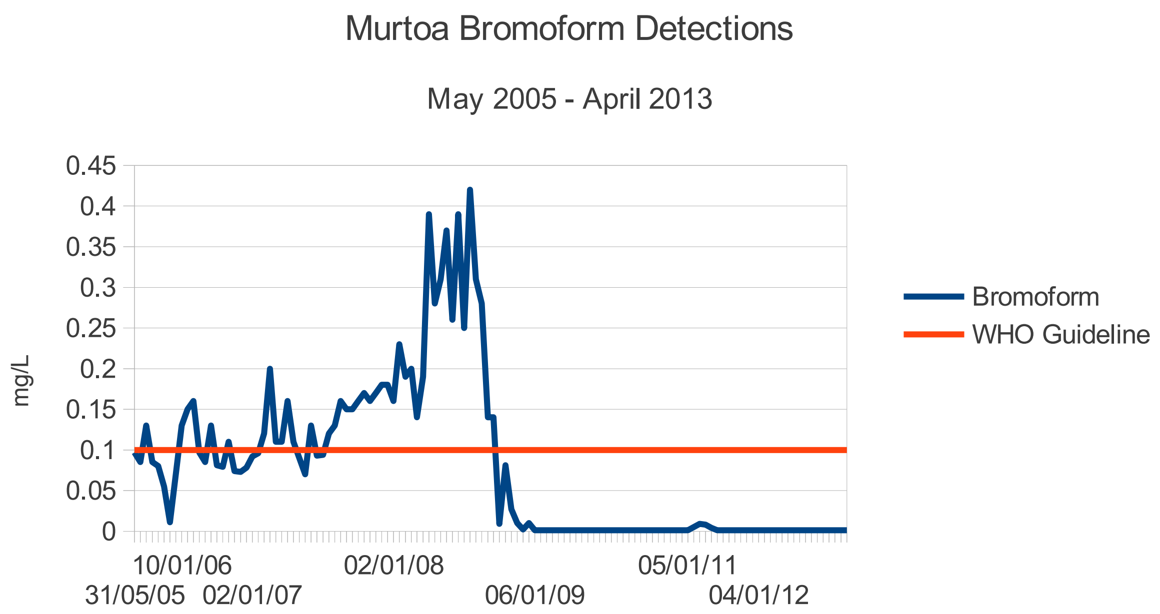
Murtoa Dibromoacetic Acid Detections
May 2005 - February 2012
mg/L
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Dibromoacetic Acid
Mean (Dibromoacetic Acid)
Health Based Concentration (Canada)
Mean (Health Based Concentration (Canada))



Murtoa Total Trihalomethane Detections
May 2005 - April 2013
mg/L
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10/01/06
02/01/08
05/01/11
31/05/05
02/01/07
06/01/09
04/01/12
THM's
Australian Guideline
US Guideline


Murtoa Bromodichloromethane Detections
May 2005 - April 2013
mg/L
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
10/01/06
02/01/08
05/01/11
31/05/05
02/01/07
06/01/09
04/01/12
BDCM
WHO Guideline


Murtoa Dibromochloromethane Detections
May 2005 - April 2013
mg/L
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
31/05/05
Dibromochloromethane
WHO Guideline



Murtoa Bromoform Detections
May 2005 - April 2013
mg/L
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
10/01/06
31/05/05
02/01/07
02/01/08
06/01/09
05/01/11
04/01/12
Bromoform
WHO Guideline

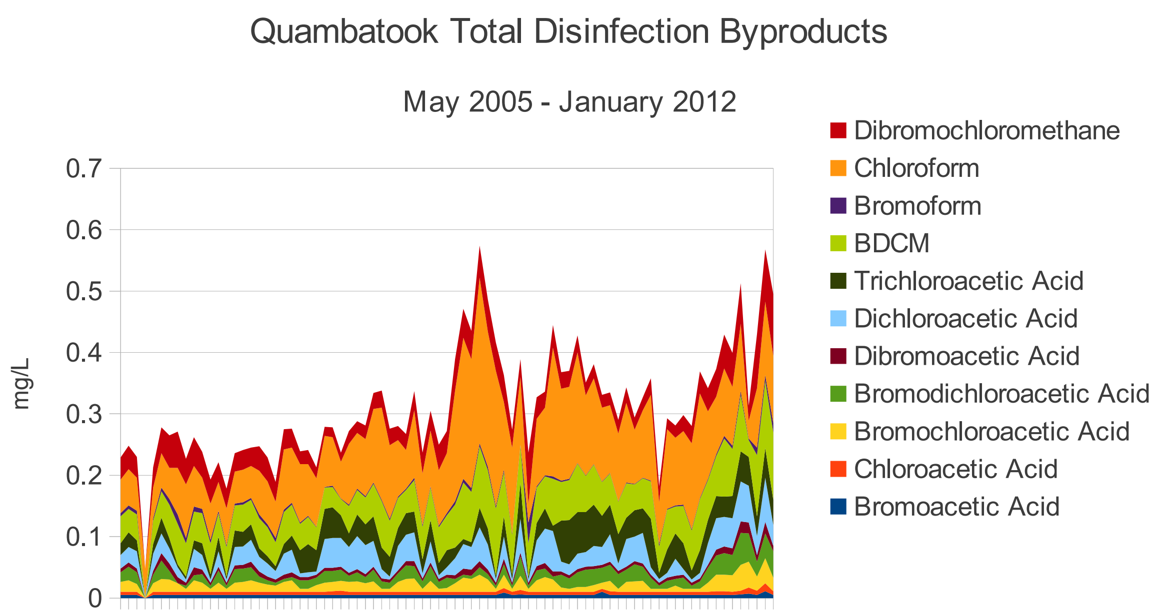
Quambatook

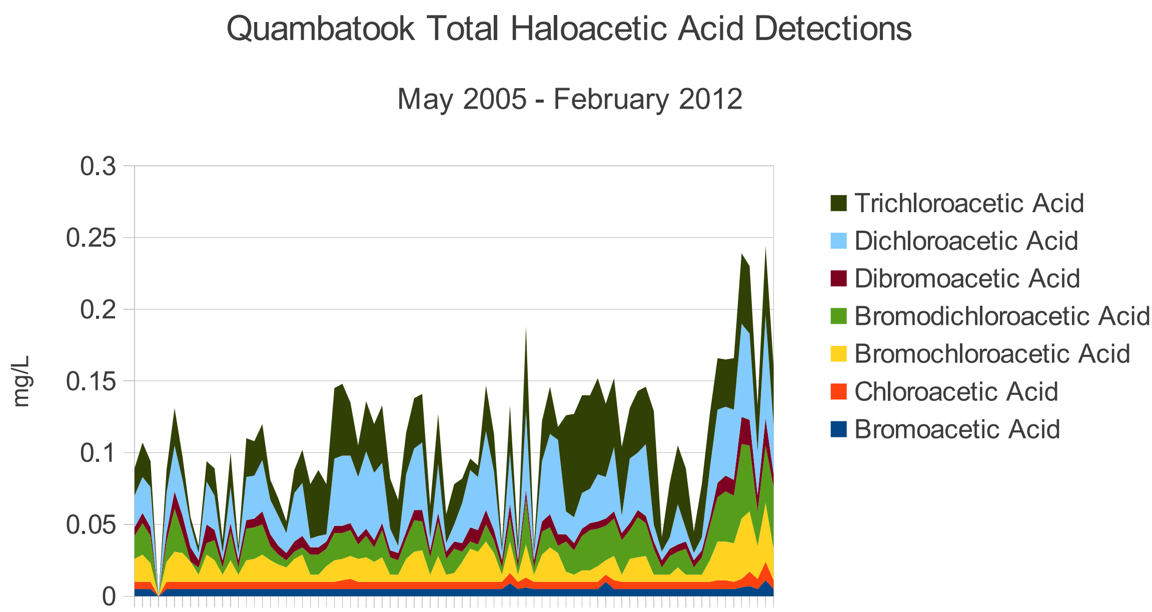
Murtoa Average Haloacetic Acid Detections May 2005 – February 2012

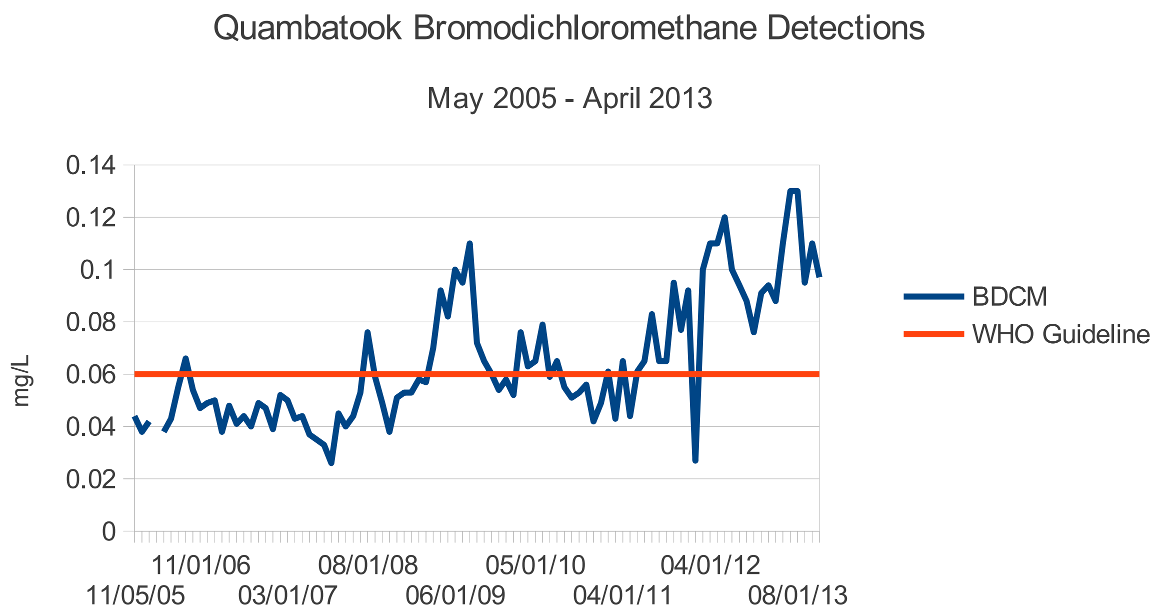
	Bromoacetic Acid	Chloroacetic Acid	Bromochloro-acetic Acid	Bromodichlor o-acetic Acid	Dibromoacetic Acid	Dichloroacet ic Acid	Trichloroacet ic Acid	Haloacetic Acids*
1/5/05-1/2/12	0.0052	0.0053	0.0149	0.0173	0.0069	0.0298	0.0313	0.1106

Murtoa Average Total Trihalomethane Detections May 2005 – January 2012

	Bromodichlor omethane	Bromoform	Chloroform	Dibromochlor omethane	Total THM's
1/5/05-1/2/12	0.0646	0.0058	0.1036	0.0436	0.2186




Quambatook Total Haloacetic Acid Detections
May 2005 - February 2012
mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
Trichloroacetic Acid
Dichloroacetic Acid
Dibromoacetic Acid
Bromodichloroacetic Acid
Bromochloroacetic Acid
Chloroacetic Acid
Bromoacetic Acid


Quambatook Bromodichloromethane Detections
May 2005 - April 2013
mg/L
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
11/01/06
08/01/08
05/01/10
04/01/12
11/05/05
03/01/07
06/01/09
04/01/11
08/01/13
BDCM
WHO Guideline

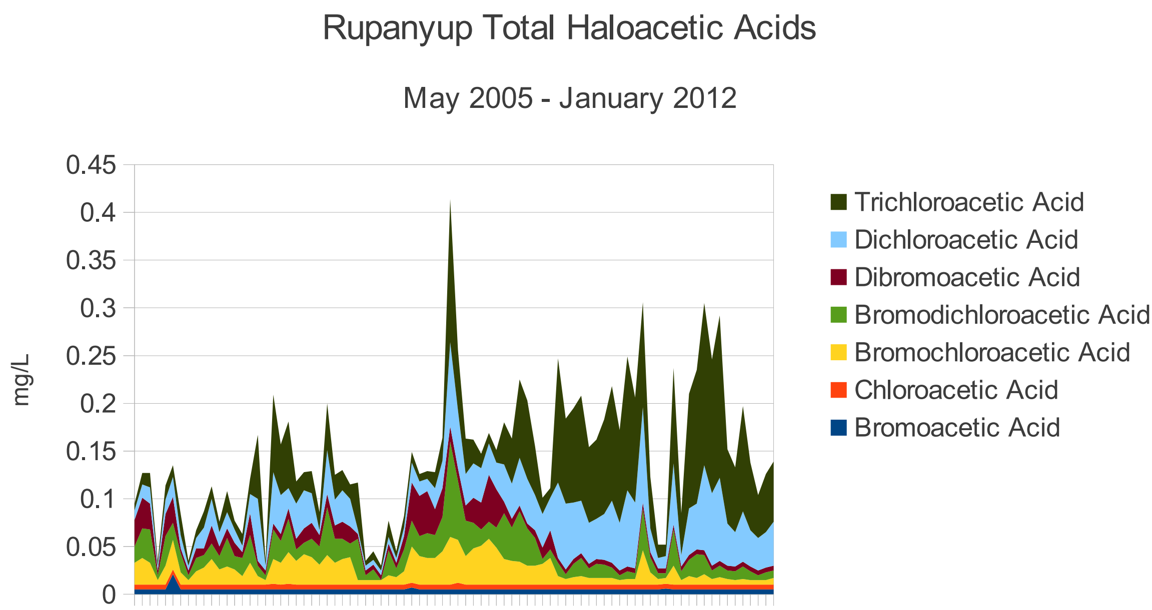
Rupanyup

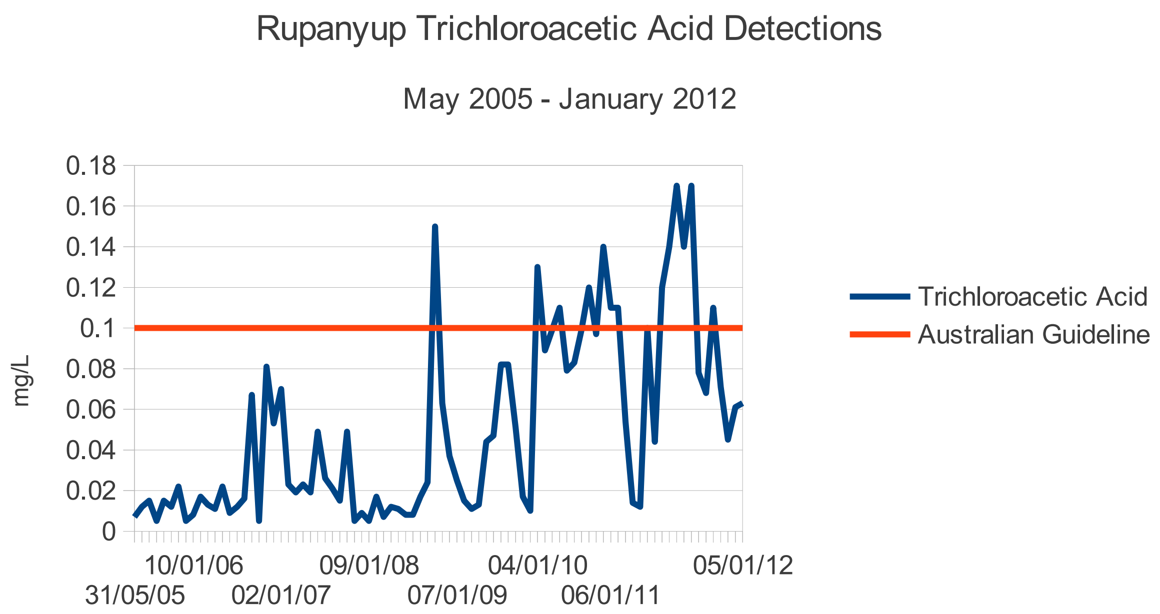
Rupanyup Average Haloacetic Acid Detections May 2005 – February 2012

	Bromoacetic Acid	Chloroacetic Acid	Bromochloro-acetic Acid	Bromodichloro-acetic Acid	Dibromoacetic Acid	Dichloroacetic Acid	Trichloroacetic Acid	Haloacetic Acids*
1/5/05-22/5/09	0.0054	0.005	0.023	0.0234	0.0171	0.0234	0.0241	0.1215
22/5/09 -1/2/12	0.005	0.005	0.0117	0.0171	0.0062	0.0486	0.0874	0.1742

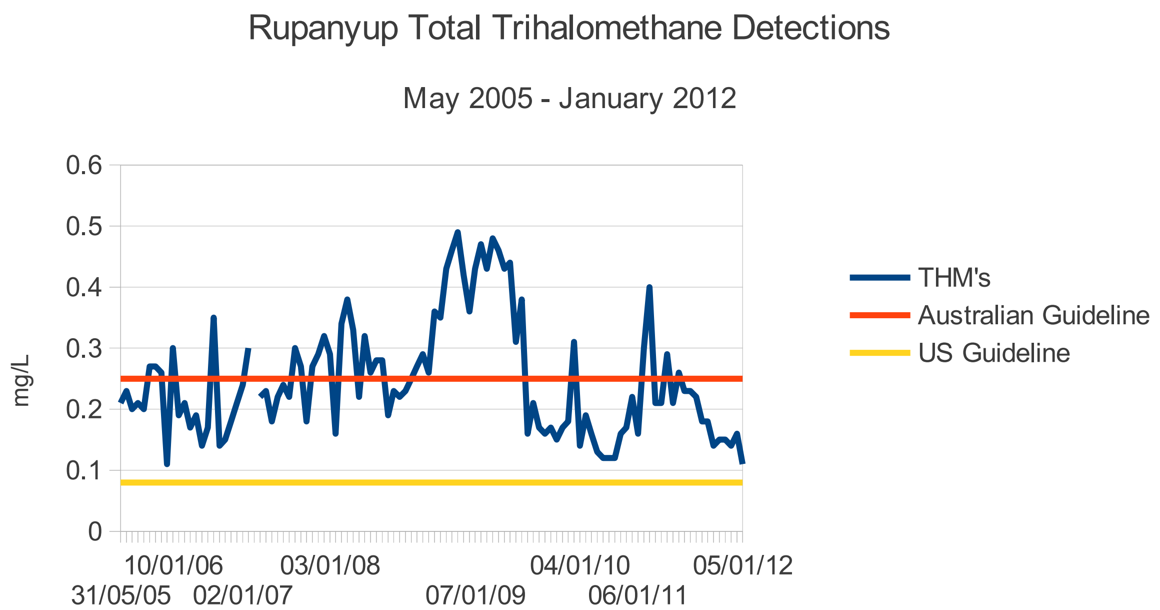
Rupanyup Average Total Trihalomethane Detections May 2005 – January 2012

	Bromodichloromethane	Bromoform	Chloroform	Dibromochloromethane	Total THM's
1/5/05 22/5/09	0.0874	0.0247	0.0745	0.094	0.2813
22/5/09-1/2/12	0.0435	0.0017	0.1328	0.0157	0.1929

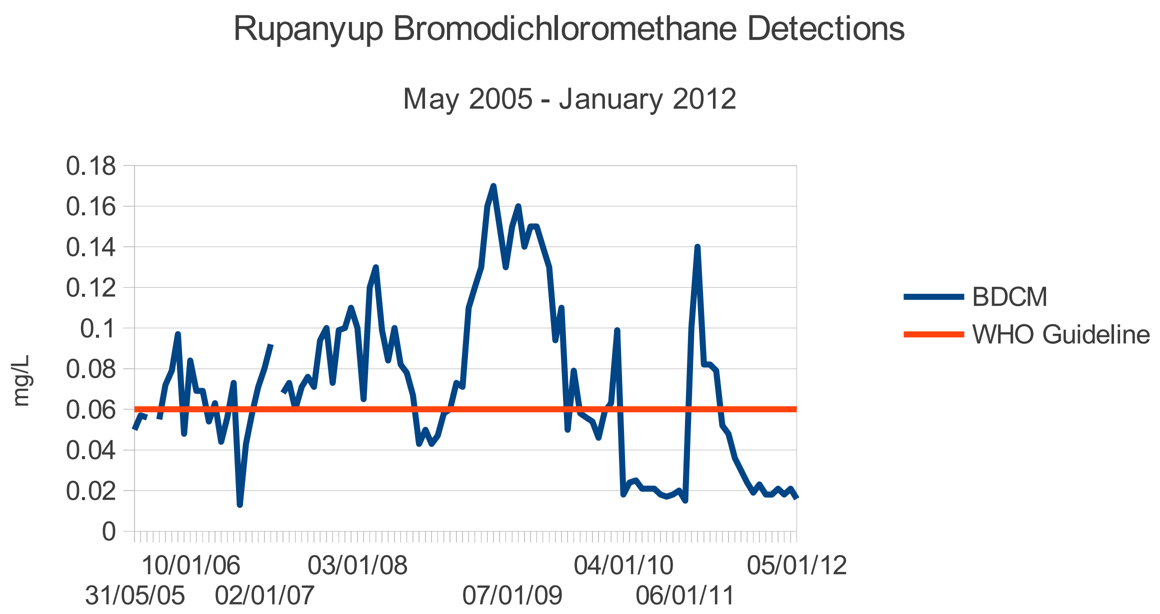


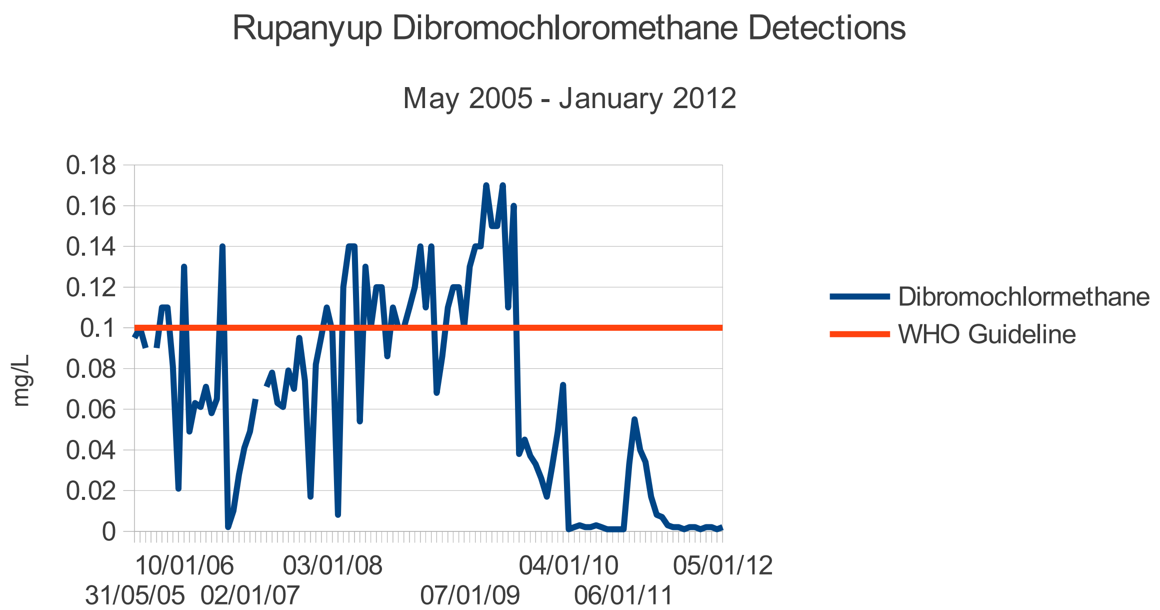


Rupanyup Trichloroacetic Acid Detections
May 2005 - January 2012
mg/L
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
10/01/06
09/01/08
04/01/10
05/01/12
31/05/05
02/01/07
07/01/09
06/01/11
Trichloroacetic Acid
Australian Guideline



Rupanyup Total Trihalomethane Detections
May 2005 - January 2012
mg/L
0.6
0.5
0.4
0.3
0.2
0.1
0
10/01/06
03/01/08
04/01/10
05/01/12
31/05/05
02/01/07
07/01/09
06/01/11
THM's
Australian Guideline
US Guideline


Rupanyup Bromodichloromethane Detections
May 2005 - January 2012
mg/L
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
10/01/06
03/01/08
04/01/10
05/01/12
31/05/05
02/01/07
07/01/09
06/01/11
BDCM
WHO Guideline


Rupanyup Dibromochloromethane Detections
May 2005 - January 2012
mg/L
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
10/01/06
03/01/08
04/01/10
05/01/12
31/05/05
02/01/07
07/01/09
06/01/11
Dibromochlormethane
WHO Guideline

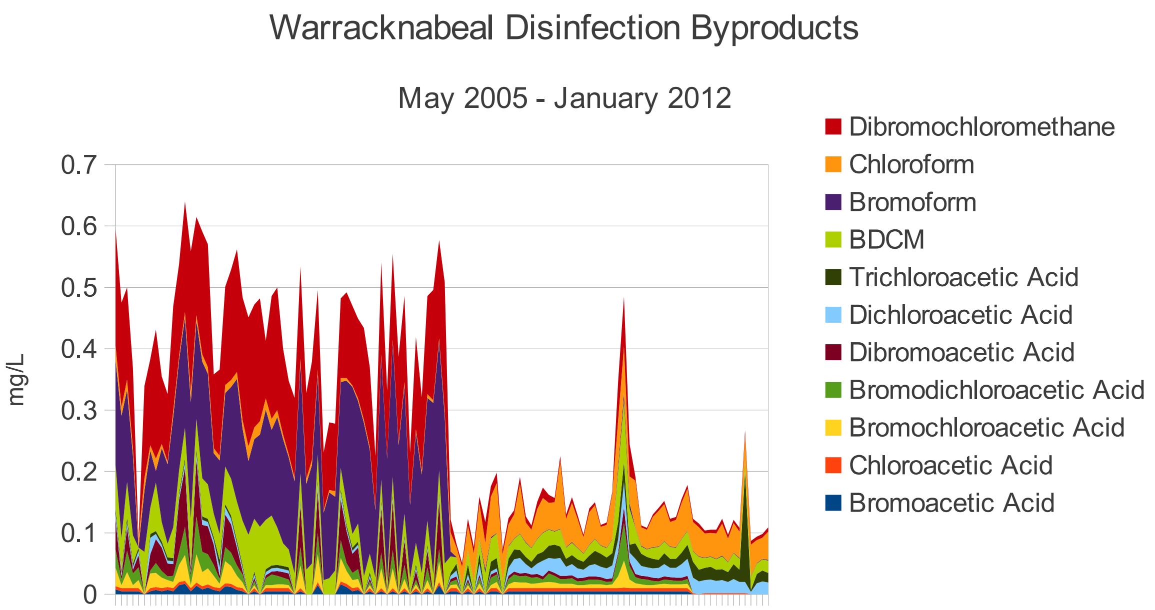
Warracknabeal

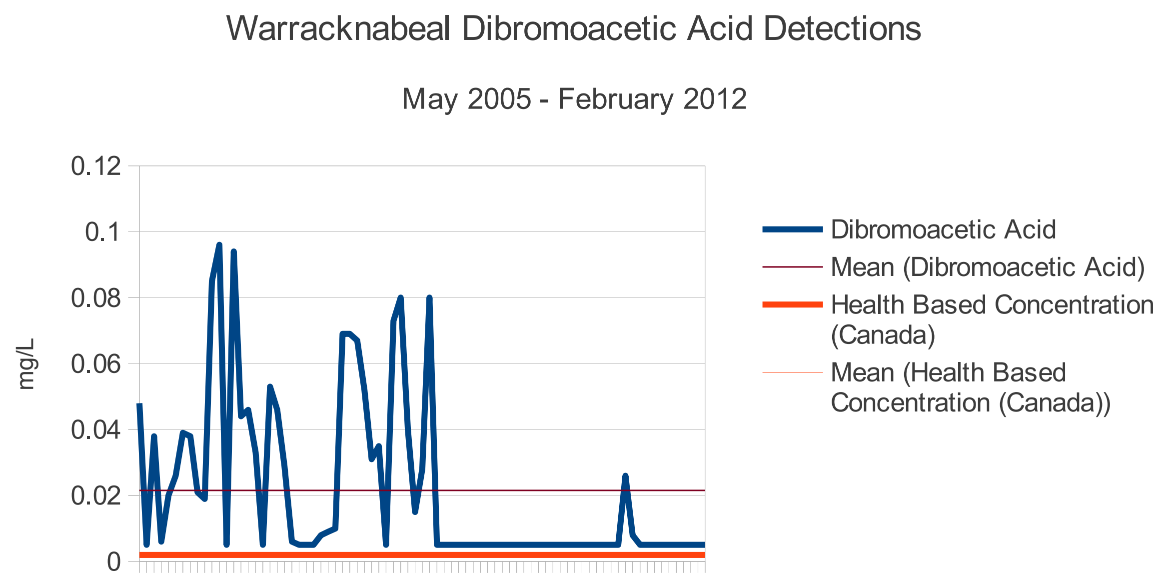
Warracknabeal Average Haloacetic Acid Detections May 2005 – February 2012

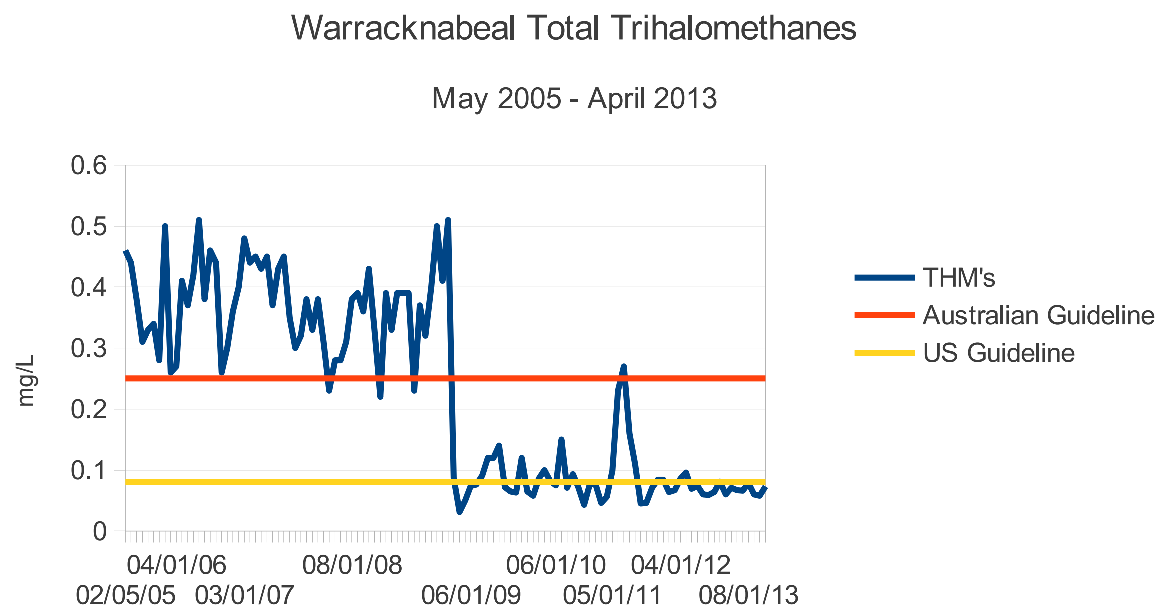
	Bromoacetic Acid	Chloroacetic Acid	Bromochloro-acetic Acid	Bromodichloro-acetic Acid	Dibromoacetic Acid	Dichloroacetic Acid	Trichloroacetic Acid	Haloacetic Acids*
1/5/05-23/10/08	0.0076	0.005	0.0187	0.0196	0.0363	0.0073	0.0055	0.1004
23/10/08 -1/2/12	0.005	0.005	0.0085	0.0109	0.0058	0.0175	0.0175	0.0712

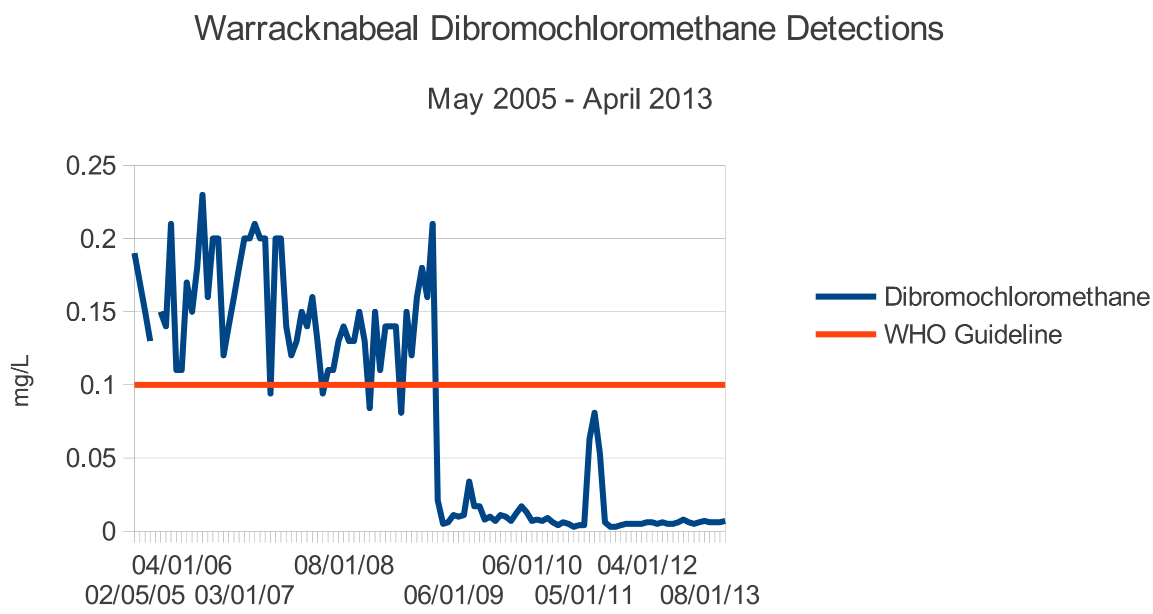
Warracknabeal Average Total Trihalomethane Detections May 2005 – January 2012

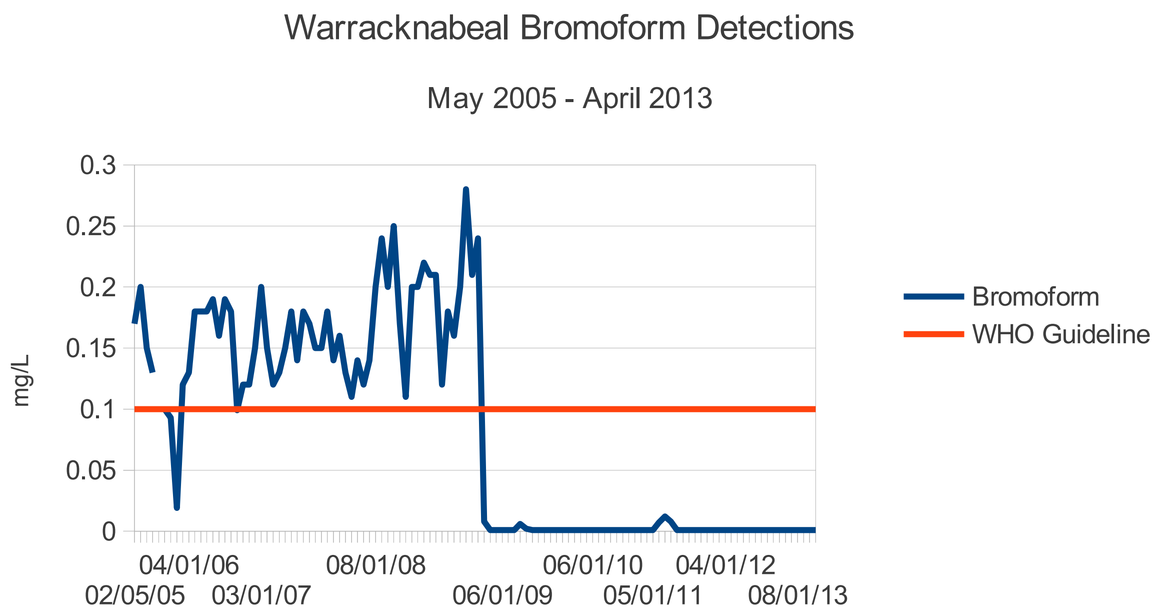
	Bromodichloromethane	Bromoform	Chloroform	Dibromochloromethane	Total THM's
1/5/05 23/10/08	0.0468	0.1632	0.0093	0.1522	0.3722
23/10/08-1/2/12	0.0242	0.0017	0.0494	0.0113	0.0857




Warracknabeal Dibromoacetic Acid Detections
May 2005 - February 2012
0.12
0.1
0.08
0.06
0.04
0.02
0
mg/L
Dibromoacetic Acid
Mean (Dibromoacetic Acid)
Health Based Concentration (Canada)
Mean (Health Based Concentration (Canada))


Warracknabeal Total Trihalomethanes
May 2005 - April 2013
0.6
0.5
0.4
0.3
0.2
0.1
0
mg/L
04/01/06
08/01/08
06/01/10
04/01/12
02/05/05
03/01/07
06/01/09
05/01/11
08/01/13
THM's
Australian Guideline
US Guideline


Warracknabeal Dibromochloromethane Detections
May 2005 - April 2013
mg/L
0.25
0.2
0.15
0.1
0.05
0
04/01/06
08/01/08
06/01/10
04/01/12
02/05/05
03/01/07
06/01/09
05/01/11
08/01/13
Dibromochloromethane
WHO Guideline


Warracknabeal Bromoform Detections
May 2005 - April 2013
mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
04/01/06
08/01/08
06/01/10
04/01/12
02/05/05
03/01/07
06/01/09
05/01/11
08/01/13
Bromoform
WHO Guideline

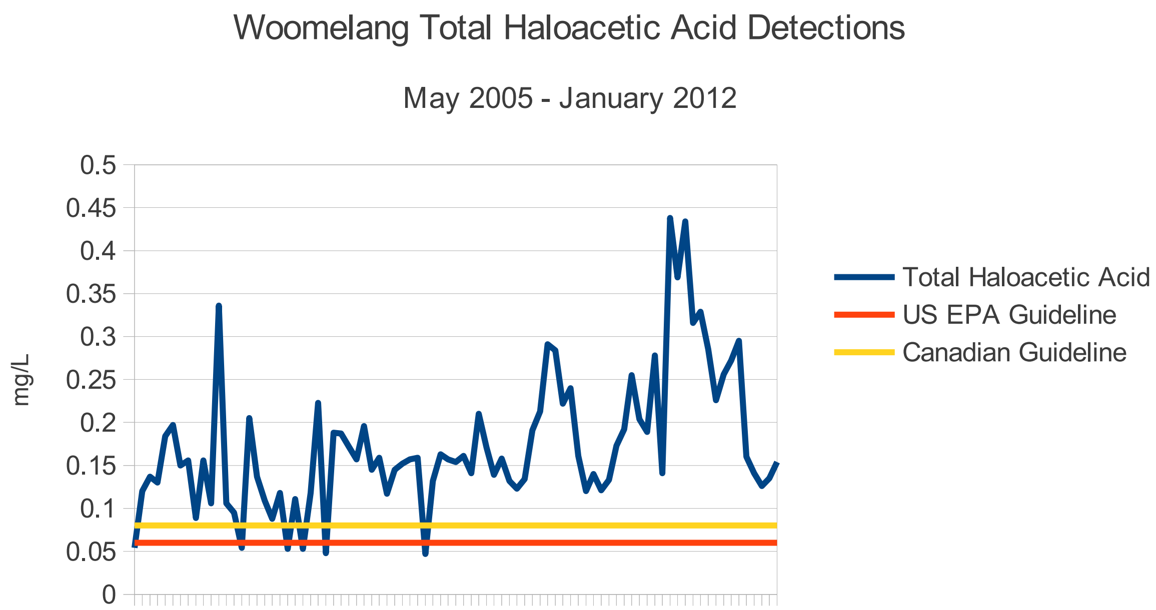
Woomelang

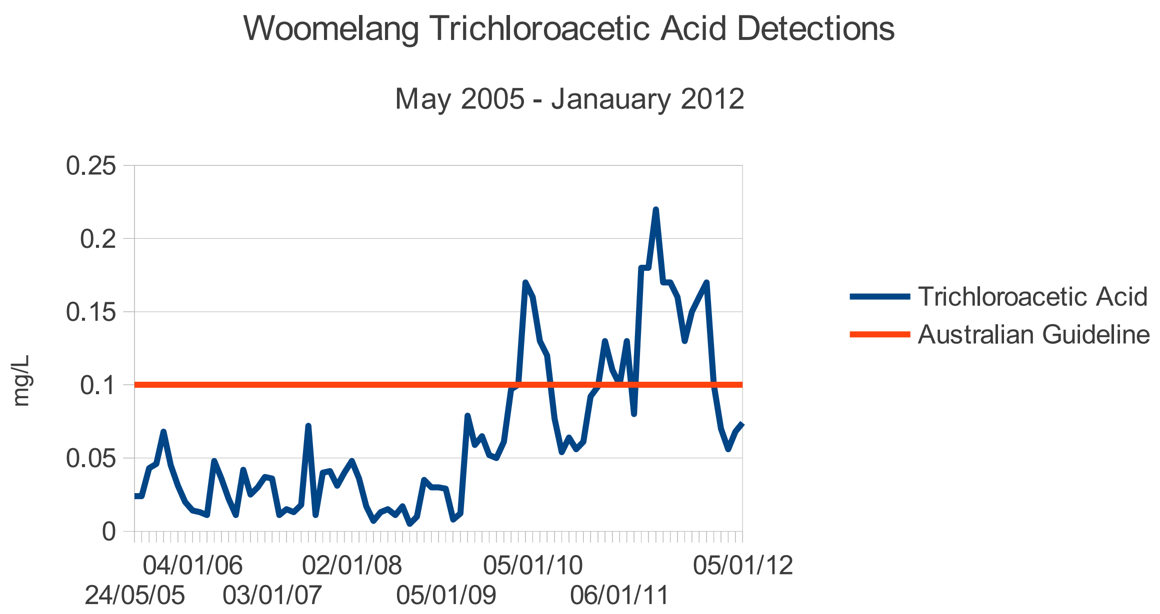
Woomelang Average Haloacetic Acid Detections May 2005 – February 2012

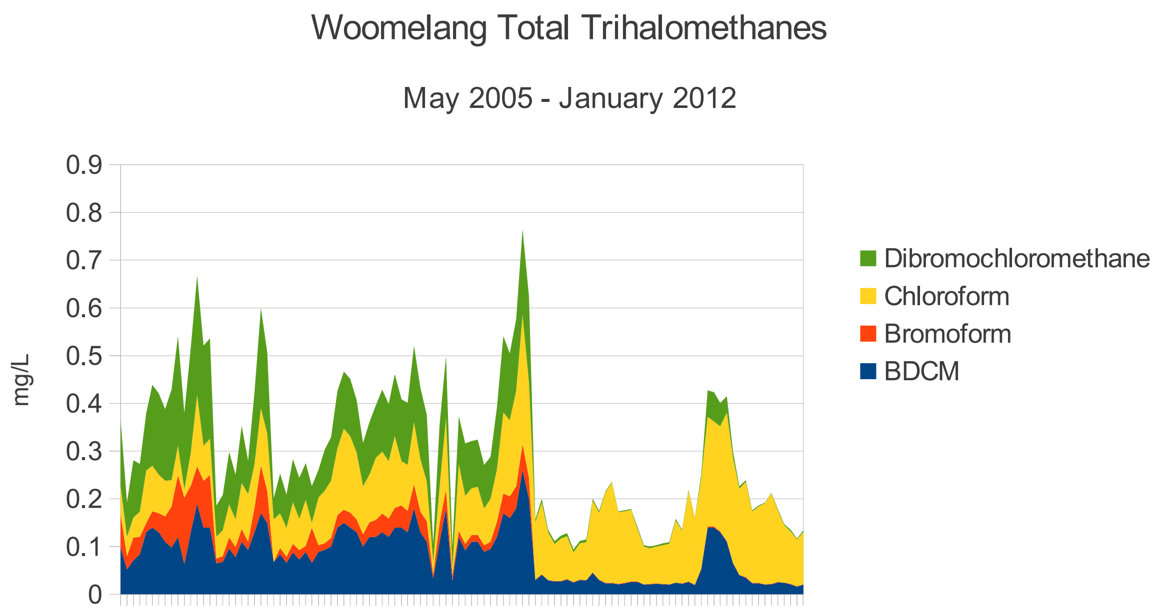
	Bromoacetic Acid	Chloroacetic Acid	Bromochloro-acetic Acid	Bromodichloro-acetic Acid	Dibromoacetic Acid	Dichloroacetic Acid	Trichloroacetic Acid	Haloacetic Acids*
1/5/05-17/3/09	0.0053	0.005	0.0255	0.0309	0.0188	0.0273	0.0027	0.1398
17/3/09 -1/2/12	0.005	0.0053	0.0107	0.0236	0.0053	0.0574	0.1112	0.2195

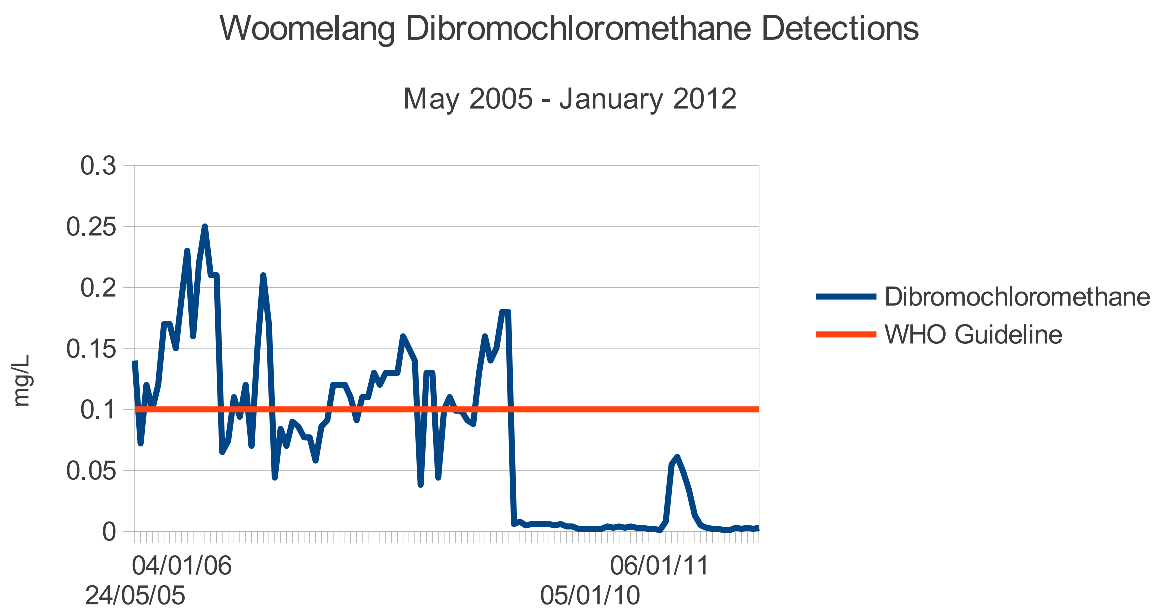
Woomelang Average Total Trihalomethane Detections May 2005 – January 2012

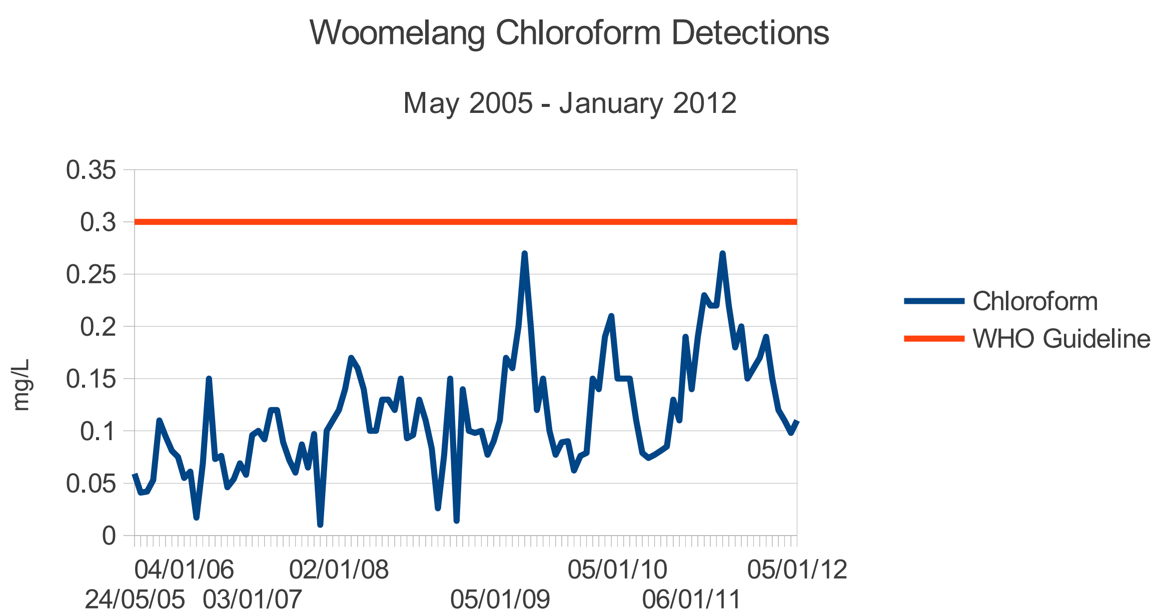
	Bromodichloromethane	Bromoform	Chloroform	Dibromochloromethane	Total THM's
1/5/05 17/3/09	0.1155	0.0407	0.0993	0.1243	0.3786
17/3/09-1/2/12	0.0378	0.001	0.1439	0.0083	0.1888

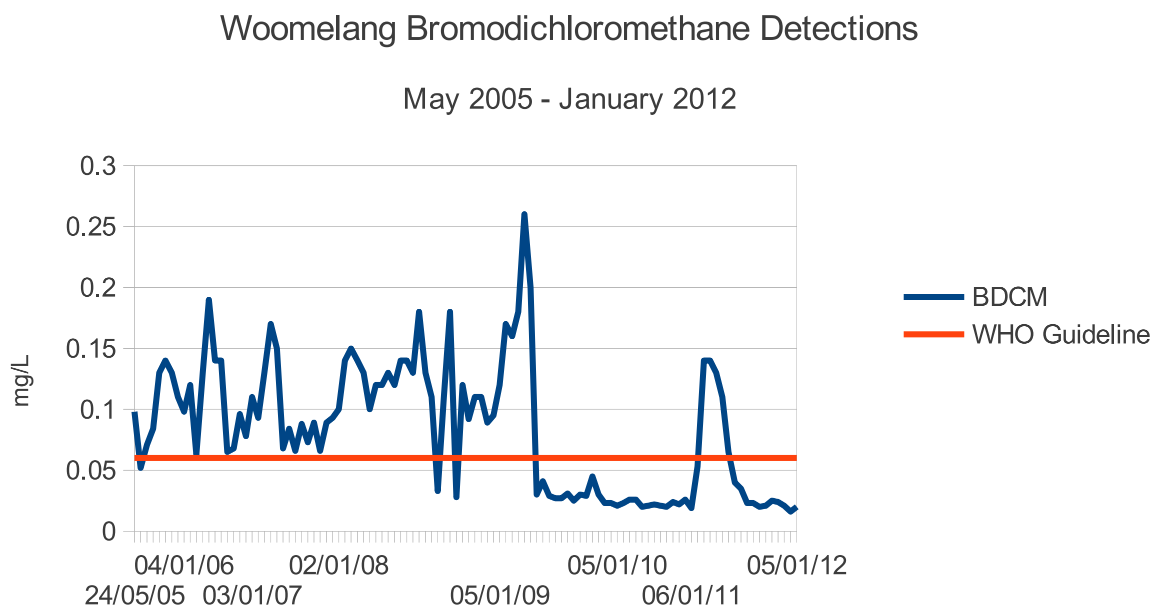


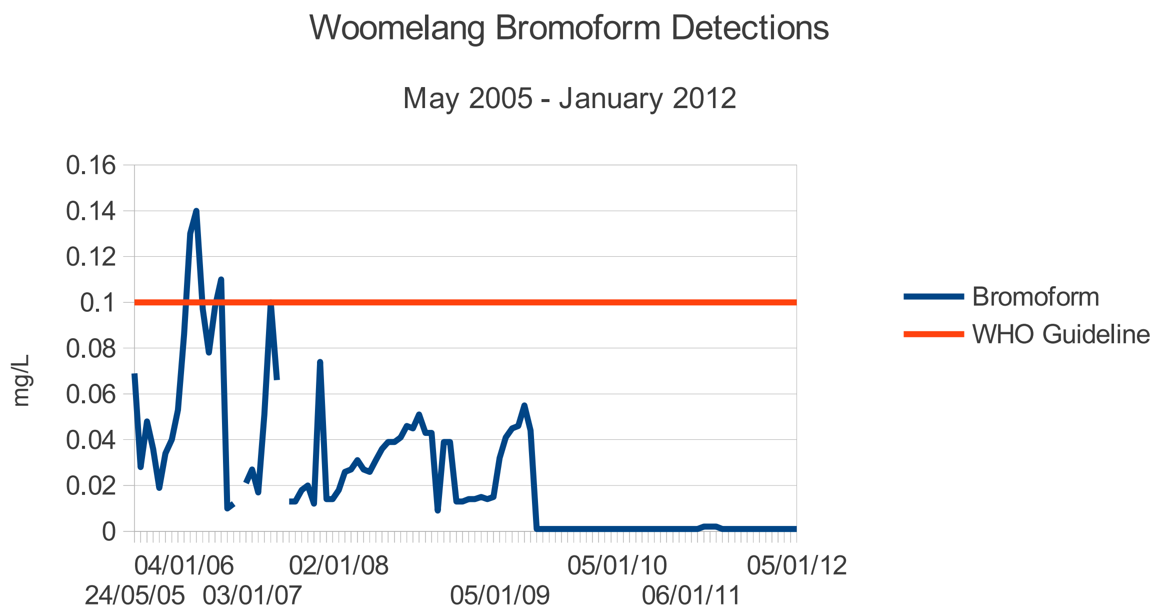

Woomelang Trichloroacetic Acid Detections
May 2005 - Janauary 2012
0.25
0.2
0.15
0.1
0.05
0
mg/L
04/01/06
02/01/08
05/01/10
05/01/12
24/05/05
03/01/07
05/01/09
06/01/11
Trichloroacetic Acid
Australian Guideline

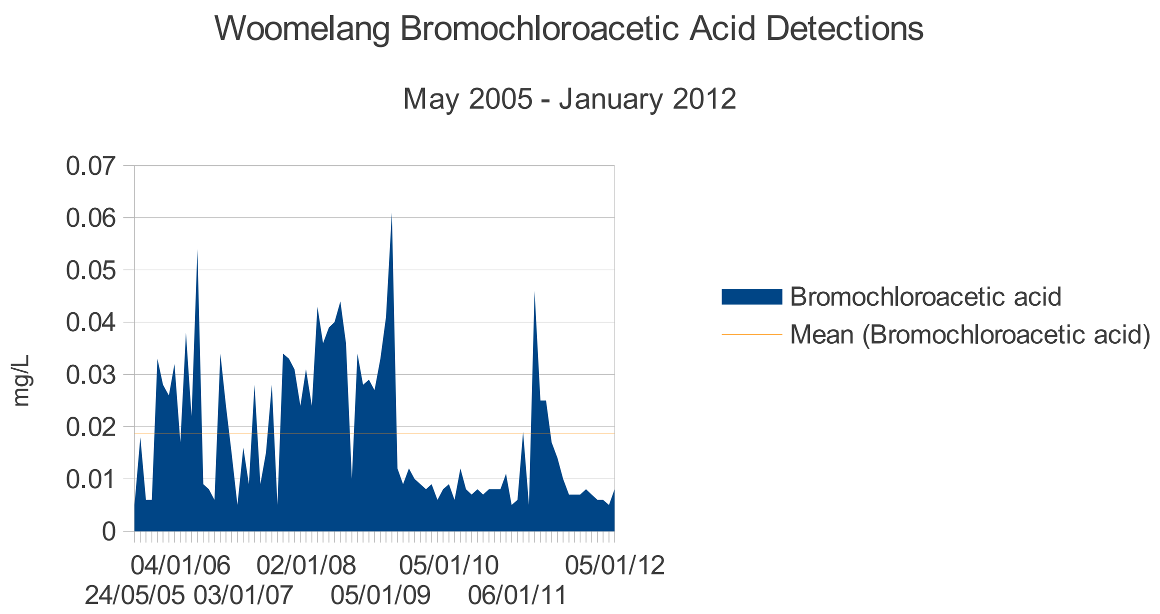

Woomelang Total Trihalomethanes
May 2005 - January 2012
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
mg/L
Dibromochloromethane
Chloroform
Bromoform
BDCM

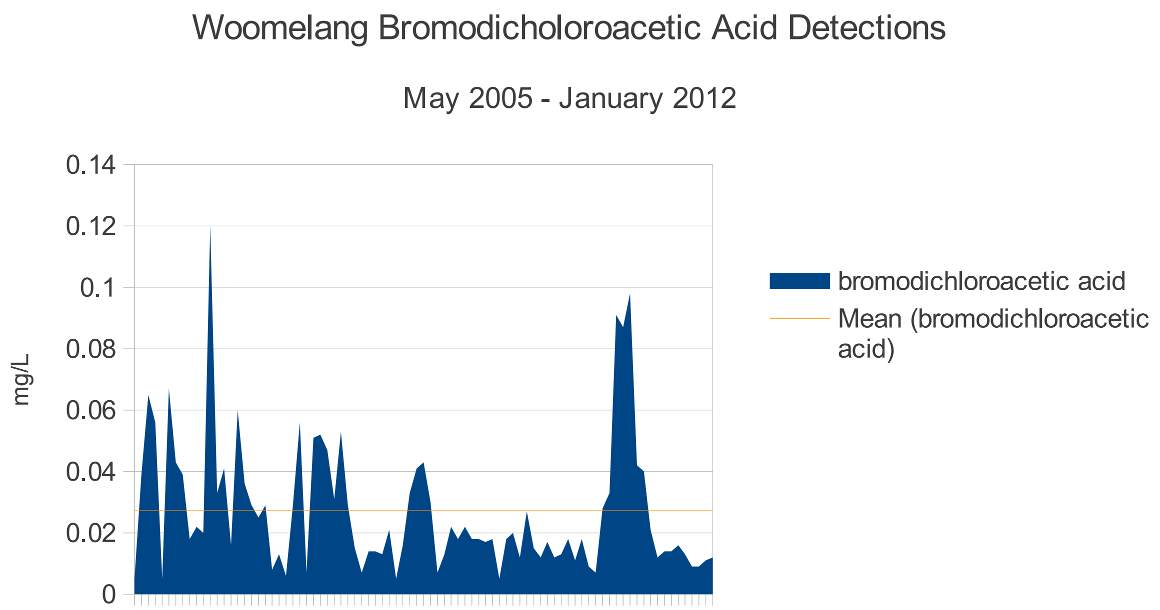

Woomelang Dibromochloromethane Detections
May 2005 - January 2012
0.3
0.25
0.2
0.15
0.1
0.05
0
mg/L
04/01/06
24/05/05
06/01/11
05/01/10
Dibromochloromethane
WHO Guideline


Woomelang Chloroform Detections
May 2005 - January 2012
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
mg/L
04/01/06
02/01/08
05/01/10
05/01/12
24/05/05
03/01/07
05/01/09
06/01/11
Chloroform
WHO Guideline


Woomelang Bromodichloromethane Detections
May 2005 - January 2012
mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
04/01/06
02/01/08
05/01/10
05/01/12
24/05/05
03/01/07
05/01/09
06/01/11
BDCM
WHO Guideline


Woomelang Bromoform Detections
May 2005 - January 2012
mg/L
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
04/01/06
02/01/08
05/01/10
05/01/12
24/05/05
03/01/07
05/01/09
06/01/11
Bromoform
WHO Guideline


Woomelang Bromochloroacetic Acid Detections
May 2005 - January 2012
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
mg/L
04/01/06
02/01/08
05/01/10
05/01/12
24/05/05
03/01/07
05/01/09
06/01/11
Bromochloroacetic acid
Mean (Bromochloroacetic acid)


Woomelang Bromodicholoroacetic Acid Detections
May 2005 - January 2012
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
mg/L
bromodichloroacetic acid
Mean (bromodichloroacetic acid)

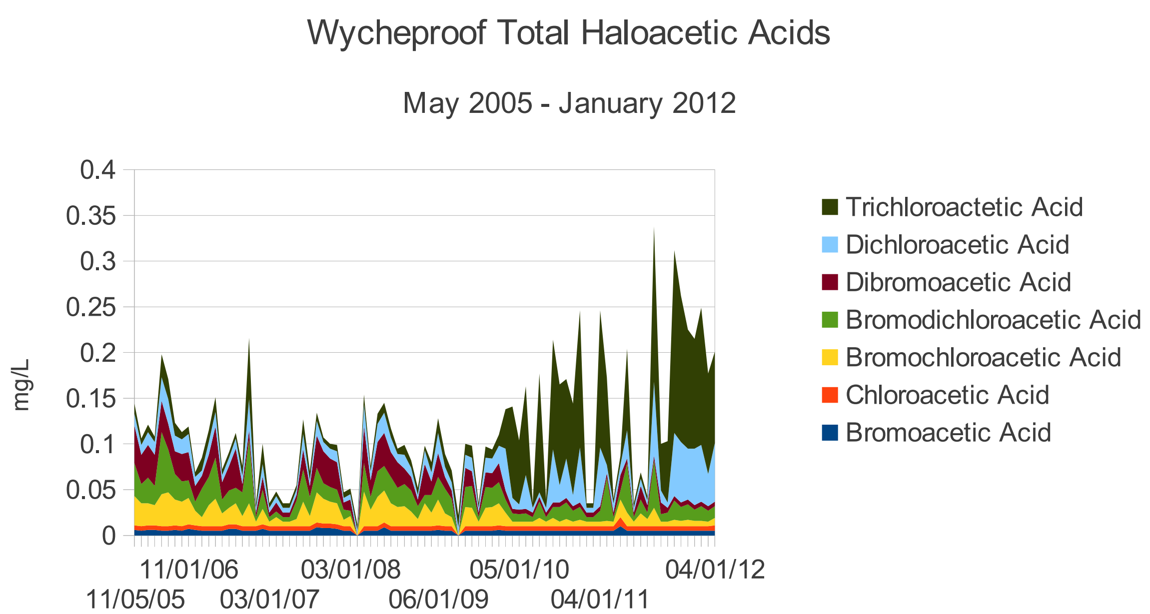
Wycheproof

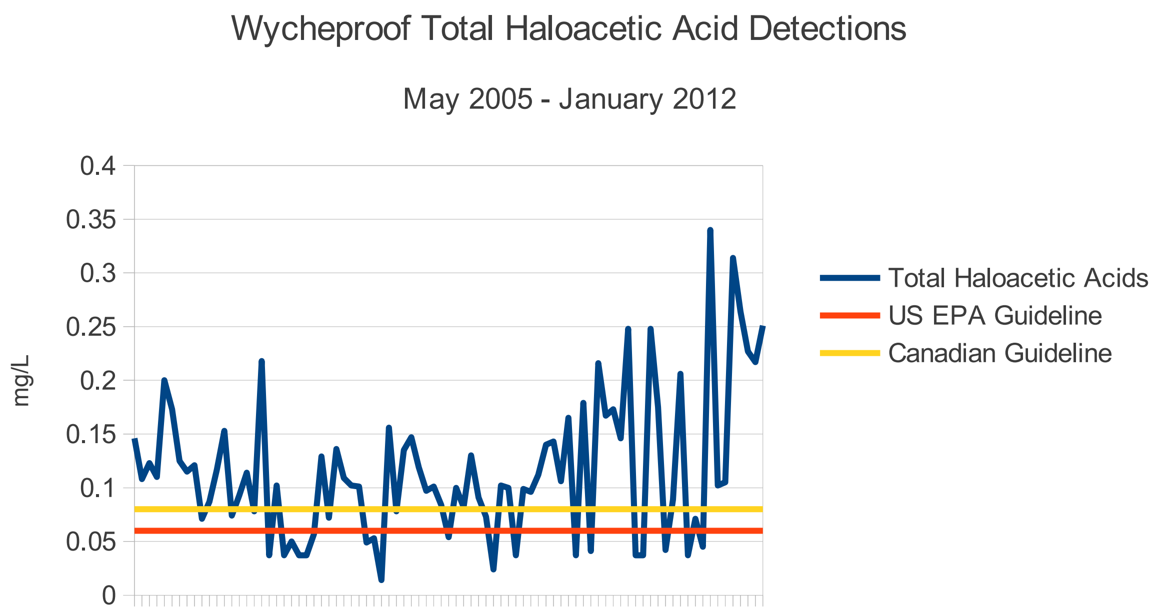
Wycheproof Average Haloacetic Acid Detections May 2005 – February 2012

	Bromoacetic Acid	Chloroacetic Acid	Bromochloro-acetic Acid	Bromodichloro-acetic Acid	Dibromoacetic Acid	Dichloroacetic Acid	Trichloroacetic Acid	Haloacetic Acids*
1/5/05-8/12/09	0.0056	0.005	0.0197	0.0222	0.0209	0.0136	0.0013	0.1
8/12/09 -1/2/12	0.0053	0.0054	0.0078	0.0158	0.0063	0.0316	0.032	0.0866

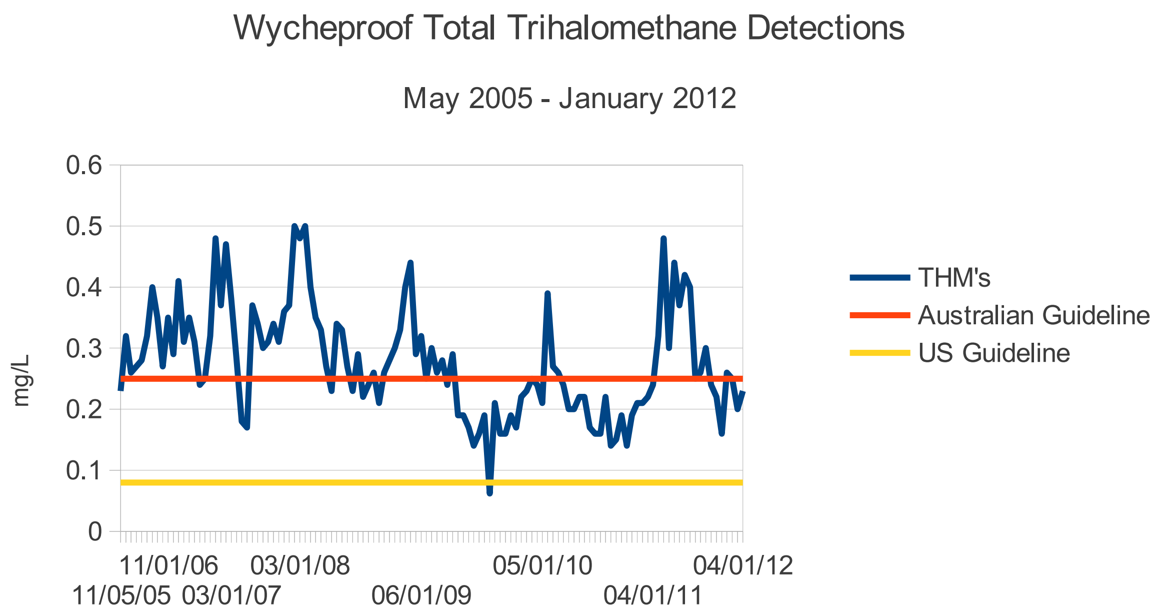
Wycheproof Average Total Trihalomethane Detections May 2005 – January 2012

	Bromodichloromethane	Bromoform	Chloroform	Dibromochloromethane	Total THM's
1/5/05 8/12/09	0.0723	0.0608	0.0404	0.1173	0.2941
8/12/09-1/2/12	0.0468	0.0141	0.1682	0.0272	0.2551

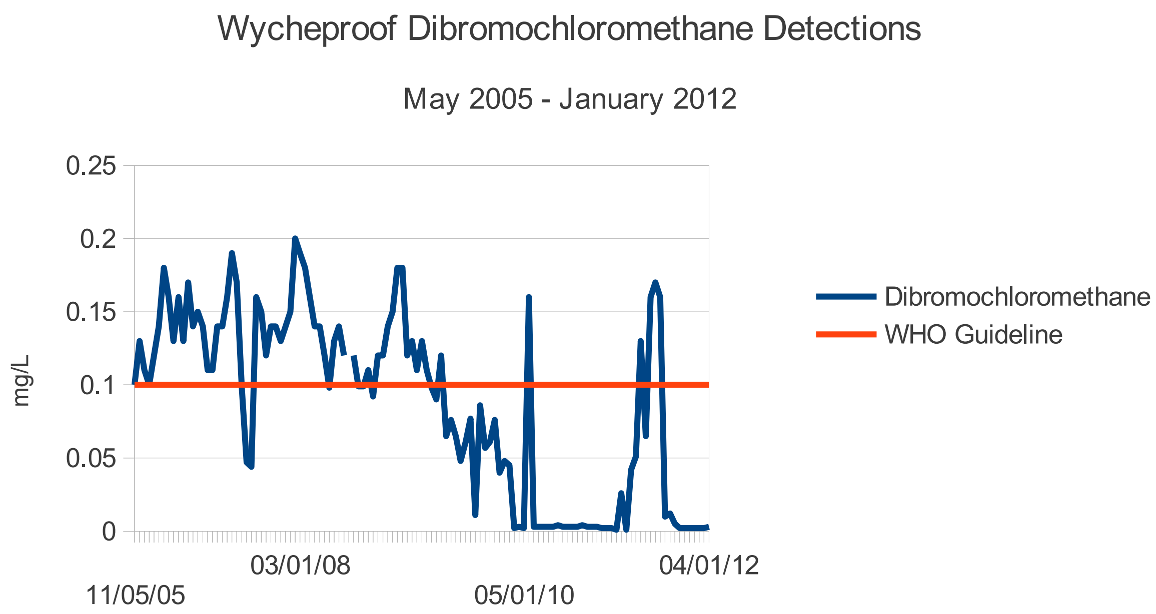


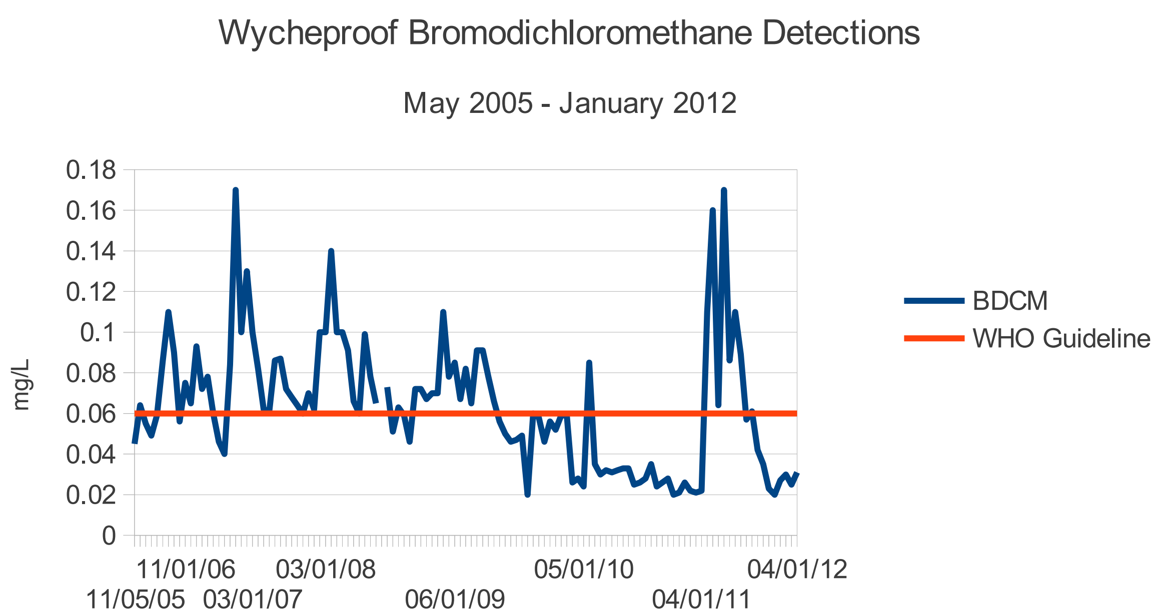


Wycheproof Total Haloacetic Acid Detections
May 2005 - January 2012
mg/L
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Total Haloacetic Acids
US EPA Guideline
Canadian Guideline



Wycheproof Total Trihalomethane Detections
May 2005 - January 2012
mg/L
0.6
0.5
0.4
0.3
0.2
0.1
0
11/01/06
03/01/08
05/01/10
04/01/12
11/05/05
03/01/07
06/01/09
04/01/11
THM's
Australian Guideline
US Guideline


Wycheproof Dibromochloromethane Detections
May 2005 - January 2012
0.25
0.2
0.15
0.1
0.05
0
mg/L
03/01/08
04/01/12
11/05/05
05/01/10
Dibromochloromethane
WHO Guideline


Wycheproof Bromodichloromethane Detections
May 2005 - January 2012
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
mg/L
11/01/06
03/01/08
05/01/10
04/01/12
11/05/05
03/01/07
06/01/09
04/01/11
BDCM
WHO Guideline