State of Florida

ORIGINAL

Public Service Commission

-M-E-M-O-R-A-N-D-U-M-

DATE: November 5, 2002
TO: Division of the Commission Clerk and Administrative Services
FROM: Ralph Jaeger - Economic Regulation Section - Office of the General Counsel
RE: Docket No. 010503-WU - Application for Increase in Water Rates for Seven Springs System in Pasco County by Aloha Utilities, Inc.
Dr. Kurien's October 30, 2002, letter

Please place the attached letter from Dr. Kurien dated October 30, 2002, with its attached analysis of the Chlorination ability of Aloha's Wells 8 and 9, in the docket file.

Thank you.

RRJ/jb

cc: Division of Economic Regulation (Willis, Fletcher, Jones, Merchant)

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FLORIDA PUBLIC SERVICE COMMISSION
OFFICE OF THE GENERAL COUNSEL

The Public Service Commission
Attn: ATTY RALPH JAEGER
2540 SHUMARD OAK BOULEVARD,
TALLAHASSEE, FL 32399-0850

October 30, 2002

Dear Atty Jaeger,

Following my usual procedure to make available to the PSC any new data that I have about why Aloha Water does not meet the community standard, I am forwarding to you an analysis of the processing plant's limitations based on data released to me by FDEP.

The analysis may seem somewhat abstruse and you may want to have it reviewed by a water utility engineer. I thought it would be relevant as you review the plan being submitted by Aloha for the elimination of 98% of sulfide in raw water as per the orders of the PSC on April 30, 2002.

As I have pointed out on a number of occasions previously, the major cause for black water may not be the sulfide present in delivered water which is extremely small (FDEP and I have documented this) even with the present methodology that Aloha uses. *It may well be related more to Aloha's inability to maintain adequate free chlorine residual (0.2mg/l) at all times and even at the most distant site in its distribution system as mandated by FDEP*. This may allow live sulfur reducing bacteria to enter the domestic water system along with sulfate (which is permitted by EPA). The SRB later converts the sulfate into sulfide in the domestic plumbing and causes black water and rotten egg smell.

Yours sincerely,

V. Abraham Kurien

V. Abraham Kurien, M.D.

cc. Mr Van Hoofnagle
Atty Steve Burgess,OPC

AN ANALYSIS OF THE CHLORINATION ABILITY OF ALOHA'S PROCESSING PLANTS AT WELLS 8 AND 9 BASED ON DATA PROVIDED BY FDEP

Mr Jeff Greenwell, P.E. Program Manager, Potable water section at the Tampa Office of the Florida Department of Environmental protection, in his letter to Dr V. Abraham Kurien, M.D. dated October 28, 2002 states " The (Aloha) Utility uses chlorinators of varying sizes. At well 8 the metering tube size is 150 lbs/day and at well 9 a 300 lbs/day metering tube is utilized".

To understand how these capabilities affect the ability to remove hydrogen sulfide in raw water and to minimize the major risk factor for black water and rotten egg smell, namely live SRB in delivered water, the following calculations are relevant:

150 lbs per day is the same as 150x 456 Gs per day as each pound is equal to 456 Gs

150lbs/Day = 68,400 Gs/day

There are 1440 minutes in each day:

So the ***maximum*** injection capability of the chlorinating tube is 47.5Gs(47500 mgs)/min of chlorine.

32 mgs of (hydrogen) sulfide will be completely converted to Sulfate by 278 mgs of chlorine gas as per the following chemical equation:

$$H_2S + 4Cl_2 + 4H_2O = H_2SO_4 + 8HCl \quad (1)$$

1 mg of Hydrogen sulfide per liter of water needs 8.68 mg of chlorine gas to completely convert it into sulfate.

Since a gallon is equal to 3.75 liters, if water is being drawn for use at 1000 gallons per minute, it will require 1000 x 3.75x 8.68 = 32550 mg chlorine/min to remove all hydrogen sulfide from the raw water.

Since the maximum capacity for sulfide-sulfate conversion at well 8 is 47500 mgs/min of chlorine, the processing unit at Well 8 can convert at maximum 1.45mg of sulfide to sulfate per liter of water (47500/32550).

When sulfide level is greater than 1.45 mg/l in raw water, there will be no chlorine residual present for bactericidal purposes in the water that leaves well 8 after processing when water is being used from well 8 at 1000 gallons per minute.

Similarly, since the maximum capacity of the tube at well 9 is 300 pounds per day, it will only be able to convert 2.92 mg sulfide per liter of water to sulfate at a demand rate of 1000 gallons per minute.

When sulfide level in raw water is greater than 2.92 mg/l, there will be no chlorine residual present for bactericidal purposes in the water that leaves well 9 after processing when water is being used from well 9 at 1000 gallons per minute.

DYNAMICS AT WELL 8

The water demand of 1000 gallons per minute on which this calculation is based is about 60,000 gallons per hour. It is not an overestimate to assume that during the morning hours of between 6-9 AM there is such a 'rush demand for water', because the daily delivery of water from wells 8 and 9 are approximately 300,000 gallons per day.

If water demand is greater at any time, and increases to say 1,500 gallons per minute, which is 5,625 liters per minute, with chlorine that can be injected remaining at the maximum rate of 47500 mg/minute, the amount of sulfide that can be removed would fall to 47,500 divided by 5,625 divided by 8.68, which is 0.972 mg per liter.

It is not clear how much free chlorine residual must be present in water as it leaves the processing plant to be able to maintain a *chlorine residual of 0.2 mg per liter at all times and even at the distant periphery of the distribution system which may be miles away.* Unless there is some clear idea about the loss of free chlorine residual per liter of water as it travels through the system, it will be difficult to know how much chlorine has to be dedicated for bactericidal purposes as the water leaves the delivery pump. Assuming that 2 mg/l of free residual chlorine must at a minimum be present at all times when the water leaves the pump house for bactericidal purposes taking into account the dissipation in the distribution system, then the calculation used above which assumed that 47500 mg/minute of chlorine is available for converting hydrogen sulfide to sulfate would be an overestimate.

When water is being drawn at 1000 gallons per minute, which is 3750 liters per minute, assuming a compartmentalized dedication of 2 mg/liter for bactericidal purposes at the well site, only 40,000 mg/minute of chlorine (47500 – 3750 x 2) is available for sulfide-sulfate conversion. That is, each liter of water can have 10.67 mg of chlorine dedicated for this conversion (40,000/3750). It will convert only 1.23 mg of sulfide to sulfate (10.67/8.68). When the water demand rises to 1500 gallons per minute, only 0.74 mg of sulfide will be converted to sulfate.

The maximum levels of sulfide that can be converted and still leave 4mg of chlorine per liter for bactericidal activity (the EPA allowed maximum) can be calculated as below:

At effluent rate of 1000 gallons (3750 liters) per minute, chlorine required for maximum bactericidal activity is 15,000 mg of chlorine per minute (3750 x4).

Subtracting this 15,000 mg/min from 47,500 mg/min that is the present maximum capacity for chlorination at **WELL 8**, there will only be 32,500mg/min chlorine available for converting sulfide to sulfate. This will effectively convert only 1.00 mg of sulfide per liter of water (32,500/3750/8.68) into sulfate.

Similarly at 1500 gallons (5625 liters) per minute, chlorine required for maximum bactericidal activity is 22,500 mg of chlorine per minute (5625 x4).

Subtracting this 22,500 mg/min from 47,500 mg/min that is the present maximum capacity for chlorination at **WELL 8,** there will be available only 25,000mg/min chlorine for converting sulfide to sulfate. This will effectively convert only 0.51 mg of sulfide per liter of water (25,000/5625/8.68) into sulfate.

Such compartmentalization of chlorine reaction with sulfide and bacteria is impossible in reality because the sulfide-sulfate reaction is instantaneous and bactericidal activity is time dependent. What happens then is that the injected dose of chlorine will instantaneously convert the maximum amount of sulfide it can to sulfate as per equation (1) above (assuming an efficiency of 100% which is never attained). There will theoretically be a free chlorine residual of at least 2mg/l when the water leaves the processing plant up to a sulfide level of 1.23 mg/l at flow rates of 1000 gallons per minute and to a sulfide level of 0.74 mg/l at flow rates of 1500 gallons per minute.

If the more appropriate level of 4 mg/l of free residual chlorine when the water leaves the processing plant is adopted, there will be inadequate levels of free chlorine residual when sulfide levels are above 1.00 mg/l of sulfide at a flow rate of 1000 gallons per minute and above 0.51 mg/l sulfide at a flow rate of 1500 gallons per minute.

It should be noted that there are **three independent variables** that limit the availability of chlorine for disinfection purposes in a system that uses chlorine for both conversion of sulfide to sulfate and for bactericidal activity:

1. The unknown **variable** concentration of sulfide in water, which determines a **variable** chlorine demand.

So continuous measurement of sulfide in raw water becomes mandatory if chlorination is the sole method for removal of sulfide to ensure adequate concentrations of chlorine for bactericidal activity.

2. The **variable** demand rates of water consumption by customers, which affect the effectiveness of the dual role of chlorination, namely its capacity to convert sulfide to sulfate as well as its role as an effective bactericidal agent that breaks down at higher water consumption rates.

Bactericidal effectiveness cannot be guaranteed through the provision of adequate amounts of free chlorine residual when flow rates are high in the presence of significant but fluctuating sulfide concentrations in raw water.

3. The need for a **variable** chlorination injection capacity if chlorination is the sole method used, for an adequate bactericidal activity to be present at all times.

***Such a chlorination system must have a variable positive pressure injection capacity the maximum of which is a function of the sulfide concentration in raw water and is expressed by the following equation (2)*:**

Dose of Chlorine that must be injected into each liter of raw water expressed as mg/liter D= Concentration of sulfide per liter in raw water x 8.68 + dose of chlorine needed to maintain 0.2 mg/liter at all times and at the most distant area of the distribution system (there is a maximum of 4.0 mg/liter mandated by EPA)

$$\mathbf{DOSE_{CHLORINE}\ mg/l = CONC_{SULFIDE}\ mg/l\ in\ raw\ water \times 8.68 + 4\ mg/l} \quad (2)$$

Since Aloha Utilities apparently does not measure sulfide levels on a continuous basis, it cannot provide a chlorine dosing system, which is adequate to meet the requirements at all times. The assumption that a maximum chlorinating capacity of 150lbs/day at well 8 is adequate also makes the assumption that the sulfide level in raw water at 8 never rises above 1.00mg/liter after providing a theoretical level of 4mg/l free residual chlorine in the water as it leaves the pump house. ***Historical evidence shows that this is neither an accurate nor a tenable assumption.***

This will result in sulfide being delivered into the distribution system when its concentration in raw water is higher than can be converted by the maximum amount of chlorine injected and at the same time, the water will in addition contain live SRB which is not eliminated due to the lack of adequate free chlorine residual. Entry of live SRB can ensue and cause conversion of sulfate to sulfide within the domestic plumbing and becomes the major cause for black water in copper plumbing and rotten egg smell in CPVC pipes.

Aloha Utilities makes a sustained attempt to deal with this situation by measuring free chlorine residuals at different sites in the distribution system and draining water that contains low levels of free chlorine residual. But this effort is doomed to failure because tests at a large a number of sites and at different times are necessary and the amount of water that will need to be drained and replaced will become too high. Nor is the waste of water justifiable.

Analogous conclusions can be drawn about the processing plant at **WELL 9** also. **WELL 9** may deal with sulfide conversion and maintenance of bactericidal levels of chlorine to a better extent because of its higher maximum chlorination capability. However the net result will not depend exclusively on this parameter, but on the three factors mentioned above.

CONCLUSION

The conclusion is inevitable that Aloha Service Area has grown beyond the capabilities of a system that depends solely on chlorination and should either be scaled back in size, or it should become a much more sophisticated system to be able to supply the present area it serves with a water quality that will meet a community standard.

October 29, 2002
New Port Richey V. Abraham Kurien, M.D.

AVAILABILITY OF FREE CHLORINE RESIDUAL
IN ALOHA WATER
UNDER DIFFERENT CIRCUMSTANCES

A THEORETICAL ANALYSIS OF WELL 8 CHLORINATION SYSTEM BASED ON DATA PROVIDED BY FDEP

Maximum chlorination capability at **Well 8: 150 pounds chlorine per day**
= 47,500 mg/min

No free chlorine residual	**Sulfide that can be converted to sulfate**
Demand of 500 gallons (1875 liters) / min:	2.92 mg/liter
Demand at 1000 gallons (3750 liters)/ min:	1.46 mg/liter
Demand at 1500 gallons (5625 liters)/ min:	0.98 mg/liter
Demand at 2000 gallons (7500 liters) / min	0.73 mg/liter
2mg/l free chlorine residual at reservoir outflow	
Demand at 500 gallons per minute	2.68 mg/liter
Demand at 1000 gallons per minute	1.23 mg/liter
Demand at 1500 gallons per minute	0.74 mg/liter
Demand at 2000 gallons per minute	0.50 mg/liter
4mg/l free chlorine residual at reservoir outflow	
Demand at 500 gallons per minute	2.45 mg/liter
Demand at 1000 gallons per minute	1.00mg/liter
Demand at 1500 gallons per minute	0.51mg/liter
Demand at 2000 gallons per minute	0.26mg/liter

October 30, 2002 Prepared by V. Abraham Kurien, M.D