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REPLY TO ATTENTION OF

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SUBJECT: Water Quality Information Paper No. 15

TRIHALOMETHANES IN DRINKING WATER

1. Purpose. The purpose of this information paper is to provide a concise overview of EPA/NIPDWR regulations governing the control of trihalomethanes (THMs) in drinking water and to update USAEHA/Army efforts and concerns in this area.

2. Regulatory Background.

a. On 14 June 1976, EPA published an Advance Notice of Proposed Rulemaking (ANPRM) entitled "Control Options for Organic Chemicals in Drinking Water" (41FR28991). This notice summarized a number of issues concerning organic chemicals in drinking water including: legislative background, health effects data, availability of control technology and economic considerations. Comments were received and evaluated by EPA.

b. On 9 February 1978 the EPA published a proposed rule (43FR5756) to amend the National Interim Primary Drinking Water Regulations (NIPDWR) to include a maximum contaminant level (MCL) and monitoring/reporting requirements for THMs. Once again, written comments were evaluated by EPA, as well as those received at the 8 public hearings held nationwide.

c. The 29 November 1979 Federal Register (Inclosure 4, reference 3) established an MCL of 0.10 mg/L for total trihalomethanes (TTHMs) in drinking water. This regulation was incorporated into the Code of Federal Regulations (40 CFR, Part 141) as an amendment to NIPDWR. Compliance with the regulation must be attained within 2 years (29 November 1981) for community systems serving greater than 75,000 customers and within 4 years (29 November 1983) for community systems serving between 10,000 and 75,000 customers. Utilities serving populations less than 10,000 are subject to compliance and monitoring requirements established by the individual states, at their discretion. Monitoring requirements for the previously mentioned community systems precede the listed compliance dates by exactly one year. THM monitoring is to be performed on four samples per quarter per distribution system -- one sample must be taken at an extreme of the distribution system while three samples are to be taken in areas representative of population densities. Inclosure 1 provides a summary of the regulations. Inclosures 2 and 3 detail the considerations for reduced monitoring requirements for surface and groundwater sources, respectively.

d. The 5 March 1982 Federal Register (47FR9796) contains a proposed rule whose purpose is to identify the "best treatment methods generally available for reducing TTHMs and to specify the decisionmaking criteria for determining when a noncompliant system shall be required to install and/or use such treatment methods." This rule lists five generally available techniques which, basically, involves the implementation of alternative disinfectants and optimal utilization of

chemical dosages and conventional treatment processes. All are relatively low cost and within the technical capability of the public utilities subject to THM regulations. Five additional treatment alternatives, along with granular activated carbon (GAC) adsorption, are mentioned for situations where further THM reduction is necessary. This reference also defines proposed guidelines by which water systems may obtain variances or extensions to this regulation, as well as the institution of compliance schedules to ensure the timely installation of such methods.

3. THMs -- Composition and Formation. Trihalomethanes are included under the classification of volatile organic compounds, and are commonly associated with potable water supplies emanating from surface water sources. Naturally occurring organics (precursors), in the form of humic and fulvic acids, entering the treatment facility in the raw water reacts with free available chlorine injected for the purposes of disinfection, taste and odor reduction, and algae control. Compounds formed by exposure to other halogens, such as bromine or iodine, also contribute to TTHM concentrations. This TTHM grouping is generally comprised of four primary constituents: trichloromethane (chloroform), bromodichloromethane, chlorodibromomethane, and tribromomethane (bromoform). THMs are not significantly removed by any of the treatment processes usually employed (coagulation/flocculation/sedimentation/filtration). In addition to pre- and post-chlorination, detention time in the distribution/storage system is a factor which compounds the problem of THM development.

4. Treatment Alternatives.

a. Three basic approaches exist by which THMs may be controlled:

(1) Use of a disinfectant that does not generate THMs in water.

(2) Treatment to reduce the concentration of precursor material prior to chlorination.

(3) Treatment to reduce THM concentrations subsequent to their formation.

b. The addition of chlorine to water supplies containing precursor material is the primary mechanism by which THMs are formed. One method of circumventing this reaction is to utilize a material which has proven to be an effective primary disinfectant, while generating negligible amounts of THMs. Chlorine dioxide, chloramines, ozone and UV light have proven to be the most feasible alternatives presently available. The use of chlorine dioxide is relatively cost-effective (Table 1) and is an excellent disinfectant. Problems arise with the potential production of several inorganic reaction products when used at high concentrations. Therefore, a continuous monitoring scheme is required in order to insure appropriate chemical dosages. Sources throughout Europe (where chlorine dioxide is widely used) and within EPA recommend that residual concentrations not exceed 0.5-1.0 mg/L.

Chloramination of potable water supplies is rapidly proving to be an effective means of controlling THMs. This process may be particularly useful within long distribution systems and areas exhibiting extended detention times. Chloramination has proven to be a cost-effective means of disinfection, and is comparatively easy to implement. Potential problems concerning undesirable ion-forms of this disinfectant produced, and the introduction of additional nitrogen into the wastewater treatment system, can be avoided by maintaining an adequate control of system pH and chemical dosages. Ozone and UV radiation have, thus far, had limited application in potable water supplies in the US. Although their disinfectant characteristics are unquestioned, neither has the capability to maintain an adequate residual throughout the distribution system, and would, therefore, not satisfy AWWA and Army guidelines and recommendations. (For example, TB MED 576 will soon require that a "free" or "combined" available chlorine residual be maintained within all portions of the distribution system.) Operational difficulties, as well as overall costs and the generation of oxidation by-products, also render these alternatives rather ineffective, at this time. Further research and development of these technologies may increase their feasibility at a future date.

Table 1. Estimated Costs of Disinfection Alternatives for a 5-MGD Plant*

Alternative	Costs - $/1000 gallons		
	Operating	Capital	Total
Chlorine (2 mg/L)	0.56	0.88	1.44
Ozone (1 mg/L)	1.05	1.36	2.41
Chlorine dioxide (1 mg/L)	1.18	0.76	1.94
Chloramines (3 mg/L)	0.78	0.89	1.67

*Taken from Inclosure 4, Reference 7.

c. The naturally occurring organics, perceived as essential elements for THM formation, may be sufficiently removed by the optimization of chemical addition and treatment processes utilized at an installation. The implementation of this relatively simple treatment alternative has, thus far, proven to be quite effective in reducing THMs in potable water supplies. It involves, basically, a thorough evaluation of chemical (e.g., lime, alum, chlorine) dosages and the insurance that treatment processes are operating as efficiently as possible (e.g., no mechanical failures or hydraulic short-circuiting). Conditions should be established within the treatment train to allow for maximum removal of free organics and organic-bound materials. Chemical composition of the water supply (particularly pH and alkalinity) must be considered and controlled when optimizing chemical addition. A noticeable reduction of THMs can be achieved by reducing prechlorination dosages or by shifting downstream the point of initial chlorination (i.e., allowing coagulation/flocculation/sedimentation to occur prior to chlorine addition). Algae growth in sedimentation basins can be controlled by periodic dosages of chlorine or

use of an appropriate algicide. The coagulation/flocculation process to reduce organics can be enhanced by the addition of a synthetic polymer or coagulation aid. Trade-offs involving chemical costs and increased sludge production must be considered when determining their potential effectiveness. Overall, chemical/process optimization can account for up to a 70% reduction of THM concentrations which, in many cases, would bring an installation into compliance with the 0.10 mg/L MCL. The most difficult obstacle to overcome in this undertaking is to convince plant operators to adhere to recommended alterations in chemical addition procedures, after years of doing things a particular way.

d. The proven methods of removing volatile organics from a water supply include aeration, granular activated carbon (GAC) adsorption and polymeric resin absorption. Average maximum removal efficiencies range between 85-99%. Although GAC treatment has achieved consistent THM removals of 99%, countercurrent packed-bed air stripping columns and specific-absorbent resins have also exhibited their ability to remove volatile organics on a continual basis. The theoretical and/or practical applications of these technologies have been well-documented in recent journal publications and conference proceedings, and will, therefore, not be discussed at length at this time.

5. Army THM Program.

a. This Agency began monitoring for THMs in early 1979, when approximately 45 installations were sampled on a one-time basis. Several installations were found to exceed the then-proposed MCL of 0.10 mg/L. In consonance with OTSG and HSC mandates, an extended THM surveillance program was established to accumulate a year of background THM data. The program commenced in May 1980, with 80 CONUS installations targeted by the various MACOMs to take part. The monthly sampling program concluded December 1981. It was determined from this data base that approximately 30 installations exhibited concentrations consistently exceeding the MCL. Continuing emphasis (i.e., monitoring and possibly on-site investigations) will be placed on these facilities. As of January 1982, installations subject to state or Federal monitoring and/or compliance requirements will continue quarterly sampling efforts, with analyses to be conducted by this Agency (as before), under the auspices of the Drinking Water Surveillance Program (DWSP). Data will be made available to the installations for submittal to the appropriate regulatory agency(-ies).

b. Of the installations determined to have on-going THM problem, approximately 12 have systems which serve a population between 10,000 and 75,000. These installations must, therefore, find some means of achieving compliance by November 1983 (Inclosure 1; Inclosure 4, Reference 3). In an effort to aid a number of installations in this quest USAEHA personnel have conducted several on-site investigations. Special studies have, thus far, been completed at the following locations:

Installation	Survey Date
Ft Dix, NJ	May 1979
Ft Monroe, VA	June 1979
Ft Pickett, VA	July 1979
Ft Gordon, GA	August 1979
Ft Jackson, SC	September 1979
Ft Knox, KY	October 1979
Ft Benning, GA	April 1980
Ft Meade, MD	June 1980 and June 1981
Presidio of San Francisco, CA	August 1981
Ft Hood, TX	September 1981

6. Future USAEHA/Army Involvement.

a. Further on site services need to be identified, scheduled and performed in an effort to assist installations in meeting the MCL requirements. This Agency can, at the request of the MACOMs, offer technical assistance in the implementation of recommended treatment alternatives and evaluate treatment technologies involving major construction activities, in those instances where a simpler (O&M-type) adjustment is not sufficient.

b. OTSG will, in the near future, be faced with a major decision concerning those installations whose water supply services less than 10,000 persons. It will, likely, be some time before individual states discern when these small communities must meet MCL limitations. Therefore, policy must be established by OTSG to determine if all installations with residential populations, regardless of size, should be required to reduce THMs below 0.10 mg/L or, simply, if the letter of State and Federal laws be maintained.

7. Technical Assistance. Informal technical consultation may be obtained telephonically from USAEHA, Aberdeen Proving Ground, MD, AUTOVON 584-3919/3554. Additional assistance should be requested in writing through channels to Commander, US Army Health Services Command, ATTN: HSPA-P, Ft Sam Houston, TX 78234.

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SUMMARY OF TTHM REGULATIONS*

Maximum Contaminant Level (MCL): 0.10 mg/l (100 micrograms per liter) Total Trihalomethanes

Applicability: Community water systems that add disinfectant to the treatment process (ground and surface)

Effective:	Systems >75,000:	2 years after promulgation
	Systems 10-75,000:	4 years after promulgation
	Systems <10,000:	State discretion

Monitoring requirements: Running annual average of a minimum of 4 samples per quarter per plant taken on same day. Systems using multiple wells drawing raw water from a single aquifer may, with State approval, be considered one treatment plant for determining the required number of samples.

Effective:	Systems >75,000:	1 year after promulgation
	Systems 10-75,000:	3 years after promulgation
	Systems <10,000:	State discretion

Sample Locations: 25% at extreme of distribution system; 75% at locations representative of population distribution.

Frequency:

For groundwater systems, reduced monitoring may be appropriate for certain systems; States may reduce the requirements through consideration of appropriate data including demonstration by the system that the maximum total trihalomethane potential (MTP) is less than 0.10 mg/l; the minimum frequency would be one sample per year for MTP.

For ground water systems not meeting the above MTP and for surface water systems, States may reduce the monitoring requirements if after one year of data collection, TTHM levels are consistently below 0.10 mg/l; the minimum frequency would be one sample per quarter for TTHM.

The original frequency would be reinstated if the levels exceed 0.10 mg/l or if the treatment or source is modified.

Reporting Requirements:

To State: Average of each quarterly analysis, within 30 days; until States have adopted the regulations, reporting will be to EPA unless State requests receipt of data from the public water systems.

*National Interim Primary Drinking Water Regulations; Control of Trihalomethanes in Drinking Water; Final Rule, 44 FR 68624, 29 November 1979.

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To Public and State: Running annual average of each quarterly sample if it exceeds MCL as prescribed by the public notification provisions.

Other Requirements:

To ensure microbiological quality: State approval of significant modifications in the treatment process for the purpose of meeting the TTHM MCL.

Analytical requirements: In accordance with specified methods (purge and trap or liquid/liquid extraction) conducted by certified laboratories.

Other Issues of Interest: Guidance on alternative disinfectants

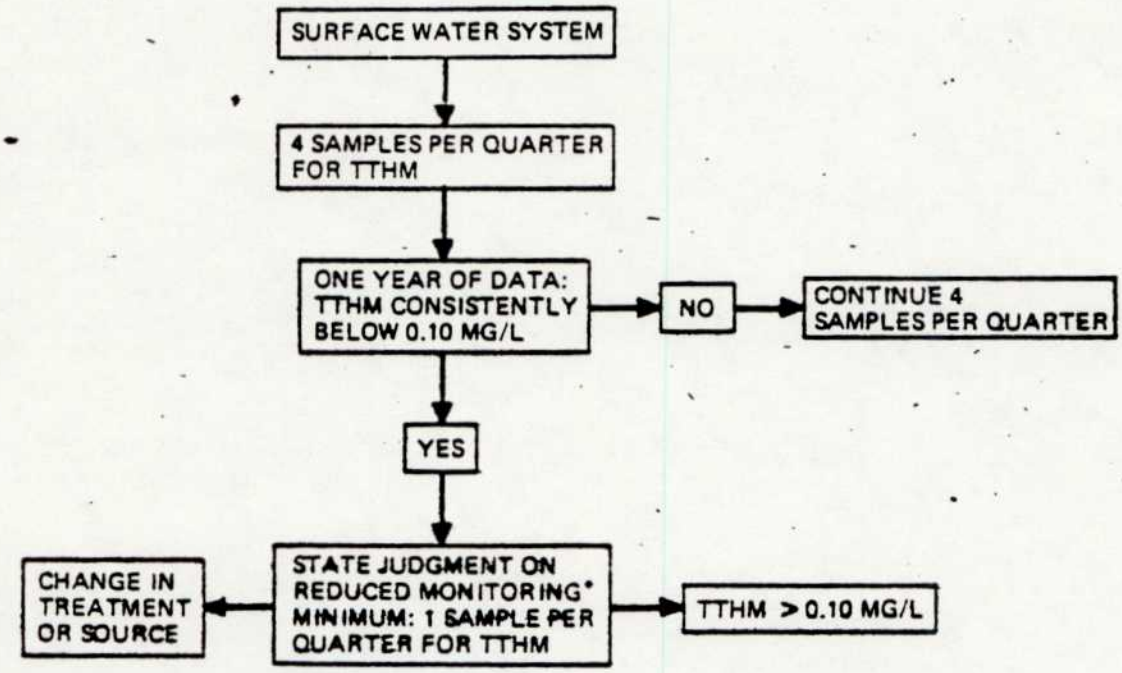
- Conduct monitoring when chlorine dioxide is used and residual oxidants should not exceed 0.5 mg/l.
- The decision of using chloramines is best made on a case-by-case basis by the State.
- Standard plate count should be a condition for State approval of systems where process modifications are contemplated.

Laboratory Availability (interim certification):

- To quality for interim certification. Laboratories will be required to demonstrate their ability to analyse the performance evaluation samples provided to them by EPA's Environmental Monitoring and Support Laboratory (EMSL) to within 20% of the "true value" for each THM as well as the total.
- A quality assurance program will be established to ensure a laboratory's ability to perform quality analyses.

FIGURE 1
CONSIDERATIONS FOR REDUCED MONITORING REQUIREMENTS
SURFACE WATER SYSTEMS

THE MINIMUM MONITORING REQUIREMENT IS FOUR SAMPLES PER QUARTER PER PLANT. REDUCED MONITORING REQUIREMENTS MAY BE APPROPRIATE IN CERTAIN CASES; UPON WRITTEN REQUEST FROM THE PUBLIC WATER SYSTEM, STATES MAY REDUCE THE REQUIREMENTS THROUGH CONSIDERATION OF APPROPRIATE DATA AS FOLLOWS:



*FACTORS FOR CONSIDERATION:
- MONITORING DATA, MTP, TTHM, TOC
- QUALITY AND STABILITY OF SOURCE WATER
- TYPE OF TREATMENT

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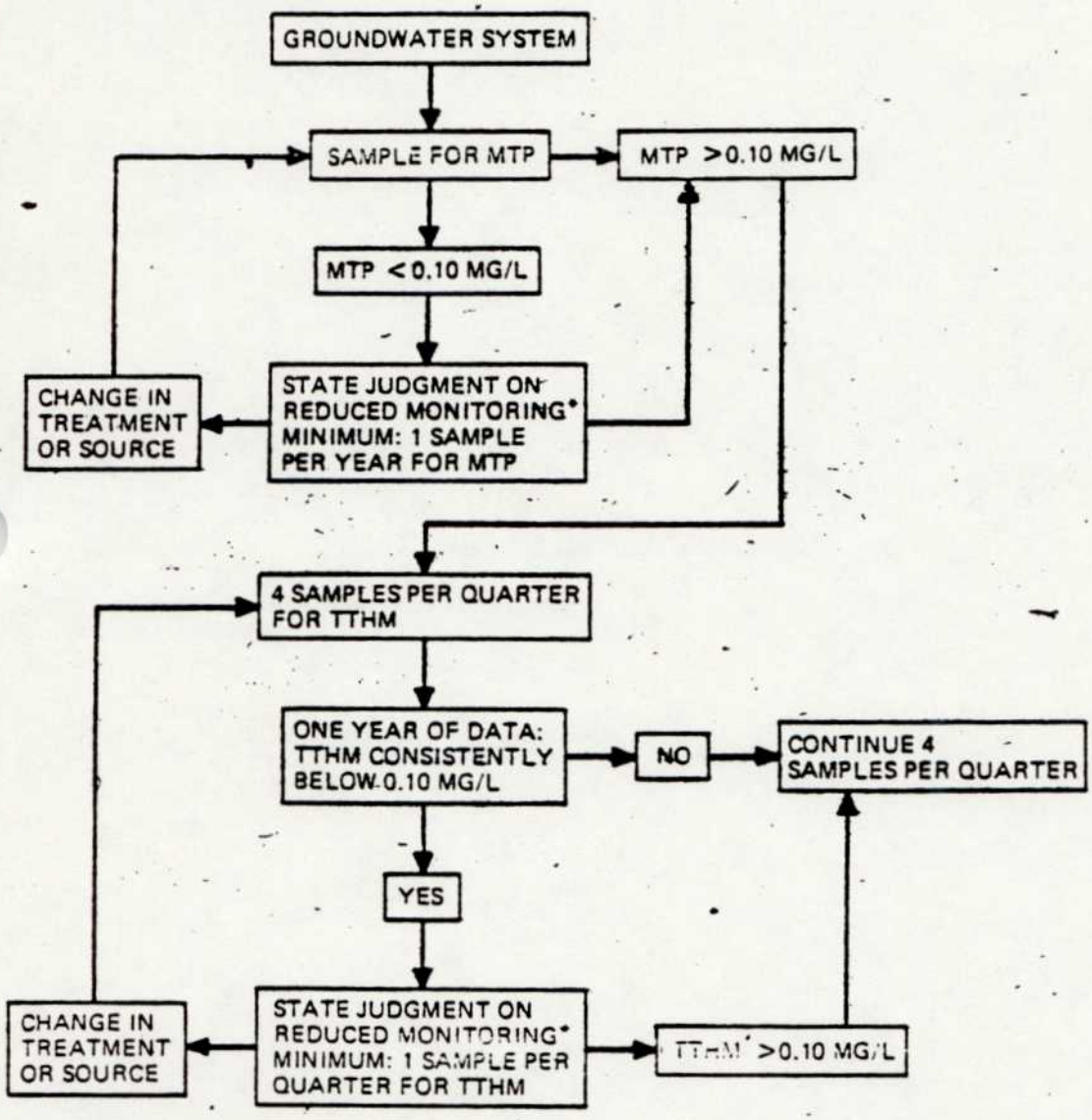
FIGURE 2
CONSIDERATIONS FOR REDUCED MONITORING REQUIREMENTS GROUNDWATER SYSTEMS

THE MINIMUM MONITORING REQUIREMENT IS FOUR SAMPLES PER QUARTER PER PLANT; SYSTEMS USING MULTIPLE WELLS DRAWING RAW WATER FROM A SINGLE AQUIFER MAY WITH STATE APPROVAL BE CONSIDERED AS ONE TREATMENT PLANT. REDUCED MONITORING REQUIREMENTS MAY BE APPROPRIATE IN CERTAIN CASES; UPON WRITTEN REQUEST FROM THE PUBLIC WATER SYSTEM, STATES MAY REDUCE THE REQUIREMENTS THROUGH CONSIDERATION OF APPROPRIATE DATA AS FOLLOWS:



*FACTORS FOR CONSIDERATION:
- MONITORING DATA, MTP, TTHM, TOC
- QUALITY AND STABILITY OF SOURCE WATER
- TYPE OF TREATMENT

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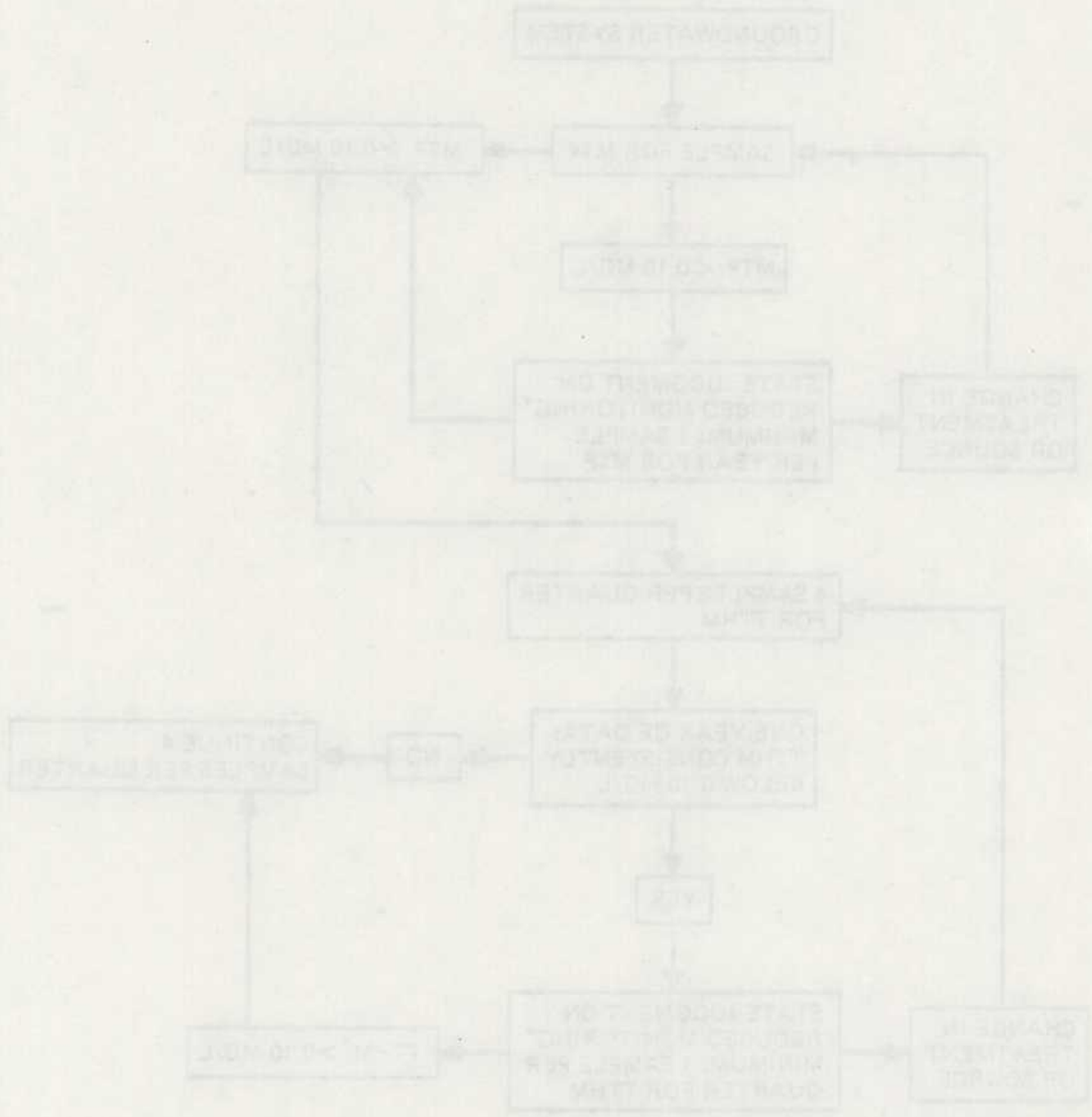
FIGURE 2

CONSIDERATIONS FOR REDUCED MONITORING REQUIREMENTS
GROUNDWATER SYSTEMS

THE MINIMUM MONITORING REQUIREMENT IS FOUR SAMPLES PER QUARTER PER PLANT. VIRTUALLY DEEP GROUNDWATER WELLS SERVING SMALL WATER SYSTEMS WHICH ARE COURSE GRAIN SYSTEMS APPROVE DE CONTROLS TO ONE YEAR MINIMUM PLANT REDUCED MONITORING REQUIREMENTS MAY BE APPROPRIATE IN SPECIFIC CASES UPON WRITTEN REQUEST FROM THE PUBLIC WATER SYSTEM. STATES MAY REQUIRE THE REQUIREMENTS THROUGH DEMONSTRATION OF APPROPRIATE DATA AS FOLLOWS:



*FACTORS FOR CONSIDERATION:
*MONITORING OF TAP SAMPLE TTHM VOCS
*QUALITY AND QUANTITY OF SOURCE WATER
*TYPE OF TREATMENT
*DISTRIBUTION SYSTEM

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8. Symons, James M., et al, Interim Treatment Guide for the Control of Chloroform and Other Trihalomethanes, Municipal Environmental Research Laboratory, EPA, June 1976.