Appendices to the Economic Analysis for the Final Stage 2 Disinfectants and Disinfection Byproducts Rule
Volume I (A-E2)

Office of Water (4606-M) EPA 815-R-05-010 December 2005 www.epa.gov/safewater

Appendix A

Surface Water Compliance Forecasts

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Surface Water Compliance Forecasts

The Surface Water Analytical Tool (SWAT) is the primary tool used by EPA to predict treatment technology changes in surface water systems to achieve compliance with the Stage 2 Disinfection and Disinfectants Byproducts Rule (DBPR). Treatment technology changes are the basis for calculating national cost estimates in this Economic Analysis (EA). SWAT is also one of the primary tools used to predict changes in national chlorination disinfection byproduct (DBP) occurrence levels as a result of the treatment technology changes. Changes in DBP occurrence levels are used to quantify benefits (specifically, reduced bladder cancer) of the Stage 2 DBPR.

The purpose of this appendix is to review the major components in SWAT; summarize its operations; itemize the uncertainties in SWAT and discuss their potential impact on cost and benefits estimates; present an alternative compliance forecast methodology for comparison to SWAT; and present detailed compliance forecast results for all sizes of surface water systems. It is organized as follows:

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A.2 Model Configuration
A.3 User Inputs for Stage 2 DBPR Model Runs
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Part I: SWAT Operations

A.1 SWAT: An Introduction

One of the major tools developed in conjunction with the Microbial-Disinfectants/Disinfection Byproducts Federal Advisory Committees Act (M-DBP FACA) process is the SWAT. SWAT is a decision support computational model designed to predict treatment technology choices and resulting changes in water quality for different rule alternatives and input conditions based on the Information Collection Rule (ICR) data. SWAT model outputs are used to generate compliance forecasts and DBP exposure estimates. The Environmental Protection Agency (EPA) used SWAT outputs to estimate costs and benefits of the Stage 2 Disinfectants and Disinfection Byproducts Rule (DBPR) regulatory alternatives.

A.1.1 Overview

This section presents an overview of how SWAT predicts DBPs and treatment technology selections for a given rule alternative[1]. The steps of a SWAT model run that predict DBPs and treatment technology selections for regulatory alternatives include the following (also shown in Exhibit A.1).

- DBP occurrence estimates are a function of total organic carbon (TOC), Ultraviolet-254 Absorbance (UVA), bromide, pH, temperature, residence time, and primary and secondary disinfectants. These data, from each valid month used in the SWAT analysis, are input from Auxiliary Database 8 (AUX8) into the Water Treatment Plant (WTP) Model.

- The WTP Model calculates trihalomethanes (THMs), haloacetic acids (HAAs), bromate, and chlorite concentrations with empirical equations at three different residence times—one representing finished water, one representing distribution system average, and one representing distribution system maximum.

- Based on an input compliance scheme (usually involving Maximum Contaminant Levels [MCLs] and a compliance aggregation method, such as running annual average), the Decision Tree Program assesses whether the plant meets the compliance criteria.

- If the plant meets the criteria, the WTP Model results are stored and no further change is made to the treatment process of the plant.

- If the plant fails to meet the criteria, the Decision Tree Program selects the next least cost treatment technology feasible for that plant (see Exhibits A.5 and A.6).

- The WTP Model is then run with the same influent water characteristics, but with the new treatment technology added to the plant record.

- The resulting DBP predictions are then compared with the compliance scheme.

- The process is repeated until either compliance is achieved or the end of the treatment technology tree is reached.

For details on SWAT components or operation beyond the descriptions in this appendix, refer to *Surface Water Analytical Tool (SWAT) Version 1.1—Program Descriptions and Assumptions* (USEPA 2000a).

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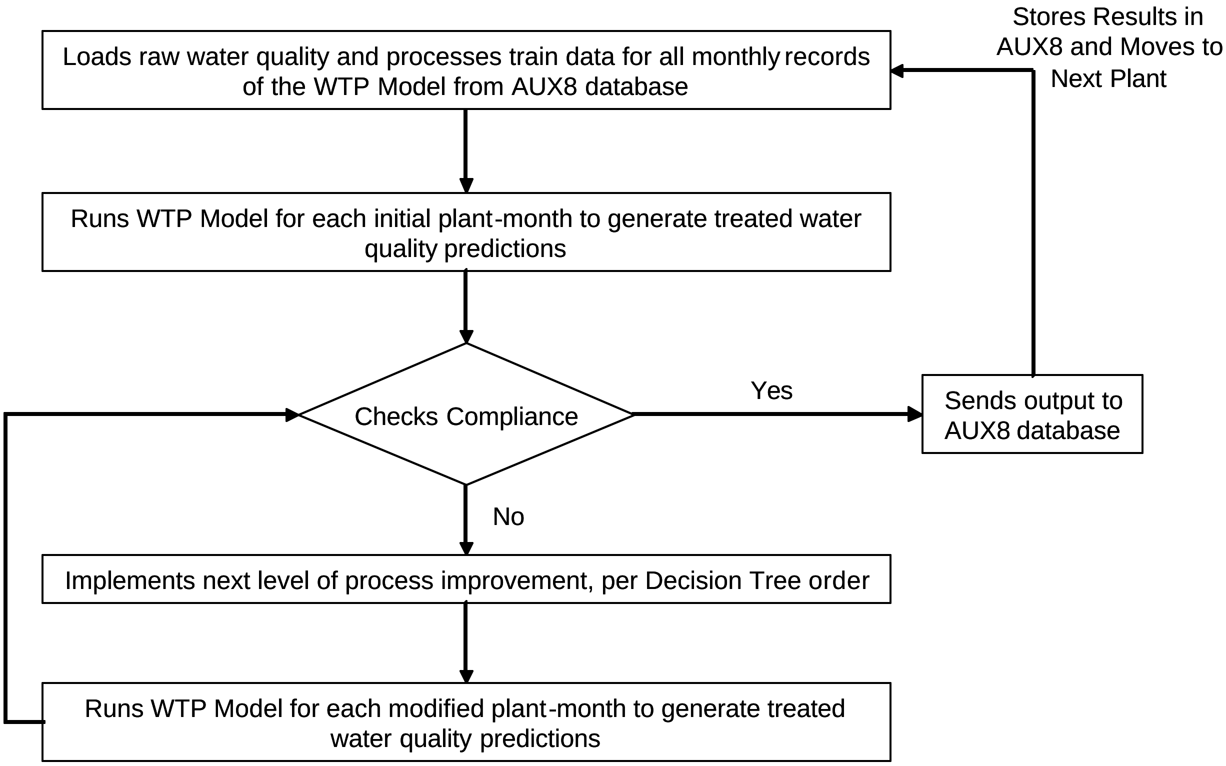
[1] The SWAT program can also be run in a mode to evaluate all possible treatment technology choices for each plant and the resulting DBP concentrations (called “Monster” SWAT runs). This section, however, focuses on regulatory compliance analyses

Exhibit A.1 Diagram of SWAT Process



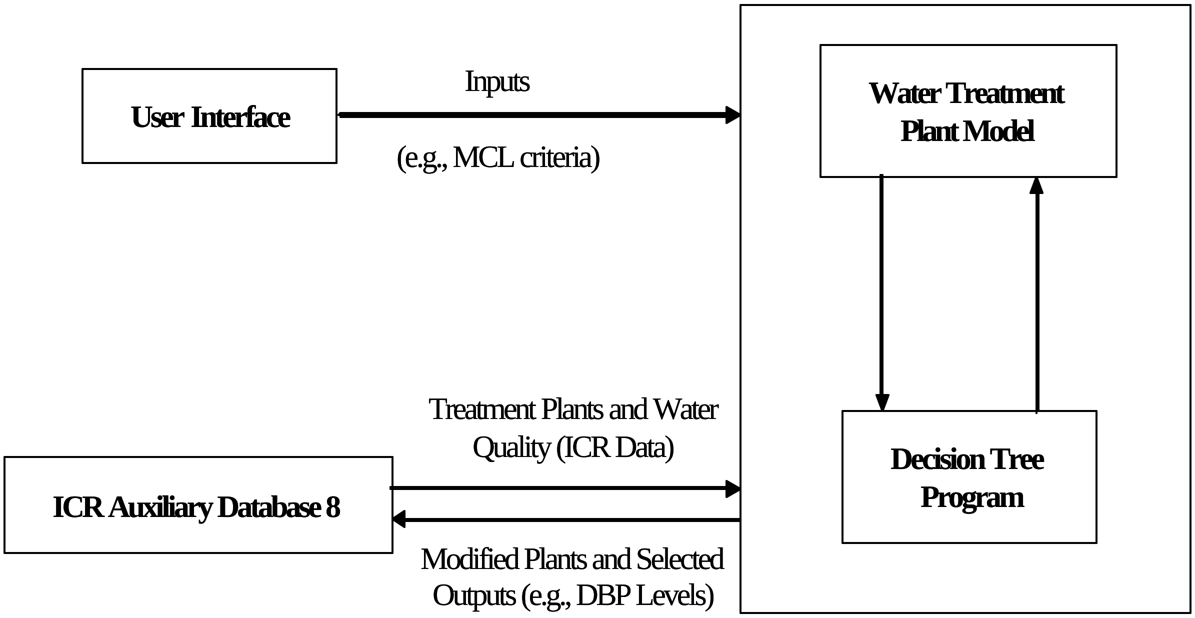
A.2 Model Configuration

This section provides an overview of SWAT's configuration. Exhibit A.2 shows the four main components and how they interact. These components can be grouped into two categories:

- The input/output components, i.e., the user interface and the AUX8 database
- The computational/analytical components, i.e., the Decision Tree Program, and the WTP Model

Sections A.2.1 through A.2.4 describe these components in more detail.

Exhibit A.2 SWAT Components



A.2.1 User Interface

A Microsoft Windows™ interface enables the user to specify the disinfection and DBP regulatory criteria, as well as numerous other assumptions for a SWAT run (e.g., use of disinfection benchmarking, use of ultraviolet light [UV]). It also allows the user to run the WTP Model, which predicts DBP occurrence, and the Decision Tree Program, which selects treatment technologies to meet specified compliance options. The SWAT Version 1.1 program description document (USEPA 2000a) shows all input screens for the SWAT user interface. Section A.4 describes the user inputs and SWAT assumptions for the Stage 2 DBPR model runs.

A.2.2 Auxiliary Database 8

AUX8 is a Microsoft Access™ database that holds inputs and outputs for SWAT analyses. The database contains only the data from AUX 1 (the primary ICR database) that was need to run the SWAT model. Only the last 12 months of the 18-month ICR collection period were used in SWAT in order to avoid seasonal bias.[2] Ground water plants generally did not have as much information as surface water plants and thus were not modeled in SWAT. The surface water plants with at least one month of all required SWAT input data in AUX1 were screened into the AUX8 database. SWAT inputs from AUX8 are grouped into five categories—source water quality, treatment plant characteristics, unit processes, chemical additions, and distribution system characteristics—and are summarized below.

<u>(1) Source Water Quality</u>

- pH
- Temperature (average and annual minimum)
- TOC

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[2] All of the 12-month series (months 1 to 12, 2 to 13, etc.) were examined during the M-DBP FACA process and determined to be similar.

- UVA[3]
- Bromide
- Alkalinity
- Hardness (total and calcium)
- Ammonia
- Turbidity

<u>(2) Treatment Plant Characteristics</u>

- Flow (average and design)
- Sequence of unit processes and parameters influencing their performance such as volumes, flow, detention times, baffling characteristics and other process specific parameters.

<u>(3) Unit Processes</u>

- Conventional processes such as rapid mix, flocculation, sedimentation, and rapid sand filtration
- Granular activated carbon
- Microfiltration
- Nanofiltration
- Ozonation

<u>(4) Chemical Additions</u>

- Coagulation/Softening related chemicals: alum, carbon dioxide, sodium hydroxide, ferric chloride, lime, soda ash, and sulfuric acid.
- Oxidation/Disinfection related chemicals: chlorine (gas), sodium hypochlorite, chloramines, chlorine dioxide, ozone, ammonia, ammonium sulfate, potassium permanganate, and sulfur dioxide.

<u>(5) Distribution System Characteristics</u>

- Average and maximum distribution system residence times

In some cases, plants reported changes in their unit processes or chemical addition inputs during the ICR period. For example, some plants installed ozone during the ICR collection period. Also, many plants change disinfectant type from chlorine to chloramines during the year. The initial treatment technology level determination and disinfectant type for a plant was always based on the treatment technology or disinfectant that was reported most often.

Unlike user inputs described in Section A.2.1, ICR data in AUX8 is not intended to be modified by the user or varied from run to run. Each run creates a series of additional records in the AUX8 database. Each run is saved in a separate version of the AUX8 database. The databases are then compiled by a summary program.

To increase the number of plant-months that could be processed by SWAT, some missing raw water quality data were estimated. For example, missing monthly values for influent pH, hardness, alkalinity, and ammonia were estimated based on the average of values that were reported in AUX1 for the other months. Missing monthly raw water temperature data were estimated based on reported

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[3] UV-254 absorbance measures the extent of absorbance of UV light (having a wavelength of 254 nanometers) by the natural organic matter (NOM) present/remaining in untreated/treated waters. It is sometimes referred to as UV_{254}, and it's units are cm^{-1}. In conjunction with TOC, it yields important insights into the characteristics of the NOM.

temperature data from other points in the plant or distribution system for the same month. TOC and UVA were determined to be too critical to the calculations to be estimated if neither value was provided for a given month. If either TOC or UVA data existed for a plant month, the missing value was estimated using the ratio of UVA to TOC for the rest of the plant-months.

Of the 350 surface water plants in the ICR, 273, or approximately 78 percent, had at least one month with all required data for SWAT analyses. There is a potential bias resulting from the exclusion of ICR plants from the analysis. The M-DBP Technical Expert Working Group (TWG) determined, however, that the 273 plants evaluated in SWAT adequately capture treatment configuration and water quality conditions of all ICR surface water plants.

Plants only needed to report one valid month of data (i.e., one month with all required parameters) to be used in SWAT, so many of the 273 plants used do not have complete records for all months. Exhibit A. shows the extent to which there are complete plant-month records in SWAT. Note that over 70 percent of plants have at least 10 months of data, and more than 90 percent have at least eight months of data.

Exhibit A.3 Extent of Plant-Month Data in SWAT

No. of Months	No. of ICR Plants With Corresponding Months of Data in AUX8	Percent of Plants with at Least That Many Months of Data in Aux8
1	3	100%
2	3	99%
3	1	98%
4	3	97%
5	5	96%
6	2	95%
7	8	94%
8	15	91%
9	38	85%
10	35	71%
11	65	59%
12	95	35%
TOTAL	273	

Source: SWAT Run Summaries (USEPA 2001b).

Outputs from the computational components in SWAT (the WTP model and Decision Tree Program) are also stored in AUX8 and consist of the following for each plant:

- Treatment technology level at compliance
- Modified process train at compliance (e.g., modified chemical doses)

- Water quality at compliance for finished water, average distribution system residence time, maximum distribution system residence time locations (see Section A.3 for a complete description of these locations in SWAT):

  Disinfection Byproduct:
  - Chloroform ($CHCl_3$)
  - Bromodichloromethane (BDCM)
  - Dibromochloromethane (DBCM)
  - Bromoform ($CHBr_3$)
  - Total trihalomethanes (TTHM)
  - Monochloracetic acid (MCAA)
  - Dichloroacetic acid (DCAA)
  - Trichloroacetic acid (TCAA)
  - Monobromoacetic acid (MBAA)
  - Dibromoacetic acid (DBAA)
  - Bromochloroacetic acid (BCAA)
  - Haloacetic Acid (HAA5) (sum of MCAA, DCAA, TCAA, MBAA, and DBAA)
  - HAA6 (sum of HAA5 and BCAA)
  - HAA9 (sum of HAA6 and BDCAA, CDBAA, and TBAA)
    where: BDCAA = Bromodichloroacetic acid
    CDBAA = Chlorodibromoacetic acid
    TBAA = Tribromoacetic acid

  Other Water Quality Parameters
  - Bromate
  - Chlorite
  - Temperature
  - pH
  - Alkalinity
  - TOC
  - UV254
  - Bromide
  - Calcium
  - Magnesium
  - Ammonia
  - Disinfectant Residuals
  - Pathogen Inactivation

SWAT outputs are discussed further in the next two sections.

A.2.3 Water Treatment Plant Model

The WTP Model predicts the formation of DBPs given source water quality conditions and water treatment plant configuration. It consists of several empirical equations that predict DBP precursor and disinfection behavior, the impact of water treatment plant processes on water quality, and concentrations of DBPs in the distribution system. The original version of the WTP Model was developed in 1992 (*Water Treatment Plant Simulation Program Version 1.21 User's Manual*, Malcolm Pirnie Inc., June 1992). In 2000, the WTP Model was thoroughly revised to incorporate new research in the areas of DBP precursor removal and DBP formation during chlorination, ozonation, and chlorine dioxide addition. The extensions and modifications to the original model have been documented in Solarik et al. (2000).

The purpose of this section is to describe how DBP precursors and other related parameters were modeled through a treatment plant and to present the final equations used by the WTP Model to predict DBP concentrations. DBP precursors need to be model as accurately as possible as the impact the amount of DBP formation. Since chlorination DBP's are formed by the interaction of chlorine with organic and inorganic matter, TOC, a measure of the organic content of water, is a key factor in predicting chlorination DBPs.

The last subsection includes a description of how the final DBP equations are used for different treatment plant scenarios. Section A.5 builds on this section by explaining how the DBP equations were calibrated using ICR data.

A.2.3.1 Predicting Changes in pH

The WTP Model predicts pH changes as a result of chemical addition during coagulation and softening using thermodynamic equilibrium assumptions in a closed system (with respect to carbon dioxide equilibrium). This may not be an entirely accurate assumption since a water treatment plant is neither a perfectly closed system because it is open to the atmosphere, nor a perfectly open system because of the depths of the basins. The WTP Model equations that predict pH changes due to softening do not account for the kinetics of processes such as calcium carbonate precipitation or carbon dioxide dissolution. Consequently, predictions are not always completely accurate. In general, the WTP Model is believed to slightly over-predict the depression of pH due to coagulant addition (Solarik et al. 2000).

Coagulation pH is an input parameter for the algorithms that calculate settled water TOC and UVA. The over-prediction of the depression in pH could result in the propagation of error in the settled water quality. However, based on observed data from several water treatment plants, these errors are not large (see section A.5, Model Calibration).

A.2.3.2 Predicting TOC Removal

In the earlier (1992) version of the Model, TOC removal by coagulation was predicted using an empirically-derived equation based on the raw water TOC, coagulant dose, and the coagulation pH. In the current version of the Model, TOC removal is predicted using a semi-empirical sorption model published by Edwards (1997). Though the semi-empirical sorption model is applicable specifically for dissolved organic carbon (DOC) removal, it has been shown to predict TOC removal nearly as well (Edwards 1997). The major differences in the 1992 model equations and the current semi-empirical sorption model are:

- The current model divides the TOC into fractions that are sorbable and non-sorbable by the coagulant, and attributes TOC removal to the sorbable fraction alone.

- In addition to TOC, coagulant dose, and the coagulation pH, the current model uses certain calculated model coefficients and the Specific UVA (SUVA – the ratio of UVA to the DOC concentration) of the raw water as inputs.

A.2.3.3 Predicting UVA Reduction

In the 1992 version of the WTP Model, the precision of the equations used to predict UVA removal was limited by the small data sets used in their derivation. The new equations are based on data analysis performed on the more extensive American Water Works Association (AWWA)/Water Industry Technical Action Fund (WITAF) database (Tseng et al. 1996), thereby improving their precision.

An analysis of predictive errors for the UVA removal equations was performed using raw water data from the AWWA/WITAF database as inputs to the equations and comparing the WTP Model results to those from the database. The analysis concluded that the equations tend to over-predict UVA removal. Further, the errors in settled water UVA predictions are greater for softening than for coagulation. However, it must be noted that the data set used for verification of UVA removal by softening (i.e., from the AWWA/WITAF database) is very limited.

A.2.3.4 Predicting Chlorine Decay

In the current version of the WTP model, chlorine decay is predicted using a single equation based on bench scale data and work published by Koechling et al. (1998). The general form of the equation is:

$$C_t = [\alpha_1 \times \ln(C_0/C_t)] - [k_2 \times SUVA_0 \times t] + C_0$$

where:

C_t = chlorine residual concentration at any reaction time t
C_0 = initial chlorine dose
α_1 = a kinetic rate parameter related to the initial dissolved organic carbon (i.e., DOC_0) and the initial UVA (i.e., UVA_0), for a given chlorine-to-TOC ratio.
$k_2 = -[a \times (UVA_0^b)]$, where a and b are fitted parameters that depend on the treatment and the chlorine dose
$SUVA_0$ = Initial Specific UVA = (UVA_0/TOC_0), where TOC_0 = initial TOC
t = reaction time

The derivation of α_1 was originally performed at a chlorine-to-TOC ratio of 2:

$$\alpha_{1@2} = 4.98*UVA_0 - 1.91*DOC$$

A correction factor was developed for α_1, making it applicable for other chlorine-to-TOC ratios (Solarik et al. 2000):

$$\alpha_1 / \alpha_{1@2} = 0.503\ (CL_2/TOC)$$

A.2.3.5 WTP Model Equations for DBP Formation

During the development of the WTP simulation model in 1992, only a limited number of research reports were available to derive predictive equations for THM formation during chlorination. As a result, the 1992 version used an empirical THM formation equation that was based on chlorination experiments of raw (i.e., no coagulation or filtration) waters only. The equation was originally used in the model irrespective of chlorine application locations throughout the water treatment plant. Chlorination conditions on which this original THM predictive equation was based included conditions that are experienced in water plants as well as some more severe chlorination conditions that are beyond normal practice at water plants.

At the time of developing the revised WTP simulation model in 2000, predictive equations for THM were available from the literature that represented more realistic chlorination conditions at various stages of treatment. Consequently, different predictive equations were used for predicting THM formation in raw water and in waters after various levels of treatment. This section discusses the different sets of equations used by the WTP Model to predict DBP formation. It includes two sets of equations used to model DBP formation as a result of (1) raw water chlorination (i.e., water not subjected to any treatment other than chlorination), and (2) chlorination of treated water (i.e., water subjected to full-scale treatment process(es) besides chlorination).

DBP Formation as a Result of Chlorination of Raw Water

"Raw water" model equations were empirically derived from studies documenting the chlorination of untreated/raw waters under laboratory conditions.

$$\mathrm{TTHM_{raw}} = 0.0412(\mathrm{TOC_{raw}})^{1.098}(\mathrm{Cl_2})^{0.152}(\mathrm{Br_{raw}})^{0.068}(\mathrm{T})^{0.609}(\mathrm{pH_{raw}})^{1.601}(\mathrm{t})^{0.263}$$

$$\mathrm{HAA5_{raw}} = 30.0(\mathrm{TOC_{raw}})^{0.997}(\mathrm{Cl_2})^{0.278}(\mathrm{Br_{raw}})^{-0.138}(\mathrm{T})^{0.341}(\mathrm{pH_{raw}})^{-0.799}(\mathrm{t})^{0.1.69}$$

where:

$\mathrm{TTHM_{raw}}$ = raw water TTHM (micrograms per liter (µg/L))
$\mathrm{HAA5_{raw}}$ = raw water HAA5 (µg/L)
$\mathrm{TOC_{raw}}$ = raw water TOC (milligrams per liter (mg/L)): $1.2 \leq \mathrm{TOC_{raw}} \leq 10.6$)
$\mathrm{Cl_2}$ = applied chlorine dose (mg/L): $1.51 \leq \mathrm{Cl_2} \leq 33.55$
$\mathrm{Br_{raw}}$ = raw water bromide concentration (µg/L): $7 \leq \mathrm{Br_{raw}} \leq 600$
T = temperature (degrees centigrade): $15 \leq T \leq 25$
$\mathrm{pH_{raw}}$ = raw water pH: $6.5 \leq \mathrm{pH} \leq 8.5$
t = reaction time (hour): $2 \leq t \leq 168$

DBP Formation as a Result of Chlorination of Treated Water

"Treated water" equations were based on work performed by Amy et al. (1998) using coagulated waters. The major difference between these equations and those applicable to chlorinated raw waters is that the TOC×UVA term (and not TOC) accounts for the impact of treatment on NOM removal and NOM reactivity.

$$TTHM = 23.9(TOC \times UVA)^{0.403}(Cl_2)^{0.225}(Br)^{0.141}(1.027)^{(T-20)}(1.156)^{(pH-7.5)}(t)^{0.264}$$

$$HAA5 = 41.6(TOC \times UVA)^{0.328}(Cl_2)^{0.585}(Br)^{-0.12}(1.021)^{(T-20)}(0.932)^{(pH-7.5)}(t)^{0.150}$$

where:

TTHM = treated water TTHM (µg/L): $13 \leq TTHM \leq 690$
HAA5 = treated water HAA5 (µg/L): $12 \leq HAA6 \leq 643$
TOC = treated water TOC (mg/L): $1.00 \leq TOC \leq 7.77$
UVA = treated water UVA (cm^{-1}): $0.016 \leq UVA \leq 0.215$
Cl_2 = applied chlorine dose (mg/L): $1.11 \leq Cl_2 \leq 24.75$
Br = treated water bromide concentration (µg/L): $23 \leq Br \leq 308$
T = temperature (degrees centigrade): $15 \leq T \leq 25$ [4]
pH = treated water pH: $6.5 \leq pH \leq 8.5$ [3]
t = reaction time (hour): $2 \leq t \leq 168$

The treated water TTHM and HAA5 equations were verified by plotting modeled results against observed values from 47 coagulated waters and 4 softened waters and analyzing the residuals (i.e., the predicted value minus the observed value) and average errors. In general, results indicated that the WTP Model slightly under-predicted the formation of TTHMs and slightly over-predicted the formation of HAA5s for coagulated waters. For TTHMs, ninety percent of the residuals were within ±24 µg/L of the measured values. For HAA5s, ninety percent of the residuals were within ±18 µg/L of the measured values. Due to the limited number of data points, the results from the analysis of the softened waters were not as conclusive as those from the coagulated waters.

A.2.3.6 Using the DBP Formation Equations for Different Chlorinating Scenarios

DBP formation is modeled as the cumulative formation through the treatment plant. This section describes how the two sets of equations presented above can be applied to different treatment plant chlorination scenarios. The following scenarios are discussed:

- Pre-chlorination only (i.e., chlorine added just prior to coagulation)
- Post-chlorination only (i.e., a single point of chlorination just prior to filtration, after the combined treatment of coagulation, flocculation, and sedimentation)
- Pre- and Post-chlorination (i.e., two points of chlorination – just prior to coagulation and just prior to filtration)

Exhibit A.4 (presented at the end of this subsection) shows where the chlorine is assumed to be applied within the treatment plant for the pre- and post-chlorination scenarios and summarizes how DBP formation is modeled. Note that separate equations for DBP formation in distribution systems were not developed—the distribution system is considered as an extension of the treatment plant, and formation is assumed to follow the same kinetics and rates.

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[4] Sufficient pH and temperature-dependent data were not available to model their effect on DBP formation for treated waters. Therefore, pH and temperature factors from the raw water equations were applied to treated water conditions. These factors are valid in the temperature range of 15-25°C and a pH range of 6.5-8.5.

Pre-Chlorination Only

The raw water model equations were originally used to predict DBP formation for plants that pre-chlorinated only. However, research by Summers et al. (1998) indicates that pre-chlorination just before or after rapid mixing results in less DBP formation than chlorination of raw water as shown in the original studies. To better predict DBP formation post-coagulation/flocculation, an empirical *pre-chlorination factor* was developed to account for the decrease in DBP formation that occurs as a result of adding chlorine just prior to the rapid mixers relative to the DBP formation that occurs as a result of adding chlorine to the raw water:

Decrease in TTHM Formation = 85.3 % of raw water model results

Decrease in HAA5 Formation = 79.4 % of raw water model results

As shown by Exhibit A.4, the raw water equations, adjusted using the pre-chlorination factors, are used to model DBP formation through the sedimentation process (prior to the filters). The treated water model is used to predict DBP formation through the filtration process and into the distribution system, using settled water quality (including settled water chlorine residual) as input parameters.

Post-Chlorination Only

For post-chlorination (prior to filtration), the treated water model was applied, with the settled water quality and chlorine residual after sedimentation being the inputs to the model equations.

Pre- and Post-Chlorination

As shown in Exhibit A.4, the raw water equations, adjusted using the pre-chlorination factors, are used to model DBP formation from the raw water through the sedimentation process (prior to the filters). The treated water model is used to predict DBP formation starting after sedimentation. The treated water model is adjusted because pre-chlorination will result in lowering the UVA of the settled water due to the oxidation of the UVA by the chlorine. The settled UVA after prechlorination (i.e., $UVA_{Pre\text{-}Cl2}$) was estimated from the settled UVA without prechlorination (i.e., $UVA_{No\ Cl2}$) using the following equation:

$$UVA_{Pre\text{-}Cl2} = 0.7437\ (UVA_{No\ Cl2}) + 0.0042$$

where the UVA concentrations are expressed in cm^{-1}.

Exhibit A.4 Application of DBP Formation Equations for Three Chlorinating Scenarios

1) PRE-CHLORINATION ONLY

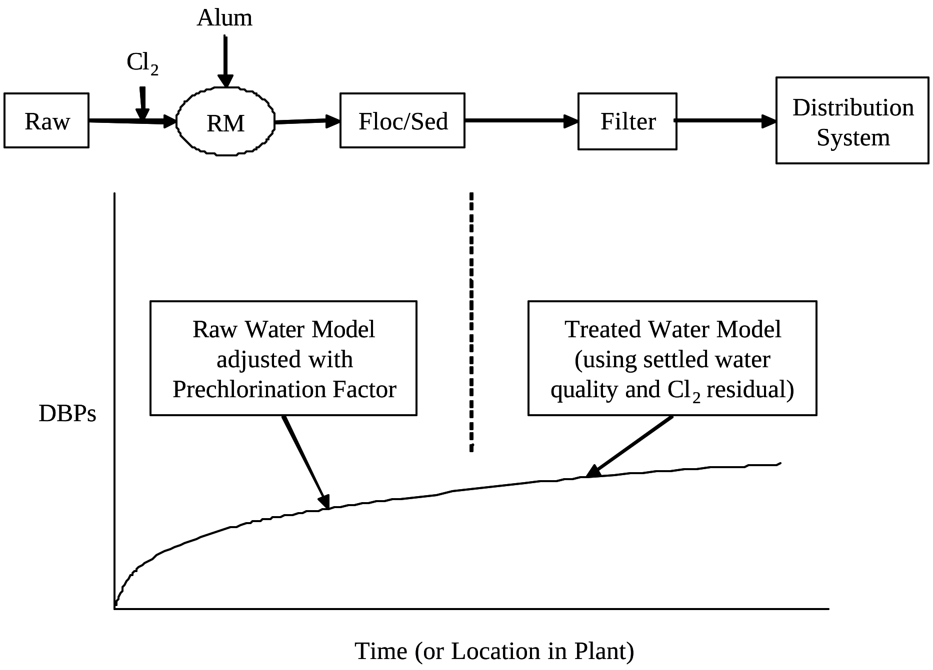
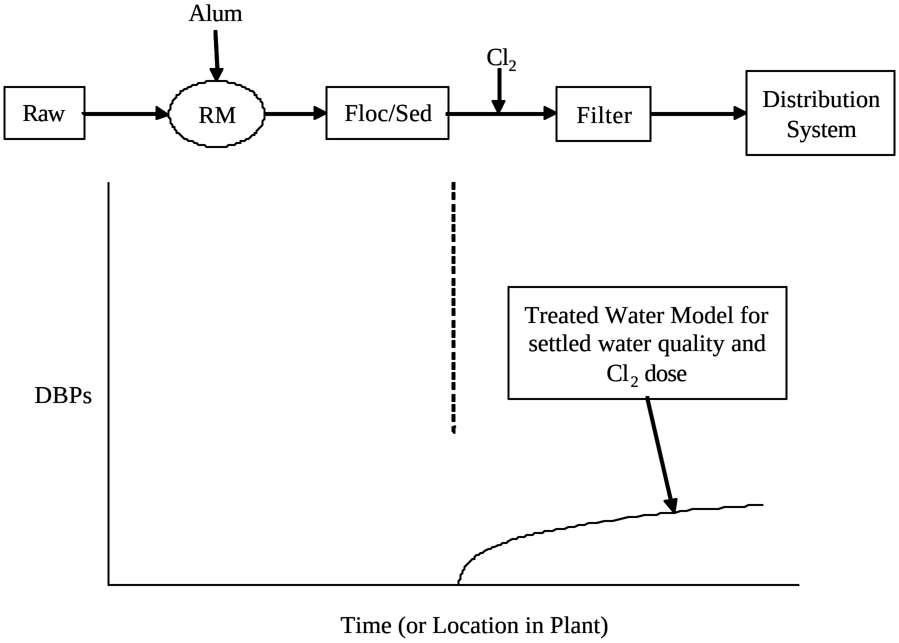
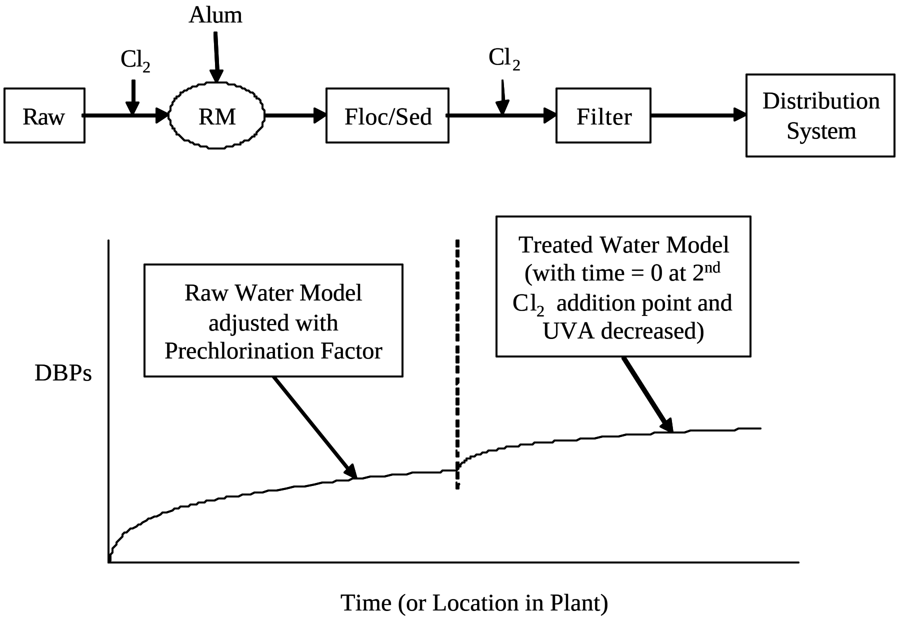


Exhibit A.4 Application of DBP Formation Equations for Three Chlorinating Scenarios (Continued)

2) POST-CHLORINATION ONLY



3) PRE- AND POST-CHLORINATION



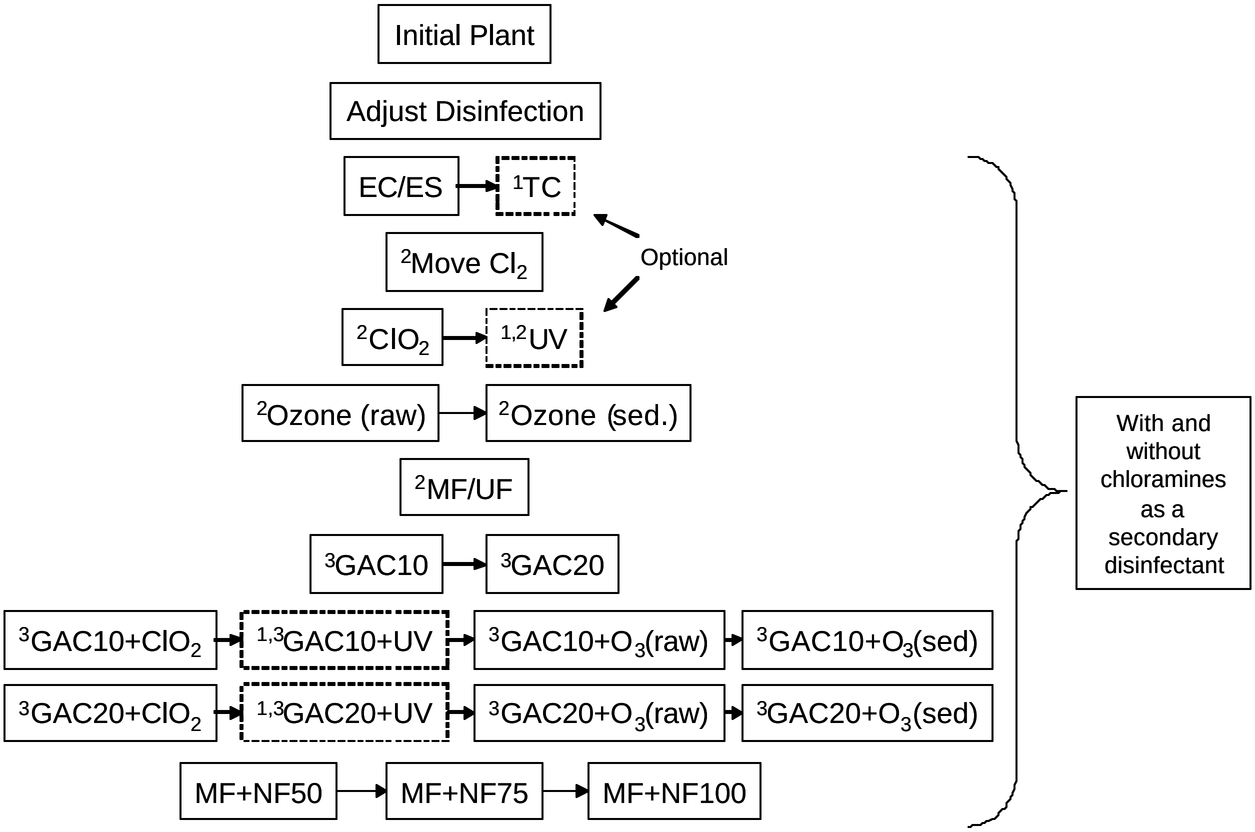
A.2.4 Decision Tree Program

This part of SWAT determines how a treatment plant is modified to comply with defined regulatory alternatives. First, the program determines if an individual plant can be modified using the least expensive (and typically least effective) treatment technology to comply with the regulatory alternative. If not, the program moves to the next least-cost treatment technology. This process continues until the plant achieves compliance. The treatment technology selection algorithm can therefore be described as a "least cost" based approach. The program receives inputs from the database (AUX8), uses the WTP Model to estimate treated water quality before and after predicted treatment technology changes, and sends the results back to the database.

The steps involved with using the Decision Tree Program are presented in Exhibits A.5 and A.6 in flow chart and table format. The starting point is at the top of the tree, and the process improvement order is from the top row to the bottom row and from left to right in any row.

For each treatment technology starting with Enhanced Coagulation/Enhanced Softening (EC/ES) there is an additional option of chloramine secondary disinfection with that treatment technology. For example, if the tree starts at EC/ES treatment technology and that treatment technology does not yield compliance, then the next option is EC/ES with chloramines. One important aspect of the decision tree is how it accounts for existing disinfection credit. To implement an advanced disinfectant in a process train, SWAT credits the train with the levels of inactivation specified by the user (see section A.3 for user inputs) and adjusts the existing primary disinfectant to achieve the necessary CT credit. Any other chlorine additions contributing to CT are decreased, if necessary.

Exhibit A.5 SWAT Decision Tree (Compliance Selection Sequence)



[1] Optional steps that the user determines whether to include in the tree. For Stage 1 and Stage 2 runs, turbo coagulation was an available treatment technology. UV was “turned off” for Stage 1 but “turned on” for Stage 2 runs. See Section A.3, User Inputs for Stage 2 DBPR Model Runs, for more information.
[2] With EC/ES.
[3] Not applicable for plants that initially soften via precipitation.

Notes: Order is top to bottom, and left to right. The granular activated carbon (GAC)10/20 + O$_3$(raw/sed) treatment technology can be implemented with or without pH adjustment. Chloramines can be used at any point in the decision tree (including initial plant).

Exhibit A.6 Abbreviations Used and Description of Decision Tree Steps

Abbreviation	Description	Abbreviation	Description
Initial Plant	Unmodified Plant	GAC10 + ClO_2	GAC10 with Chlorine Dioxide
Adjust Disinfection	Adjust Disinfection	GAC10 + UV	GAC10 with UV Disinfection
EC/ES	Enhanced Coagulation/ Enhanced Softening	GAC10 + O_3(raw)	GAC10 with Ozonation of raw water
TC	Turbo Coagulation	GAC10 + O_3(sed.)	GAC10 with Ozonation of settled water
Move Cl_2	Move Chlorination Point	GAC20 + ClO_2	GAC20 with Chlorine Dioxide
ClO_2	Chlorine Dioxide	GAC20 + UV	GAC20 with UV Disinfection
UV	UV Disinfection	GAC20 + O_3(raw)	GAC20 with Ozonation of raw water
Ozone (raw)	Ozonation (raw water)	GAC20 + O_3(sed.)	GAC20 with Ozonation of settled water
Ozone (sed.)	Ozonation (settled water)	MF + NF50	MF/UF with 50% of flow treated by Nanofiltration
MF/UF	Microfiltration/Ultrafiltration	MF + NF75	MF/UF with 75% of flow treated by Nanofiltration
GAC10	GAC (10-min. EBCT)	MF + NF100	MF/UF with 100% of flow treated by Nanofiltration
GAC20	GAC (20-min. EBCT)		

The least cost decision approach, as used in SWAT, has two inherent limitations that contribute to uncertainty in national cost and benefit estimates:

- The decision tree does not include operational or design modifications of the distribution system that could reduce DBPs and allow the plant to achieve compliance without a treatment technology change.

- The model cannot take into account site specific factors (e.g., taste and odor) that could cause a system to choose a more expensive treatment technology than the SWAT least cost algorithms say is necessary.

Uncertainties are discussed further in Section A.6.

A.2.5 Improvement in Decision Tree for Stage 2 versus Stage 1

In the Stage 1 DBPR Regulatory Impact Analysis (RIA) (USEPA 1998a), EPA estimated treatment technologies in place at treatment plants prior to the Stage 1 DBPR, as well as treatment technology changes that systems would make to comply with the Stage 1 DBPR. This estimate of treatment technologies in place for the pre-Stage 1 baseline is not the same as the pre-Stage 1 baseline derived in this EA. The two estimates differ because new information and treatment technologies, such as UV disinfection, have become available since the promulgation of the Stage 1 DBPR. For the Stage 2 DBPR analyses, new tools and processes were used to forecast the costs of complying with the Stage 1 DBPR. These tools and processes, summarized in Chapter 7, included:

- SWAT
- ICR Ground Water Delphi process
- Expert opinion process for small systems (both surface and ground water)

These tools and processes provided a larger and more detailed set of treatment technology choices than those used in the Stage 1 DBPR RIA. Consequently, the estimate of treatment technologies in place for both the pre-Stage 1 and post-Stage 1 baselines, while different from those in the Stage 1 DBPR RIA, are based on a more complete set of compliance options and a more rigorous analysis. Exhibit A.7 compares the treatment technology choices used in the Stage 1 DBPR RIA to those used in the Stage 2 DBPR EA.

The detailed treatment technology choices evaluated for the Stage 2 DBPR EA were aggregated into more general categories for the purposes of estimating national costs. The final 12 major treatment technology categories evaluated in this EA are summarized in Exhibit A.8. They are generally ordered according to cost, with the most expensive at the bottom of the exhibit. With each treatment technology, systems are expected to use either free chlorine or combined chlorine (chloramines) as the residual disinfectant. Conversion from free chlorine to chloramine residual disinfection is a relatively inexpensive way for systems to reduce DBP levels.

The first four treatment technologies (in italic font in Exhibit A.8) represent operational changes to existing treatment configurations. Although these changes may result in small increases in chemical usage or minor capital improvements, EPA assumes their costs to be negligible when compared to the costs of the advanced treatment technologies (e.g., UV, ozone, granulated activated carbon, microfiltration/ultra-filtration) shown in Exhibit A.8 (refer to *Technologies and Costs for Control of Microbial Contaminants and Disinfection Byproducts* [USEPA 2003o] for comparison). Also, most systems that are able to use these treatment technologies are predicted to do so to meet the Stage 1 DBPR. For these reasons, the predicted costs for the Stage 2 DBPR do not include costs for operational changes. (Section A.6 and Chapter 7 further explain that this uncertainty may lead to an underestimate in national costs.)

Because UV is an emerging treatment technology, it was not considered an option for most systems for the Stage 1 DBPR. For the Stage 2 DBPR, UV is an advanced disinfection option for all surface water systems and small ground water systems. Adjustments to the compliance forecast to account for use of UV are discussed in Chapter 5 and Appendices A and B.

As indicated in Exhibit A.8, fewer treatment technologies are listed for ground water plants than for surface water plants. As summarized in Appendix B, section B.2.2, the ICR Ground Water Delphi Group concluded that large ground water systems would choose primarily from four treatment technologies: conversion to chloramines, ozone, granular activated carbon - 20-minute contact time (GAC20), or nanofiltration; small ground water systems would also consider UV. The selection of treatment technologies as a function of source water types and small systems' constraints are summarized in Chapter 5 and discussed in detail in the compliance forecasts for surface and ground water plants, as described in Appendices A and B, respectively.

Exhibit A.7 Treatment Technologies Considered for the Stage 1 DBPR in the Stage 1 DBPR RIA and their Stage 2 DBPR EA Equivalent

Stage 1 DBPR RIA Treatment Technologies	**Stage 2 DBPR EA Treatment Technologies**
Chlorine/Chloramine	Adjust Primary Disinfection Move Points of Disinfection with Chloramines
Enhanced Coagulation	Enhanced Coagulation with Chlorine Turbo Coagulation with Chlorine
Enhanced Coagulation with Chloramines	Enhanced Coagulation with Chloramines Turbo Coagulation with Chloramines
Chlorine Dioxide	Chlorine Dioxide with Chlorine Chlorine Dioxide with Chloramines
Ozone with Chloramines	Ozone with Chlorine Ozone with Chloramines
GAC10	GAC10 with Chlorine GAC10 with Chloramines GAC10 + Chlorine Dioxide with Chlorine GAC10 + Chlorine Dioxide with Chloramines GAC10 + UV (Small Systems)
GAC20	GAC20 with Chlorine GAC20 with Chloramines GAC20 + Chlorine Dioxide with Chlorine (Large and Medium Systems) GAC20 + Chlorine Dioxide with Chloramines (Large and Medium Systems) GAC20 + Ozone with Chlorine (Small Systems) GAC20 + Ozone with Chloramines (Small Systems) GAC20 + UV (Small Systems)
Membranes	Microfiltration/Ultrafiltration with Chlorine Microfiltration/Ultrafiltration with Chloramines Integrated Membranes with Chlorine (Surface Water Systems) Integrated Membranes with Chloramines (Surface Water Systems) Nanofiltration with Chlorine (Ground Water Systems) Nanofiltration with Chloramines (Ground Water Systems)

Source: Stage 1 DBPR RIA (USEPA 1998a) for Stage 1 treatment technologies; Federal Advisory Committees Act (FACA) deliberations for Stage 2 treatment technologies (USEPA 2000n).

Exhibit A.8 Aggregated Treatment Technology Categories for Stage 1 DBPR Used for the Stage 2 DBPR EA

Treatment Technology Category	Explanation of Technology for Surface Water Plants	Explanation of Technology for Ground Water Plants
Adjust Primary Disinfectant Dose	*Reduce primary disinfectant dose (usually chlorine)*	*NA*
Enhanced Coagulation/Enhanced Softening	*Increased TOC removal through increased coagulant addition to meet Stage 1 DBPR requirements*	*NA*
Turbo Coagulation	*Increased TOC removal through increased coagulant addition, but higher than that required by enhanced coagulation*	*NA*
Moving Point of Disinfection	*Move point of disinfection downstream to minimize formation of DBPs*	*NA*
Chlorine Dioxide	Chlorine dioxide instead of chlorine for primary disinfection	NA
Ozone	Ozone instead of chlorine for primary disinfection, applied to raw or settled water	Ozone instead of chlorine for primary disinfection, applied to raw or settled water
MF/UF	Microfiltration or ultrafiltration as the particle removal process	NA
GAC10	Granular activated carbon with a 10-minute Empty Bed Contact Time (EBCT)	NA
GAC10 + Advanced Disinfectants	GAC10 + chlorine dioxide (large and medium systems) GAC10 + UV (small systems)	NA
GAC20	Granular activated carbon with a 20-minute EBCT	Granular activated carbon with a 20-minute EBCT
GAC20 + Advanced Disinfectants	GAC20 + UV or ozone	NA
Membranes	Integrated membranes as the particle removal process (MF/UF and nanofiltration)	Nanofiltration alone as the particle removal process

Notes: NA = Not applicable plant type. Italic font indicates that treatment technology was not considered in estimating costs of rule alternatives.

Source: Technology and Cost Document (USEPA 2003o); applicability to ground water systems discussed in Chapter 5 and Appendix B of this EA.

A.3 User Inputs for SWAT Model Runs

This section summarizes the inputs and settings (as entered into the SWAT user interface) used for the Stage 2 DBPR regulatory alternatives. SWAT was also used to support the development of the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). The inputs presented here, however, are specific the Stage 2 DBPR development process. Those specific to the LT2ESWTR are described in the *Economic Analysis for the LT2ESWTR* (USEPA 2003c). A complete listing of the user inputs for each SWAT Run used in the Stage 2 DBPR can be found in the Access databases that contain the results for each run. The compliance scheme, and compliance aggregation method, are also inputs to the SWAT Model and are described in Section A.4.

Average and Maximum Residence Times

SWAT computes DBP concentrations at theoretical locations representing average and maximum residence times in the distribution system. The inputs for the average residence time location (DS Average) and the maximum residence time location (DS Maximum) are based on ICR data from four distribution system residence times reported by the system as follows.

- Distribution System Equivalent (DSE)—a sample point in the distribution system that has a residence time equivalent to a laboratory sample.

- Average 1 and Average 2 (AVG1 and AVG2)—two locations having average residence times in the distribution system, as designated by the system.

- Distribution System Maximum (MAX)—the location having the longest residence time in the distribution system, as designated by the system.

The input for the DS Average is the average of those four residence times. The input for DS Maximum is the highest residence time reported for those four locations.

Flowrate Conditions Used

Three flowrate conditions are available for SWAT execution: 1) flow at time of ICR sampling; 2) average monthly flow for a given ICR period; and 3) plant design flow. All calculations of DBP concentrations were completed using the average monthly flow. All new unit processes “built” by SWAT were sized using the design flow condition.

Inclusion of Biofiltration

All Stage 2 DBPR regulatory evaluations included biofiltration processes for ozone treatment technologies. This assumed that the filters downstream of ozonation would achieve enhanced DBP precursor removal.

Surface Water Treatment Rule Disinfection Requirements

For all regulatory alternatives, the plants must meet, at a minimum, the Surface Water Treatment Rule (SWTR) *Giardia* and virus log removal requirements of 3 and 4 logs, respectively. The “Initial Plant Run” did not have this requirement since it represents pre-Stage 1 or existing conditions. Therefore, all systems are not assumed to be compliant with the SWTR. In other words, if SWAT predicted a plant to achieve lower *Giardia* or virus log removals, the plant was not modified for this run.

Log Removal Credits for Pathogens

Log removal credits for pathogens were based on (1) the recommended credits contained in the *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources* (USEPA 1990), and (2) as recommended by the Microbial Treatment subcommittee of the TWG (Exhibit A.9). *Cryptosporidium* inactivation/removal requirements were not included (they are considered under the LT2ESWTR). If the removal credits used in SWAT are overstated (i.e., the credits are greater than the treatment provides), then the estimates provided would under-specify treatment selection and consequently under-predict national compliance costs and benefits. Likewise, if the removal credits used in SWAT are understated, then the treatment technology selection could be over-specified and both the national compliance costs and benefits over-predicted.

Exhibit A.9 Log Removal Credits Used as Default Values in SWAT

Unit Process	Log Removal Credits (logs)	
	Giardia	**Virus**
Microfiltration/Ultrafiltration	3.0	2.0
Nanofiltration	3.0	2.0
Sedimentation	0.5	1.0
Filtration	2.0	1.0

Source: *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources* (USEPA 1990)

Use of Disinfection Benchmarking

Disinfection benchmarking is the lowest monthly average of microbial inactivation during the disinfection profile period. Benchmarking is used to ensure a plant does not compromise microbial protection when changing treatment technologies. If “Benchmarking OFF” is selected, then SWAT selects disinfectant doses to meet the most stringent of the log removal and/or inactivation requirements set for the regulatory option. If “Benchmarking ON” is selected, SWAT determines the minimum monthly level of log removal plus inactivation for each plant under existing conditions and sets these as the log removal plus inactivation requirements for that plant for all process modifications. If the benchmark is less stringent than the disinfection requirements set for that SWAT run, SWAT will default to the most stringent requirements.

All Stage 2 DBPR regulatory evaluations, as well as the Stage 1 baseline evaluation, were conducted with “Benchmarking ON.” Maximum benchmark levels for *Giardia* and viruses were set at 8.0 and 9.0 logs, respectively. *Cryptosporidium* disinfection was not benchmarked because most systems currently don’t achieve any *Cryptosporidium* inactivation. Using the “Benchmarking ON” option most likely causes an overall higher treatment technology selection estimate. Some systems may use a high dose of oxidant for other reasons (e.g., taste and odor control); the high level of disinfection is a secondary benefit. In the SWAT model, if a plant currently has a high oxidant dose and its DBP estimates are above the user-defined MCLs, then the next treatment technology in the decision tree is selected and the same high level of inactivation corresponding to the annual high oxidant dose must be maintained. (However, in implementation of the DBPR the State may allow lower disinfection for improved DBP control, as long as the level of disinfection is higher than the existing standards.)

Chloramine Conversion Rate

SWAT can evaluate three settings to represent whether treatment plants that initially use free chlorine for secondary or residual disinfection will convert to chloramines.

- All free chlorine plants can convert
- No free chlorine plants can convert
- A specified percentage of free chlorine plants can convert, and are assigned randomly through a Monte Carlo probability function

For regulatory evaluation, 77 percent of free chlorine plants were randomly allowed to convert to chloramines. This was set as the maximum possible conversion rate expected for all free chlorine plants in the United States. This percentage rate was recommended by the TWG during the M-DBP FACA. This maximum national chloramine usage level is intended to incorporate site-specific circumstances and other local factors that would preclude chloramine usage at some plants for reasons other than technical suitability. The maximum chloramine conversion rate was approached only when more stringent regulatory alternatives (i.e., 40/30 Running Annual Average (RAA)) were evaluated.

Use of UV

Adding UV disinfection to a treatment process is an optional step in the SWAT decision tree. Because UV is an emerging treatment technology for drinking water treatment it was not considered a viable option for Stage 1 compliance. However, EPA believes the treatment technology and necessary regulations will be available for systems to use UV to achieve compliance with the Stage 2 DBPR. Therefore, the UV option was “turned off” for the Stage 1 DBPR run and “turned on” for the Stage 2 DBPR runs. (Part III of this Appendix for further discussion on the inclusion of UV for the Stage 2 runs.)

Clearwell Baffling Improvement Rate

For regulatory evaluation, 90 percent of plants were assumed able to make improvements to clearwell baffling. The TWG assumed that a 0.70 value for the clearwell baffling factor (the ratio of the time required for 10 percent of a system’s flow to pass through the clearwell to the theoretical detention time in the clearwell) was a reasonable upper limit for improvements to hydraulic retention through such basins. An analysis of the ICR data on clearwell baffling factors showed that 10 percent of ICR plants had baffling factors at or above 0.70. Therefore, the remaining 90 percent of the plants could improve their clearwell hydraulic regime to attain such a baffling factor. While SWAT allowed 90 percent of the plants to increase the hydraulic retention time performance of clearwells, it did not require plants to do so in evaluating regulatory alternatives. The clearwell baffling factor was considered only when increased disinfection performance was necessary and could be achieved by such measures.

Nanofiltration Performance for Precursors

Nanofiltration performance for precursors was assigned based on ICR Treatment Studies data, representing the median performance of nanofilters for precursor control. The performance and operating parameters were assigned as follows.

- TOC removal = 92 percent
- UVA removal = 87 percent
- Bromide removal = 78 percent
- Molecular weight cutoff = 200 daltons
- Water recovery = 85 percent

GAC10 and GAC20 Regeneration Frequency

When the decision tree program chooses GAC10 or GAC20 as the next feasible treatment technology to achieve compliance, it adopts the following sequence of reactivation frequencies to check for compliance: An initial evaluation with a reactivation frequency of 360 days, followed by reactivation frequencies of 300, 240, 180, 120, and 90 days in that order, until the plant is in compliance. The TWG verified that the cost hierarchy of the compliance decision tree was maintained under this sequence.

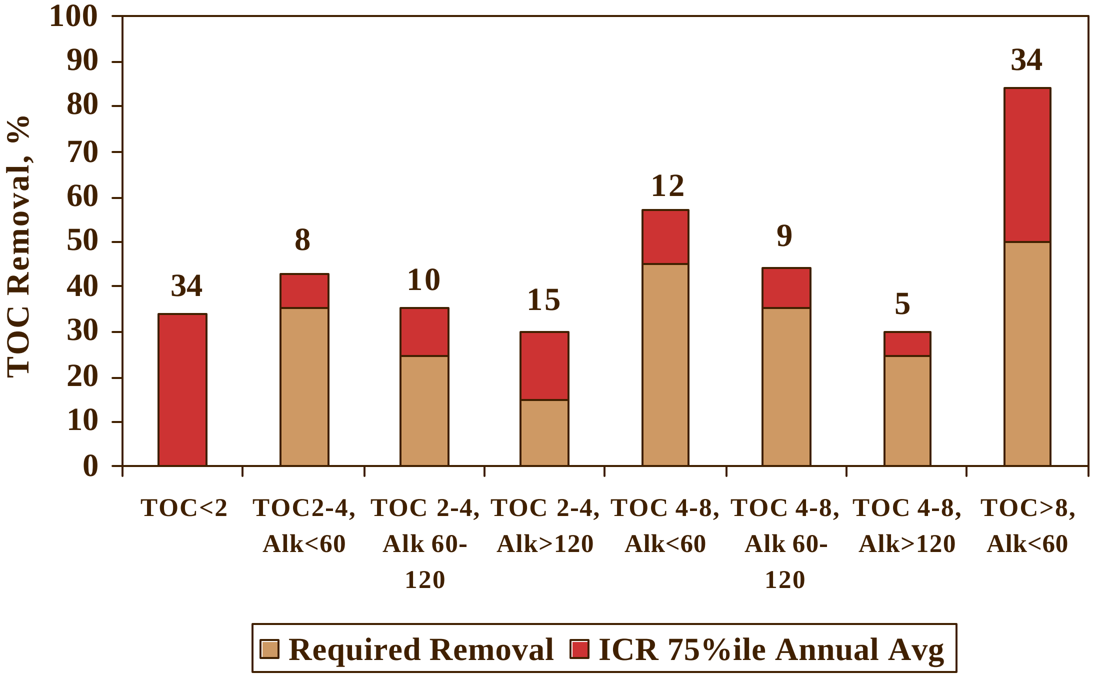
Turbo Coagulation

Turbo coagulation achieves increased TOC removal using coagulant doses higher than those required by enhanced coagulation. A (4x3) matrix of raw water TOC and alkalinity defines the percent TOC removal in SWAT. The default turbo coagulation setting used in SWAT represents the 75th percentile ICR values for a given raw water TOC-alkalinity category (i.e., 25 percent of ICR water treatment plants in a given raw water TOC-alkalinity category achieved TOC removal greater than or equal to the specified level). Exhibit A.10 shows the additional TOC removal achieved with turbo coagulation at these settings.

To determine if turbo coagulation was a viable treatment alternative, the ICR data were analyzed to see if additional TOC removal was possible. For surface water plants with conventional treatment (non-softening plants), the TOC removal was found for each month where available data existed. Each plant was characterized within the Stage 1 DBPR enhanced coagulation matrix for TOC removal, based on the annual average source water alkalinity and TOC. The distribution of annual average TOC removal for ICR plants was determined for each alkalinity and TOC category in the matrix. The median performance of the plants within each of the categories was found to be very close to the TOC removal requirements in the Stage 1 DBPR. Therefore, the ability of such plants to achieve even more TOC reduction by further enhancing their treatment performance was considered a viable treatment alternative.

SWAT did not require any plants to meet the TOC removal performance criteria contained in the turbo coagulation step, but allowed conventional plants to further optimize TOC removal as a means of meeting DBP requirements. The inclusion of the turbo coagulation treatment step contributes to more realistic national compliance costs by reducing the number of plants requiring more advanced, but possibly unnecessary, treatment technologies to meet DBP standards.

Exhibit A.10 Additional Increase in TOC Removal for the Turbo Coagulation Treatment Step



Numbers above bars indicate additional TOC percent removal with Turbo Coagulation

A.4 Model Operation

This section explains how compliance is determined and lists several uncertainties associated with SWAT's compliance determination methodology.

A.4.1 Compliance Determination

Each plant's compliance was determined in one of three ways:

- RAA is the calculated average of all distribution system samples. For SWAT, the RAA was calculated by averaging the SWAT-predicted monthly concentrations at the DS Average location, as described in Section A.3, over the 1-year period.

- Locational Running Annual Average (LRAA) is the average of four quarters of data from each distribution system location. For SWAT, the LRAA was calculated by averaging the

SWAT-predicted monthly concentration at the DS Maximum location, as described in Section A.3, over the 1-year period.

- Single high is the highest concentration of the four distribution system samples collected. For SWAT, the single high value was determined by selecting the maximum of the SWAT-predicted monthly concentrations at the distribution system maximum location.

In addition, SWAT determines compliance for bromate and chlorite. The bromate MCL was determined using an annual average of predicted bromate at the finished water sample point. The chlorite MCL was determined as a single high concentration of chlorite predicted in the finished water.

The M-DBP TWG recommended that a mean 20 percent operational safety margin be used for DBP MCLs (TTHM, HAA5, bromate, and chlorite) when evaluating all regulatory alternatives. This safety margin is consistent with practices in prior DBP regulatory development efforts and is intended to represent the level at which systems typically take some action to ensure consistent compliance with a new drinking water standard. In addition to representing industry practices, the safety margin also is intended to account for year-to-year fluctuations in DBP data (ICR data are limited to one year and might not represent the highest DBP concentrations that occur in a system). There is uncertainty, however, in the concentration below the MCL value at which systems are confident operating (in other words, the safety margin may be more or less in some specific cases). A 25 percent operation safety margin run was also conducted for the Preferred Regulatory Alternative to estimate the impacts of the IDSE. See Chapter 5 for more information.

A.5 Description of WTP Model Calibration Process and Results

The WTP Model was calibrated using observed data to improve its ability to predict the central tendency of the ICR data and to better general national level predictions. The methodology and results of the calibration process can be found in Chapter 8 of the report, *Information Collection Request Data Analysis* (McGuire et al. 2002). It is important to summarize results of the calibration in this economic analysis, however, to help characterize the uncertainties in SWAT (see Section A.6). The remainder of this section summarizes the WTP Model calibration process and presents the results.

A.5.1 Calibration Methodology

Water Quality Parameters that were calibrated: The calibration process focused on the following parameters:

- pH adjustment (in softening and non-softening plants)
- TOC removal (in softening and non-softening plants)
- Free chlorine decay
- Chloramine decay
- THM and HAA formation with free chlorine (in treatment plant and distribution systems)

- THM and HAA formation with chloramines

The Model algorithms were calibrated starting with pH and ending with DBPs since the algorithms in some of the processes in the above list use the results of algorithms for processes preceding them.

Note that calibration was not performed for DBP formation for plants using chlorine dioxide or ozone due to the lack of sufficient data sets. This introduces uncertainty in compliance forecasts for systems using these treatment technologies (see Section A.6 for a summary of uncertainties associated with the SWAT).

Data Set Used for Calibration: Although the ICR database contains data from 350 large surface water treatment plants across the US, only a subset of those records were used for calibrating the WTP Model. The following rules were applied to this subset of ICR plants, which further reduced the number of plants/plant-month records used for the calibration analysis:

1) To avoid seasonal bias, the calibration analysis used the last 12 months of ICR data (i.e., from January to December 1998), instead of all 18 months.

2) Plants using unit processes such as air stripping or process configurations such as mid-stream blending were excluded, since the WTP Model was unable to handle those.

3) Plant-month records with missing water quality or treatment train parameters were excluded from the analysis.

4) Plant-months with predicted finished water alkalinities less than zero were excluded from further consideration (see step 1 of the calibration approach discussed below). A finished water alkalinity of less than zero indicated erroneous chemical dosages (most likely errors with the units). Hence, these plant-months were excluded.

Calibration Approach: The calibration approach is summarized by the following steps:

1) Generate uncalibrated model predictions, which are stored in AUX8 along with the observed data. Plant-months with predicted finished water alkalinity less than zero were eliminated from further consideration.

2) Calculate absolute residuals, i.e., the absolute value of the difference between observed and predicted data for a particular parameter.

3) Exclude observed and predicted data pairs having the highest 10 percent of absolute residuals for the parameter being calibrated from further consideration. This was done to ensure that the extreme outliers in the ICR data didn’t skew the calibration of the WTP Model.

4) Generate scatter plots of predicted versus observed data for a given parameter to identify if calibration adjustments were required. To determine whether a calibration factor was required, a line of best fit forced through the origin was applied to the scatter plot. If the slope of that line was within 5 percent of unity, no calibration factor was applied. If the above was not true, one of the following two calibration adjustments was applied:

(a) Slope-based adjustment: This was applied when the best-fit line not forced through the origin had an intercept close to zero. Calibration was then performed using the best-fit line forced through the origin. If the slope of this line was beyond 5 percent of unity, a multiplicative calibration factor equal to the inverse of this slope was applied to the appropriate WTP algorithm.

(b) Slope and intercept-based adjustment: This was applied when a clear linear relationship existed between the observed and predicted values and the best-fit line not forced through the origin did not have an intercept close to zero. In such cases, there was a clear trend of under-prediction at one end and over-prediction at the other end. The slope and intercept of the best-fit line were then used to calibrate the appropriate WTP algorithm.

Model Performance Evaluation: After the Model was calibrated, its performance was evaluated as follows:

1) The WTP Model was re-run to generate a set of calibrated predictions.

2) Observed and predicted (new) data were queried from AUX8 for the same plant subsets, and scatter plots were constructed. The square of the correlation coefficient (i.e., r^2) was calculated for the scatter plots to assess the predictive performance of the Model. An r^2 value of close to unity indicates a strong correlation between the observed and predicted data, and thus a better predictive performance of the Model.

3) Cumulative distributions of all data observed (without the exclusion of any data pairs as described in step 5 above) were compared to cumulative distributions of predicted data to assess the ability of the Model to predict full-scale treatment performance on a national level.

4) Paired data were analyzed to investigate the Model's correlation with site-specific ICR observations. This was achieved by calculating residuals (i.e., SWAT predicted minus ICR observed value) for paired data for each water quality parameter.

A.5.2 Calibration Results

A summary of the calibration results for all the parameters is presented in Exhibit A.11. The exhibit summarizes:

- The calibration adjustment factor for each parameter (refer to step 5 of "Calibration Approach")

- The r^2 value of the scatter plots after calibration (refer to step 2 of "Model Performance Evaluation")

- The 5th, 50th, and 95th percentile of the actual residuals for each parameter after calibration (refer to step 4 of "Model Performance Evaluation").

Box plots showing distributions of observed and predicted data after calibration (refer to step 3 of "Model Performance Evaluation") are not presented here but are included in chapter 8 of the ICR data analysis book (McGuire et al. 2002).

A.5.3 Discussion of the Calibration Results for each Parameter

pH

Softening plants: An adjustment in the slope and the intercept was required in this case (i.e., $pH_{cal} = (pH_{orig} - 1.86) \div 0.71$). After calibration, the r^2 of the scatter plot increased from 0.33 to 0.37. The slope of the best-fit line, forced through the origin, was within 5 percent of unity. This indicated that the observed and predicted data pairs were more symmetrically distributed around the line with a slope of unity, after calibration.

Non-softening plants: No calibration was required since the slope of the best-fit line, forced through the origin, was very close to unity (i.e., 0.98). The r^2 of the scatter plot was substantially higher than that of the softening plants (i.e., 0.69), indicating a strong correlation between the data pairs.

TOC

Softening plants: A slope adjustment was required in this case (i.e.,$TOC_{cal} = TOC_{orig} \div 0.87$). After the calibration, the r^2 of the scatter plot was 0.58, thus indicating a fairly strong correlation between the data pairs.

Non-softening plants: No calibration was required since the slope of the best-fit line, forced through the origin, for the uncorrected predicted data, was very close to unity. The r^2 of the scatter plot was the highest among all the parameters investigated (i.e., 0.84), indicating a very strong correlation between the data pairs.

A comparison of the distributions of the observed and predicted (after calibration) data (including data from both softening and non-softening plants) indicated that:

- Predicted values at the 75th percentile or below exceeded observed values by only 0.1-0.2 mg/L.

- The Model predictions were generally slightly higher than the observed values.

Free Chlorine

No calibration was required since the slope of the best-fit line, forced through the origin, for the uncorrected predicted data, was within 5 percent of unity. The r^2 of the scatter plot was 0.49, indicating a reasonable correlation between the data pairs.

Exhibit A.11 Summary of Calibration Results

Parameter	Sampling Locations Included in Analysis	Treatment Conditions	Calibration Adjustment	Result with Calibration	Cumulative Distribution of Residuals (Calibrated Results)		
					5th %ile	50th %ile	95th %ile
pH	Any in-plant site but mainly settled, filtered, and finished water	Softening	$pH_{cal} = (pH_{orig} - 1.86) \div 0.71$	Slope = 0.97, $r^2 = 0.37$	-1.8	-0.2	1.6
		Non softening	None	Slope = 0.98, $r^2 = 0.69$	Not reported		
TOC	Any in-plant site but mainly settled, filtered, and finished water	Softening	$TOC_{cal} = TOC_{orig} \div 0.87$	Slope = 0.95, $r^2 = 0.58$	-1.0	0.2	1.2
		Non softening	None	Slope = 1.05, $r^2 = 0.84$	Not reported		
Free Chlorine	Any in-plant site but mainly settled, filtered, and finished water	Plants using free chlorine as primary disinfectant	None	Slope = 0.95, $r^2 = 0.49$	-1.4	0.0	1.8
Chloramine	Any in-plant site but mainly settled, filtered, and finished water	Plants using chloramines within the plant	None	Slope = 0.87, $r^2 = 0.21$	-2.9	0.1	3.0
TTHM: Finished	Finished water	Free chlorine only in plant and distribution system	$TTHM_{cal} = TTHM_{orig} \div 0.77$	Slope = 0.96, $r^2 = 0.50$	Not reported		
TTHM: DS_AVG	Location in distribution system corresponding to average res. time	Free chlorine only in plant and distribution system	$TTHM_{cal} = TTHM_{orig} \div 0.77$	Slope = 1.04, $r^2 = 0.52$	-43	1.7	69
TTHM: DS_AVG	Location in distribution system corresponding to average res. time	Chloramine in distribution system	$TTHM_{Clm} = 0.3 \times TTHM_{cal,\ free\ Cl}$	Slope = 0.99, $r^2 = 0.27$	Not reported		
HAA5: Finished	Finished water	Free chlorine only in plant and distribution system	None	Slope = 0.98, $r^2 = 0.47$	Not reported		

Parameter	**Sampling Locations Included in Analysis**	**Treatment Conditions**	**Calibration Adjustment**	**Result with Calibration**	**Cumulative Distribution of Residuals (Calibrated Results)**		
					5th %ile	50th %ile	95th %ile
HAA5: DS_AVG	Location in distribution system corresponding to average res. time	Free chlorine only in plant and distribution system	None	Slope = 1.00, $r^2 = 0.37$	-30	1.7	55
HAA5: DS_AVG	Location in distribution system corresponding to average res. time	Chloramine in distribution system	$HAA5_{Clm} = 0.35 \times HAA5_{cal,\ free\ Cl}$	Slope = 1.02, $r^2 = 0.27$	Not reported		

Notes: “cal” = calibrated predicted value of a parameter; “orig” = uncalibrated predicted value of a parameter; $TTHM_{Clm}$ = calibrated value of predicted TTHM concentration with chloramines; $HAA5_{Clm}$ = calibrated value of predicted HAA5 concentration with chloramines; $TTHM_{cal,\ free\ Cl}$ = calibrated value of predicted TTHM with free chlorine; $HAA5_{cal,\ free\ Cl}$ = calibrated value of predicted HAA5 with free chlorine

Source: McGuire et al. 2002, Chapter 8

Chloramine

No calibration adjustment was made in this case even though the slope of the best-fit line forced through the origin (for the uncorrected predicted data) was not within 5 percent of unity. The reasons for this are:

- The predicted and observed data were weakly correlated to start with (since $r^2 = 0.21$). Consequently, multiple attempts at calibration failed to produce a desirable improvement.

- The combined effects of the errors in reported dosages of chlorine and ammonia (required for chloramine formation) compounded the errors in the predicted chloramine residual.

- Chloramine residual is not a critical parameter and is rarely used to achieve disinfection credit.

Paired data analysis indicated that a substantial spread in the distribution of the residuals (see Exhibit A.11), although an evaluation of the observed and predicted distributions indicated that the median values matched reasonably.

TTHM

For plants using chlorine in the distribution system, modeled TTHM formation was calibrated using observed ICR data from the finished water location and calculated distribution system average (or RAA). For plants using chloramines, the DBP formation is estimated as a percent of the predicted TTHM in plants using free chlorine. Results from the calibration of TTHM formation under different disinfection scenarios is summarized below:

- TTHM formation at the finished water location when disinfecting with chlorine in the treatment plant and the distribution system: A slope adjustment was required in this case (i.e.,$TTHM_{cal} = TTHM_{orig} \div 0.77$). After the calibration, the r^2 of the scatter plot was 0.50, indicating a reasonable correlation between the data pairs.

- TTHM formation at the DS Average location when disinfecting with chlorine in the treatment plant and the distribution system: The slope adjustment factor of 0.77 (from the TTHM in finished water case described above) was applied to the data set for the DS_AVG location (i.e.,$TTHM_{cal} = TTHM_{orig} \div 0.77$). After the calibration adjustment, the r^2 and the slope of the scatter plot were found to be 0.52 and 1.04 respectively, indicating a reasonable correlation between the data pairs.

- TTHM formation at the DS Average location when disinfecting with chloramine in the distribution system: The calibration analysis for the chloramine condition indicated that TTHM formation with chloramine = 0.30 × TTHM formation with free chlorine.

HAA5

Like TTHM, HAA5 was calibrated based on finished water and RAA results for chlorine plants, and RAA results for chloramine plants. Results from the calibration of HAA5 formation under the following disinfection scenarios is summarized below:

- Chlorine in treatment plant and distribution system (finished water location): The r^2 of the scatter plot for the uncorrected predicted data was marginally lower than that in the case of TTHMs (i.e., 0.47). However, no calibration was required since the slope of the best-fit line forced through the origin (for the uncorrected predicted data), was within 2 percent of unity.

- Chlorine in treatment plant and distribution system (DS_AVG location): The r^2 of the scatter plot for the uncorrected predicted data was marginally lower than that in the case of TTHMs (i.e., 0.37). However, no calibration was required since the slope of the best-fit line, forced through the origin, for the uncorrected predicted data was nearly unity.

- Chloramine in distribution system (DS_AVG location): The calibration analysis for the chloramine condition indicated that HAA5 formation with chloramine = 0.35 × HAA5 formation with free chlorine.

The middle 50 percent of the observed and predicted distributions of both TTHM and HAA5 show a very good match. However, the predicted values beyond the 90th percentile are significantly higher than those of the observed values (approximately 25-30 µg/L higher). There is a progressive increase in disparity at the tails of the two distributions as one moves from pH, to TOC, to chlorine residual, and finally to TTHM or HAA5. Since the parameters at the beginning of this list serve as inputs to the algorithms for TTHM and HAA5 formation, the predictive errors propagate from the pH algorithm to the DBP algorithms. Thus the probability of generating outlier predictions increases accordingly. This coupled with the fact that there are large uncertainties in the distribution system residence time estimates, results in the DBP predictions exhibiting the greatest spread in residuals of all the parameters.

Part II: Evaluation of SWAT Predictions

A.6 Uncertainties in SWAT Compliance Forecasts

EPA has identified 12 areas of uncertainty in SWAT compliance prediction, as listed in Exhibit A.12, that can be grouped into four main categories:

- Uncertainty in ICR observed data, upon which the SWAT model is based

- Uncertainty in predictive equations for DBP formation

- Uncertainty in the SWAT compliance determination

- Uncertainty in SWAT treatment technology selection

There may be others, but EPA believes this list captures the ones that have the largest impact on costs and benefits.

Exhibit A.12 includes information on the potential effect of each source of uncertainty on the cost and benefit estimates. Note that the direction of the potential bias resulting from each uncertainty source (i.e., whether it results in an over- or under-estimate) is the same for both costs and benefits in every case. The direction of the impact of the uncertainty is unknown for a majority of the cases.

Exhibit A.12 Summary of Uncertainties and Their Impact On Costs and Benefits

Uncertainty		Effect on Benefit Estimate			Effect on Cost Estimates		
		Under-estimate	Over-estimate	Unknown Impact	Under-estimate	Over-estimate	Unknown Impact
Uncertainty in ICR Observed Data as SWAT Inputs							
1	There are possible reporting errors during the ICR and the ICR data may not be representative.			X			X
2	The residence times reported for the four ICR distribution system locations may not represent the actual residence times.			X			X
3	A single quarterly DBP sample may not represent average water quality conditions in that quarter. Distribution system samples were not required to be evenly spaced.			X			X
4	Water quality records were not available for all months in the ICR database. These were “filled in” in Aux 8.			X			X
Uncertainty in Predictive Equations for DBP Formation							
5	Generic treatment process configurations were used to represent real ICR plants.			X			X
6	Empirical model equations are based on bench-scale tests and may not represent site-specific plant conditions.			X			X
7	WTP algorithms for predicting DBP occurrence for ClO_2 and Ozone plants were not calibrated using ICR observed data.			X			X
Uncertainty in the SWAT Compliance Determination							
8	The IDSE may impact the maximum residence times and predicted DBP values.	X			X		
9	Compliance determinations are based on plant-level rather than system-level analyses for RAA compliance determinations.	X			X		
10	Some plants that switch from surface water to ground water during certain times of the year can affect RAA and LRAA calculations.		X			X	
Uncertainty in SWAT Treatment Technology Selection							
11	The maximum chloramine conversion rate was set at 77 percent based on best professional judgement. Actual limitations on chloramine use could be lower or higher.			X			X
12	Benchmarking was turned “on” for all Stage 1 and Stage 2 runs, meaning that plants had to maintain their initial level of inactivation when switching disinfectants.		X			X	

A discussion of each of the 15 areas of uncertainty is given in Section A.6.1. Validation of SWAT treatment technology selections as performed during the M-DBP FACA is described in Section A.6.2

EPA has developed an approach to account explicitly for two key areas of uncertainty in the surface water compliance forecast: the potential impacts of the IDSE (# 8), and uncertainty in predictive equations for DBP formation (#'s 5 through 7). Chapter 5 provides details on how these uncertainties are addressed quantitatively in the final compliance forecast estimates.

A.6.1 Discussion of Individual Areas of Uncertainty

Uncertainty in ICR Observed Data as SWAT Inputs

1. Possible reporting errors during the ICR

The are several sources of uncertainty in the DBP data collected under the ICR. The American Water Works Association Research Foundation (AWWARF) has compiled a description of the ICR data collection challenges and ultimate quality of the data in a publication, *Information Collection Rule Data Analysis* (the AWWARF ICR Report) (McGuire et al. 2002). Data quality controls were developed by a group of industry experts and strictly enforced; thus, EPA believes that the data quality in the ICR database is very high.

One key area of uncertainty that is addressed in the AWWARF ICR Report relates to the representativeness of all data collected during the ICR. Weather and rainfall during the ICR sampling period were compared to historical data to make this assessment (see Chapter 3, section 3.8 for additional data on weather and rainfall patterns). On a nationwide basis, 1998 was hotter and wetter than normal, although several mid-Atlantic states experienced severe droughts during the summer.

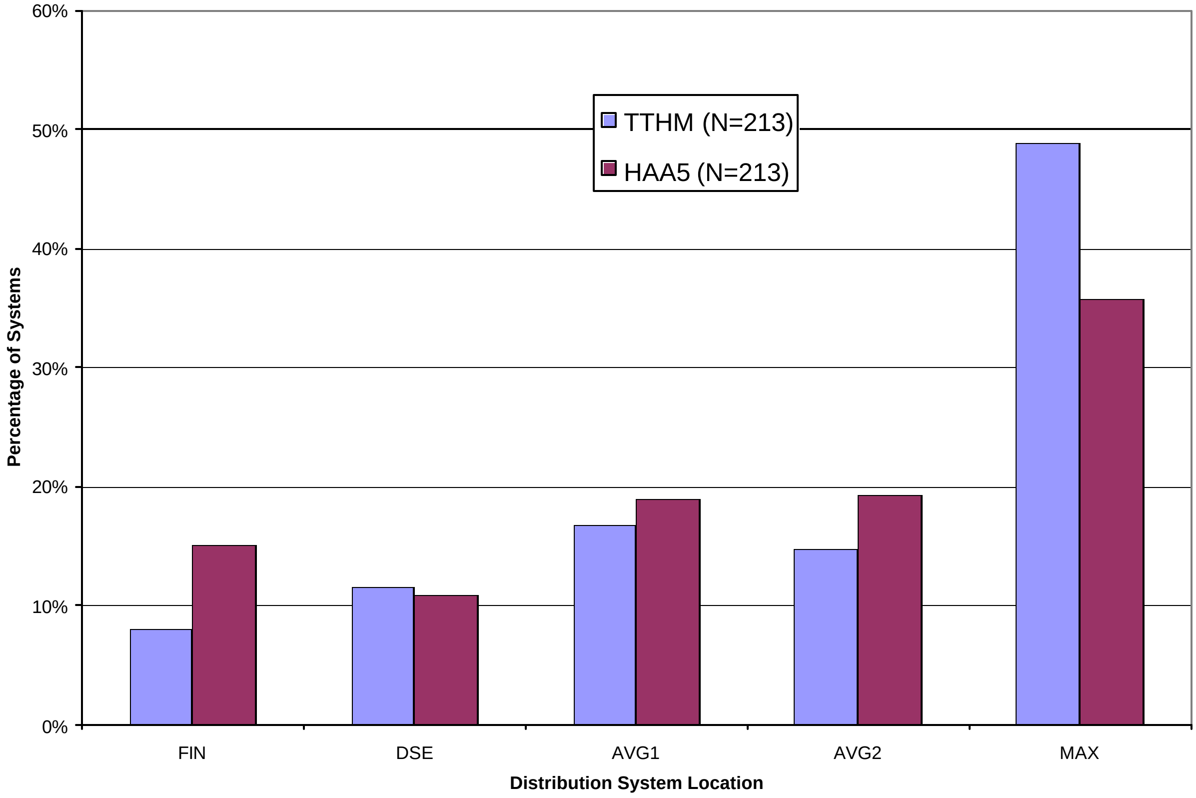
It is unknown how year-to-year variability in source water quality will affect estimated DBP occurrence. The year of data collection (1998) could represent a worst-case, best-case, or typical year depending on water-quality trends for a given plant. It is likely that some plants may experience higher DBP occurrence in future years than what is represented in the ICR database.

2. Uncertainty in the residence time reported at the four ICR distribution system locations

The accuracy of residence time estimates for ICR distribution system sample locations depends on operator experience with the system and the extent to which distribution system modeling or tracer studies have been conducted. Moreover, residence time fluctuates at any given location in the distribution system, and the ICR sample may not represent the typical or average residence time at that location. Because modeled DBP formation (particularly TTHM formation) is highly dependent on the residence time, uncertainty in residence time inputs would result in inaccurate estimates of DBP concentration by the WTP Model.

There is also reason to suspect that the uncertainty in the maximum residence time input in SWAT is greater than the uncertainty in the average residence time input in SWAT. As explained in Section A.3, the average residence time in the SWAT model is based on the mean of the four distribution system residence times reported in the ICR (for the DSE, AVE1, AVE2, and MAX locations). The maximum residence time is the largest residence time reported (usually at the MAX location). The MAX residence times reported in the ICR have already been shown in the Occurrence Document (USEPA 2003h) not to be predictive of the highest DBP levels. Therefore, they may not, in fact, represent the maximum residence time in the distribution system. Exhibit A.13 shows that only 53 percent of ICR plants have the highest TTHM LRAA concentration occurring at the maximum residence time monitoring site. The highest HAA5 LRAA occurred at the maximum residence time monitoring site in only 41 percent of the plants.

Exhibit A.13 Percentage of Highest TTHM or HAA5 Value Occurring at a Given Location



Source: ICR data analysis. Detailed source information provided in the Stage 2 DBPR Occurrence Document (USEPA 2003h).

3. *Uncertainty that a single quarterly sample represents average water quality conditions in that quarter*

ICR quarterly samples were not necessarily collected at evenly spaced intervals. (A minimum of two months was required between quarterly samples; however, samples were not required to be taken approximately 90 days apart, as required in the Stage 2 DBPR.) Thus, a single sample may not be representative of that quarter, especially if the seasonal influence is strong.

4. Water quality records were "filled in" in Aux 1 for missing months

Missing records in the ICR resulted in fewer plant-months being estimated by SWAT. In order to increase the number of data points available as input to SWAT, missing values were estimated based on the average of values for the other months. Influent pH, hardness, alkalinity, and ammonia levels were among the parameters that were "filled in" (see Section A.2.2 for more information on how plants were screened and how some missing data were "filled in" in AUX8).

Uncertainty in Predictive Equations for DBP Formation

5. Generic treatment process configurations were used to represent real ICR plants

The WTP Model uses generic treatment process configurations to represent real ICR plants. For example, it represents a conventional treatment process train using a specific configuration of the pertinent unit processes. However, ICR plants employing conventional treatment could have a slightly different configuration from the generic conventional treatment plant used by the WTP Model.

6. Empirical model equations may not represent site specific plant conditions

The WTP Model uses empirical equations (based mainly on bench-scale tests) to predict DBP concentrations. However, it does not take into account site-specific factors such as non-uniform flow within a plant, actions of microbes, etc. As a result, the predicted finished water DBP concentration is likely to be different from the ICR observed data.

7. WTP algorithms for predicting DBP occurrence for ClO_2 and Ozone plants were not calibrated using ICR observed data.

There were not enough data on plants using chlorine dioxide or ozone disinfection in the ICR to conduct an appropriate calibration of the SWAT model for these parameters. The model may be inaccurately predicting the formation of DBPs in plants using these treatment technologies. If the model over-predicts the DBP reduction in these types of plants, the treatment technology selection may be biased in favor of selecting these plants. If the model under-predicts the DBP reduction in these plants, the treatment technology selection would be biased in favor of higher-performing treatment technologies, such as UV for chlorine dioxide plants, or GAC and membrane treatment technologies for both chorine dioxide and ozone plants. However, the direction of this bias is not known.

Note that EPA explicitly accounts for uncertainty in SWAT predictive equations (uncertainties 5 through 7) by using an alternative approach to estimate the percent of plants changing treatment technology. The alternative approach is presented in Chapter 5. The ways in which the results from the alternative approach are incorporated into the Stage 2 benefit and cost models are discussed in Chapters 6 and 7 respectively.

Uncertainty in the SWAT Compliance Determination

8. Effects of the Initial Distribution System Evaluation on the compliance forecast

The purpose of the IDSE is to identify compliance monitoring sites that are representative of high TTHM and HAA5 concentrations in the distribution system. The IDSE may result in systems finding sites with higher residence times and, thus, higher TTHM and HAA5 concentrations than predicted by

SWAT. The IDSE could ultimately result in more systems making treatment technology changes than estimated by SWAT. A discussion of how EPA accounts for the uncertainty in the impacts of the IDSE is provided in Chapter 5.

The likelihood of finding a site with higher TTHM and HAA5 concentrations depends on many system-specific factors. First, the overall variability of DBP levels affects whether systems will find higher DBP levels at a new site. This variability is influenced by the source water type (surface water versus ground water) and the type of disinfectant used in the distribution system. Analysis of the ICR data has shown that systems employing chloramines as the distribution system disinfectant have more stable DBPs that chloramine systems.

Second, the configuration of the distribution system will affect the likelihood of find a new site with higher DBP levels. Distribution systems that are non-linear, which including looping and circuitous routes to establish new connections instead of extension of the nearest line, make finding the highest site difficult. In addition, systems with multiple storage facilities and booster disinfection pumping stations may find site with higher residence times during the IDSE. This is more likely to be an issue with large system than with small systems.

Finally, the technical resources employed during the ICR and Stage 1 selection of monitoring sites may help to eliminate the likelihood of finding a higher site. Any system that has extensive information of residual data, DBP data, employs hydraulic models, or has employed tracer studies should have a better idea of their maximum residence time sites.

9. Compliance determinations are based on plant-level rather than system-level analysis (Stage 1 only).

Stage 1 requires utilities to sample from a certain number of distribution system monitoring locations for each plant in their distribution system. The required number of monitoring locations varies by source water type and system size (e.g., 4 monitoring locations are required for large surface water systems). Although monitoring requirements are specified on a per-plant basis, compliance with Stage 1 MCLs is based on system-wide TTHM and HAA5 monitoring results. Because not all plants in a given system were available for SWAT modeling, SWAT-predicted DBP results for each plant are evaluated separately to determine regulatory compliance.

In systems having multiple plants, high DBP results from one plant could be averaged with low DBP results from other plants to produce a system-level RAA that is below the MCL, even if the one plant would exceed the MCL if evaluated alone. For example, say that plant A is a surface water plant with a TTHM RAA of 85 μg/L. Plants B and C are ground water plants with much lower TTHM RAA's of 40 and 45 μg/L respectively. Assuming that each plant had an equal number of DBP monitoring sites and samples, the system-wide RAA would be (85+40+45) /3 = 56.6 μg/L. Since SWAT evaluates compliance for each plant separately, SWAT could potentially predict that a plant needed to change treatment technology when in fact, it is part of a system that is in compliance.

A potential overestimate of the percentage of plants changing treatment technology affects the compliance predictions for the Stage 1 Baseline and Alternative 3 (40/30 RAA). The Unadjusted Preferred Alternative, Alternative 1 (80/60 LRAA with Bromate of 10 ug/L), and Alternative 2 (80/60 single highest) are not affected because compliance with the MCLs is based on sample results from each location individually. If this phenomenon causes the Stage 1 predictions to be overestimated but not the Stage 2 predictions, there could be an underestimation of the incremental costs and benefits of Stage 2.

10. The Effect of Switching From Surface Water to Ground Water on Compliance Determination

Some ICR plants reportedly switch from surface to ground water sources during different times of the year. DBP results for the ground water use periods were not included in SWAT. Switching from a surface to a ground water source would most likely decrease TTHM and HAA5 formation and would impact RAA and LRAA compliance calculations. Not accounting for ground water use periods could result in an over-prediction in the compliance forecast predicted by SWAT.

Uncertainty in SWAT Treatment Technology Selection

11. Setting the Maximum Chloramine Conversion Rate at 77 Percent

The rate of 77 percent was assumed to be the maximum percentage of systems in the United States that would be able to convert to chloramines. This rate was set by the TWG in order to accommodate plants that may not be able to use chloramines due to site-specific circumstances or local factors other than technical suitability. This rate may be too high or too low, and represents an unknown impact on the SWAT estimates.

12. Benchmarking was used for all Stage 1 and Stage 2 Runs

Plants were assumed to maintain their initial level of pathogen inactivation when switching disinfectants. The disinfectant level may be set high for reasons other than disinfection, such as taste and odor control. Forcing plants to maintain their disinfectant levels could lead to selection of higher-performing treatment technologies in order to avoid DBP non-compliance. It is possible that the State would allow a system to lower its disinfectant levels to avoid higher DBPs, provided that the disinfectant level still meets existing standards.

A.6.2 Validation of SWAT Treatment Technology Selection Results

To validate the reasonableness of the SWAT treatment technology selection methodology, including the decision tree, the TWG compared two independent analyses of treatment technology forecasts to SWAT's pre-Stage 2 (post-Stage 1) DBPR predictions.[5] The two independent analyses are referred to as the "Delphi Poll" and the "Utility Poll" and are described below. A discussion of results follows.

ICR Surface Water Expert Poll (Delphi Poll)

The TWG conducted an expert, or "Delphi," poll to obtain Stage 1 DBPR impact estimates, based on technical expertise. Experts were provided with detailed water quality and treatment process characteristics from the AUX1 database for all ICR plants that appeared not to meet the MCLs for the Stage 1 DBPR (based on the ICR data, assuming a 20 percent safety margin for compliance). The experts then reviewed each plant to determine the most likely treatment technology choice to meet the Stage 1 DBPR. They were also asked to choose the least-cost treatment technology option. If an expert had knowledge about a specific plant that would lead him or her to choose a treatment technology other than the least-cost, the expert was asked to identify that treatment technology and the reasons for the choice. The results were collected from the experts, summarized, and presented to the M-DBP FACA (USEPA 2000n, TWG Presentation to FACA Committee, March 29, 2000).

ICR Surface Water Industry Poll (Utility Poll)

The industry poll was developed by the AWWA and served a similar role as the expert poll. It compared SWAT results to the Stage 1 DBPR impacts anticipated by industry representatives. In this process, AWWA asked ICR systems to identify the treatment technology they were planning to implement in response to the Stage 1 DBPR. The summarized results were presented to the M-DBP FACA and compared with the other predictions (USEPA 2000n).

Results

Exhibit A.14 compares the treatment technology selection forecasts predicted by SWAT, the Delphi poll (both expected and least-cost results), and the utility poll. In general, the distributions of Post-Stage 1 treatment technologies-in-place predicted by the polls and by SWAT are in good agreement with each other. Relative to the two polls, SWAT does not significantly over-predict or under-predict the expected prevalence of any treatment technology following the implementation of the Stage 1 rule. Based on these comparisons, the M-DBP FACA determined that SWAT was sufficiently reliable to serve as the basis for Stage 2 treatment technology selection forecasts and relied upon SWAT outputs to compare and evaluate regulatory options during its deliberations.

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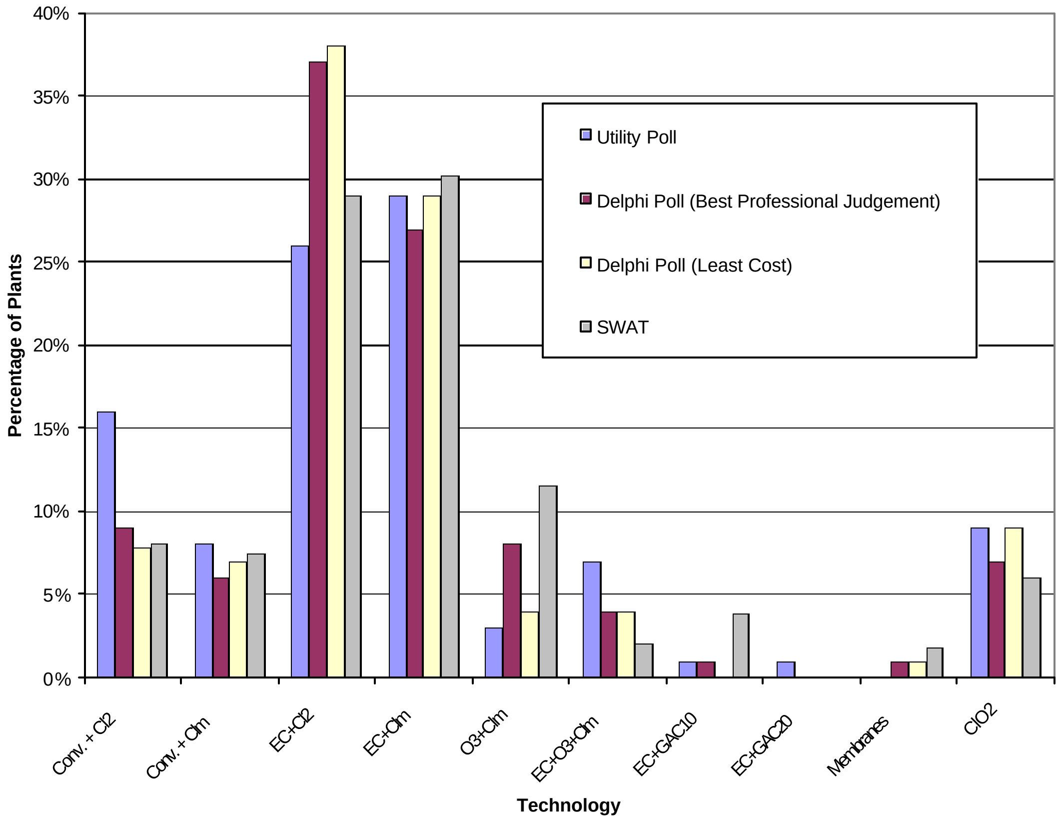
[5] Although validation of Post-Stage 2 results would have been preferable, the validation was done for post-Stage 1 because, at this time of this analysis, there were many potential Stage 2 DBPR regulatory alternatives still being evaluated. Performing the independent analyses for several compliance alternatives was considered by the TWG to be too time intensive.

Exhibit A.14 Comparison of Predicted Post-Stage 1 Treatment Technologies-in-Place



Part III: Compliance Forecasts

To estimate total benefits and costs of the rule, accurate forecasting of the compliance of surface water systems with the Stage 2 DBPR is critical. The compliance forecasts for large surface water systems were derived from ICR data using SWAT. Comprehensive data on operational parameters and water quality, similar to those gathered for large systems under the ICR, were not available for medium and small systems. Because the quality of the source water and the operational capabilities of medium and small systems were anticipated to differ from those of large systems, a detailed evaluation was performed to accurately estimate impacts of the Stage 2 DBPR on medium and small systems. A Non-ICR Subgroup of the TWG for the Microbial-Disinfection Byproducts Advisory Committee (the Subgroup) was charged with understanding the nature of medium and small systems and developing methodologies for further analysis. Detailed descriptions of the methodologies used in developing compliance forecasts for each system size category are provided in the latter sections of this appendix.

A.7 SWAT-based Compliance Forecasts for Large Surface Water Systems

Converting SWAT Results to the "Screening" Database

The compliance forecasts for large surface water systems were derived primarily using SWAT. Plant-level results from SWAT were converted to a "screening" database using a SAS program developed during the M-DBP FACA deliberations. The SAS screening program compiled individual plant results and makes adjustments based on knowledge of specific system practices. It also removed plants making minor treatment technology changes (enhanced coagulation, enhanced softening, moving point of chlorination, adjusting chlorine dose) because these are all implemented during Stage 1, so there is no change from Stage 1 to Stage 2.

The SWAT screening database provides three primary outputs: DBP Exposures, Treatment Technology Selection Forecasts, and Ending Treatment Technologies. DBP Exposures provides the predicted values of TTHM, HAA5, chlorite, and bromate for each rule option being examined. Treatment Technology Selection describes the distribution of treatment technologies only for those plants predicted to change to chloramine or an advanced treatment technology. Ending Treatment Technologies predicts the percentages of all plants using each type of treatment technology after the rule option is implemented. (The Treatment Technology Selection cannot be used for this purpose as some plants not making treatment technology changes already use advanced treatment technologies.) Only the Treatment Technology Selection results are presented below. Ending Treatment Technology results are presented in Appendix C and DBP Exposures are presented in Chapter 5.

Adjustments for the Stage 1 Baseline

SWAT cannot take compliance with the Stage 1 DBPR into account when predicting compliance forecasts for Stage 2. Hence, treatment technology shifts from Stage 1 to Stage 2 are estimated by subtracting the treatment technology shift between pre-Stage 1 and Stage 1 from the treatment technology shift between pre-Stage 1 and Stage 2. Different treatment technologies, however, were assumed to be available to meet the regulatory requirements of the Stage 1 and Stage 2 DBPRs. UV was not a proven disinfectant for *Cryptosporidium*, *Giardia*, or viruses at the time of the ICR or when plants were expected to make treatment decisions to meet Stage 1 DBPR requirements. EPA now considers UV a viable alternative disinfectant to chlorine to meet Stage 2 DBPR regulatory alternatives.

Because UV is considered an available treatment technology for the Stage 2 DBPR, some plants are predicted to use UV instead of more expensive treatment technologies such as ozone, microfiltration/ultrafiltration (MF/UF), or GAC. If the compliance forecasts for the Stage 1 and Stage 2 DBPRs were used independently, more expensive treatment technologies installed to meet Stage 1 would effectively be removed from the plant to install less expensive treatment technologies under Stage 2. This is not realistic. In reality, systems that added treatment technology for Stage 1 may not need to add another treatment technology for Stage 2.

To account for the effect of UV, a less expensive treatment technology, becoming available after Stage 1 came into effect, EPA used the following approach to adjust the Stage 2 compliance forecast:

- Model Stage 1 without UV. Model the Stage 2 regulatory alternatives with and without UV as an available treatment technology.

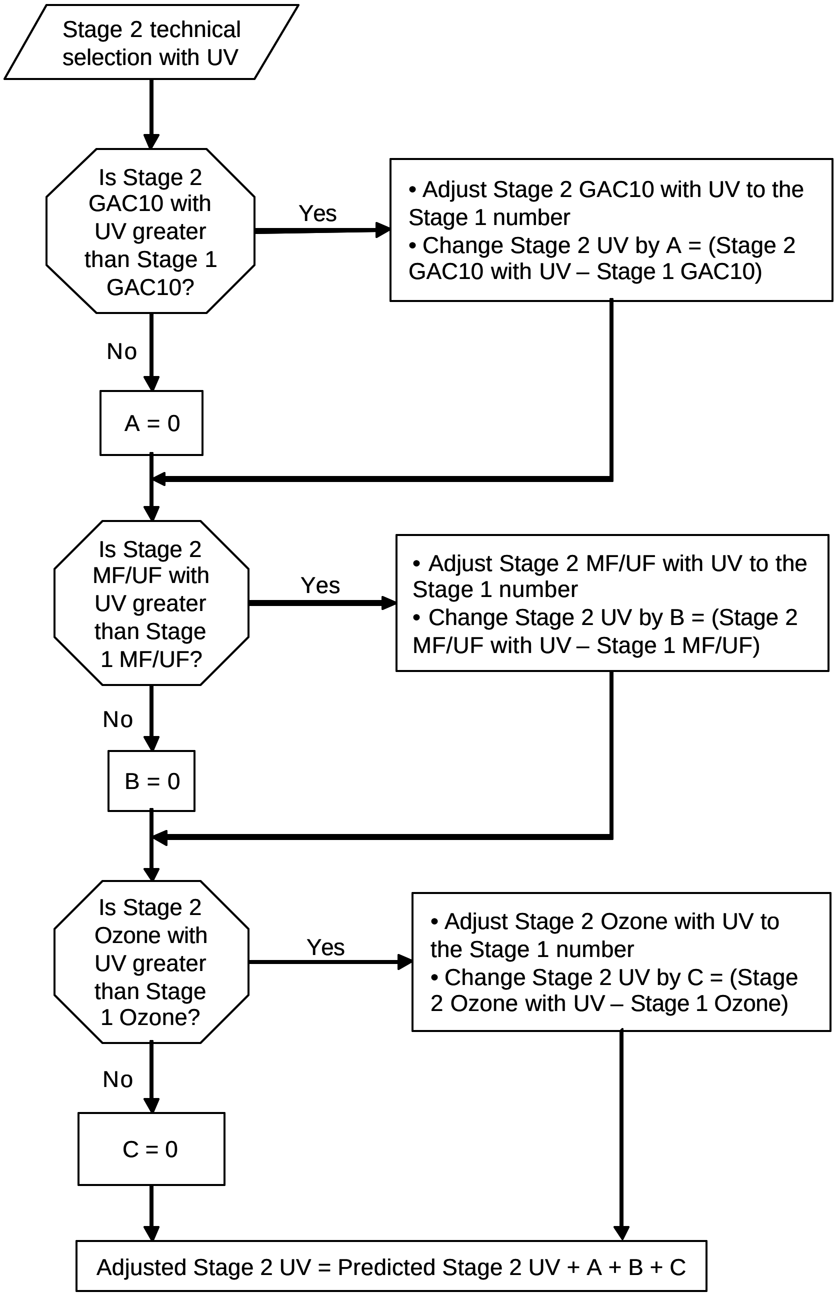
- Use the Stage 1 DBPR estimates of ozone, MF/UF, and GAC10 usage if they are higher than the Stage 2 results with UV, since systems are predicted to use these treatment technologies for Stage 1 and will not remove them to install UV.

- Decrease the percentage of plants using UV accordingly.

- To obtain the percentage of plants adding chloramine, use the percentage from the Stage 2 run without UV as an available treatment technology. This percentage decreases when UV is an available treatment technology. Since the percentage of plants changing to UV to comply with Stage 2 has been reduce, the estimate from the Stage 2 DBPR without the UV option is taken for the adjusted option.

These steps are displayed in Exhibit A.15a, and an example calculation for the Unadjusted Preferred Alternative is presented in Exhibit A.15b. Final adjusted compliance forecasts for large surface water systems are presented in Exhibit A.16.

Exhibit A.15a Adjustments to Stage 2 Treatment Technology Selection Forecasts for the Stage 1 Baseline



Note: A = Adjustment to Stage 2/UV percentage for GAC10.
B = Adjustment to Stage 2/UV percentage for MF/UF.
C = Adjustment to Stage 2/UV percentage for Ozone.

Exhibit A.15b Illustration of the Adjustment Steps to Stage 2 Compliance Forecasts for the Stage 1 Baseline

Step 1: GAC10 Adjustment

	Switch to CLM	Switch to CLM Only	Chlorine Dioxide	UV	Ozone	MF/UF	GAC10	GAC10 + Advanced Disinfectant	GAC20	GAC20 + Advanced Disinfectant	Membranes
Stage 1 DBPR	A1	B1	C1	D1	E1	F1	G1	H1	I1	J1	K1
Option w/o UV	A2	B2	C2	D2	E2	F2	G2	H2	I2	J2	K2
Option w/ UV	A3	B3	C3	D3	E3	F3	G3	H3	I3	J3	K3
Step 1 Subtotal	A4 = A3	B4 = B3	C4 = C3	D4 = If G1>G3 Then D3-(G1-G3) Else D3	E4 = E3	F4 = F3	G4 = If G1>G3 Then G1 Else G3	H4 = H3	I4 = I3	J4 = J3	K4 = K3

Step 2: MF/UF Adjustment

	Switch to CLM	Switch to CLM Only	Chlorine Dioxide	UV	Ozone	MF/UF	GAC10	GAC10 + Advanced Disinfectant	GAC20	GAC20 + Advanced Disinfectant	Membranes
Stage 1 DBPR	A1	B1	C1	D1	E1	F1	G1	H1	I1	J1	K1
Option w/o UV	A2	B2	C2	D2	E2	F2	G2	H2	I2	J2	K2
Option w/ UV	A3	B3	C3	D3	E3	F3	G3	H3	I3	J3	K3
Step 2 Subtotal	A4	B4	C4	D5 = If F1>F3 Then D4-(F1-F3) Else D4	E4	F5 = If F1>F3 Then F1 Else F4	G4	H4	I4	J4	K4

Step 3: Ozone Adjustment

	Switch to CLM	Switch to CLM Only	Chlorine Dioxide	UV	Ozone	MF/UF	GAC10	GAC10 + Advanced Disinfectant	GAC20	GAC20 + Advanced Disinfectant	Membranes
Stage 1 DBPR	A1	B1	C1	D1	E1	F1	G1	H1	I1	J1	K1
Option w/o UV	A2	B2	C2	D2	E2	F2	G2	H2	I2	J2	K2
Option w/ UV	A3	B3	C3	D3	E3	F3	G3	H3	I3	J3	K3
Step 3 Subtotal	A4	B4	C4	D6 = If E1>E3 Then D5-(E1-E3) Else D5	E5 = If E1>E3 Then E1 Else E4	F5	G4	H4	I4	J4	K4

Step 4: CLM Adjustment

	Switch to CLM	Switch to CLM Only	Chlorine Dioxide	UV	Ozone	MF/UF	GAC10	GAC10 + Advanced Disinfectant	GAC20	GAC20 + Advanced Disinfectant	Membranes
Stage 1 DBPR	A1	B1	C1	D1	E1	F1	G1	H1	I1	J1	K1
Option w/o UV	A2	B2	C2	D2	E2	F2	G2	H2	I2	J2	K2
Option w/ UV	A3	B3	C3	D3	E3	F3	G3	H3	I3	J3	K3
Step 3 Subtotal	A5 = If A2>A3 Then A2 Else A3	B4	C4	D6	E5	F5	G4	H4	I4	J4	K4

Exhibit A.16 Final Adjusted Compliance Forecasts for Surface Water Systems Serving > 10,000 (Percent of Systems Changing Treatment Technologies from the Pre-Stage 1 Baseline to Stage 2)

Stage 2 Preferred Alternative, 20 Percent Safety Margin: 80 µg/L TTHM as LRAA, 60 µg/L HAA5 as LRAA, Bromate 10 µg/L

	Switch to CLM	Switch to CLM only	Chlorine Dioxide	UV	Ozone	MF/UF	GAC10	GAC10 + Advanced Disinfectant	GAC20	GAC20 + Advanced Disinfectant	Membranes
Stage 1 DBPR	13.92%	78.39%	5.13%	0.00%	10.99%	1.83%	1.83%	1.10%	0.37%	0.00%	0.37%
Stage 2 Option w/o UV	19.05%	76.19%	5.49%	0.00%	11.72%	1.83%	1.83%	1.83%	0.73%	0.00%	0.37%
Stage 2 Option w/UV	18.68%	76.19%	5.49%	7.33%	6.23%	0.37%	1.47%	1.83%	0.73%	0.00%	0.37%
Stage 2 Option adjusted	19.05%	76.19%	5.49%	0.75%	10.99%	1.83%	1.83%	1.83%	0.73%	0.00%	0.37%

Stage 2 Preferred Alternative, 25 Percent Safety Margin: 80 µg/L TTHM as LRAA, 60 µg/L HAA5 as LRAA, Bromate 10 µg/L

	Switch to CLM	Switch to CLM only	Chlorine Dioxide	UV	Ozone	MF/UF	GAC10	GAC10 + Advanced Disinfectant	GAC20	GAC20 + Advanced Disinfectant	Membranes
Stage 1 DBPR	13.92%	78.39%	5.13%	0.00%	10.99%	1.83%	1.83%	1.10%	0.37%	0.00%	0.37%
Stage 2 Option w/o UV	22.34%	72.53%	4.76%	15.02%	2.56%	1.83%	2.56%	0.37%	0.37%	0.00%	0.00%
Stage 2 Option w/UV	21.25%	72.53%	4.76%	8.79%	8.06%	0.73%	1.83%	2.56%	0.37%	0.00%	0.37%
Stage 2 Option adjusted	22.34%	72.53%	5.13%	4.40%	10.99%	1.83%	1.83%	2.56%	0.37%	0.00%	0.37%

Stage 2 Rule Alternative 1: 80 µg/L TTHM as LRAA, 60 µg/L HAA5 as LRAA, Bromate 5 µg/L

	Switch to CLM	Switch to CLM only	Chlorine Dioxide	UV	Ozone	MF/UF	GAC10	GAC10 + Advanced Disinfectant	GAC20	GAC20 + Advanced Disinfectant	Membranes
Stage 1 DBPR	13.92%	78.39%	5.13%	0.00%	10.99%	1.83%	1.83%	1.10%	0.37%	0.00%	0.37%
Stage 2 Option w/o UV	19.05%	75.82%	5.49%	0.00%	10.99%	2.20%	1.83%	1.47%	0.73%	0.00%	1.47%
Stage 2 Option w/UV	18.68%	75.82%	5.49%	6.96%	6.23%	0.37%	1.47%	1.47%	0.73%	0.00%	1.47%
Stage 2 Option adjusted	19.05%	75.82%	5.49%	0.37%	10.99%	1.83%	1.83%	1.47%	0.73%	0.00%	1.47%

Stage 2 Rule Alternative 2: 80 µg/L TTHM as Single Highest, 60 µg/L HAA5 as Single Highest, Bromate 10 µg/L

	Switch to CLM	Switch to CLM only	Chlorine Dioxide	UV	Ozone	MF/UF	GAC10	GAC10 + Advanced Disinfectant	GAC20	GAC20 + Advanced Disinfectant	Membranes
Stage 1 DBPR	13.92%	78.39%	5.13%	0.00%	10.99%	1.83%	1.83%	1.10%	0.37%	0.00%	0.37%
Stage 2 Option w/o UV	28.94%	54.58%	10.62%	0.00%	12.45%	2.56%	10.62%	6.59%	1.10%	0.37%	1.10%
Stage 2 Option w/UV	29.30%	54.58%	10.62%	5.49%	8.79%	1.47%	10.26%	6.23%	1.10%	0.37%	1.10%
Stage 2 Option adjusted	28.94%	54.58%	10.62%	2.93%	10.99%	1.83%	10.26%	6.23%	1.10%	0.37%	1.10%

Stage 2 Rule Alternative 3: 40 µg/L TTHM as RAA, 30 µg/L HAA5 as RAA, Bromate 10 µg/L

	Switch to CLM	Switch to CLM only	Chlorine Dioxide	UV	Ozone	MF/UF	GAC10	GAC10 + Advanced Disinfectant	GAC20	GAC20 + Advanced Disinfectant	Membranes
Stage 1 DBPR	13.92%	78.39%	5.13%	0.00%	10.99%	1.83%	1.83%	1.10%	0.37%	0.00%	0.37%
Stage 2 Option w/o UV	29.67%	42.12%	13.19%	0.00%	12.45%	4.03%	17.58%	7.69%	1.47%	0.37%	1.10%
Stage 2 Option w/UV	30.77%	42.12%	13.19%	7.33%	6.96%	2.93%	17.22%	7.33%	1.47%	0.37%	1.10%
Stage 2 Option adjusted	29.67%	42.12%	13.19%	3.30%	10.99%	2.93%	17.22%	7.33%	1.47%	0.37%	1.10%

A.8 SWAT based Compliance Forecasts for Medium Surface Water Systems

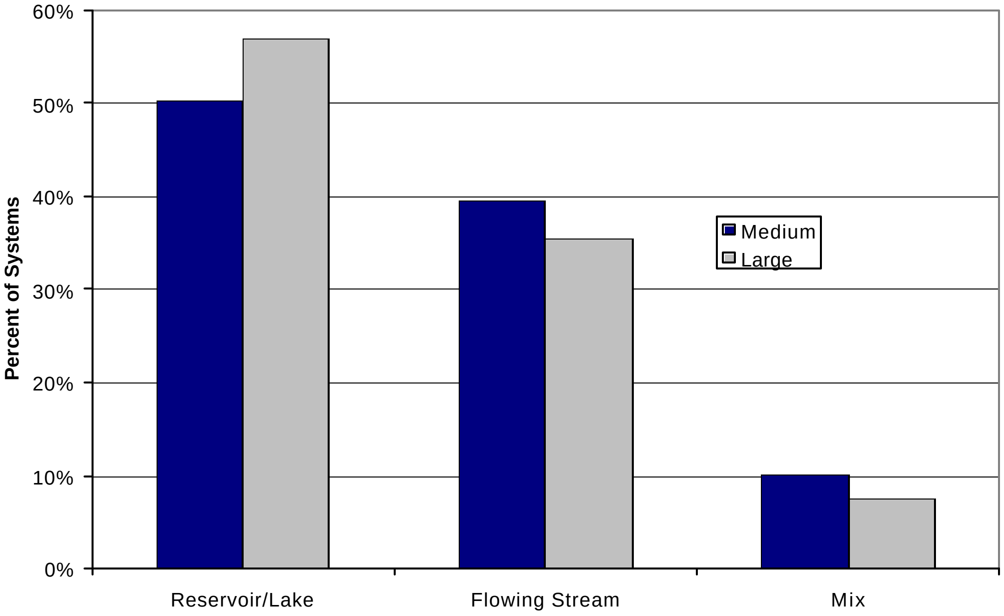
After a detailed review of available data, the TWG Small/Medium Systems Subgroup concluded that the influent water quality, treatment characterization, and DBP occurrence for medium surface water plants are similar to large surface water plants. This section describes and examines the data that support this conclusion.

The Water Utility Database (WATER:\STATS [AWWA 2000]), developed by AWWA, was used in this analysis. Its data were collected during a 1996 survey of approximately 900 primarily medium and large systems. This database includes information on influent water quality, treatment, and the occurrence of DBPs in finished water for all system sizes.

Exhibit A.17 compares source water types for medium and large surface water systems. Further information is provided in the Stage 2 DBPR Occurrence Document (USEPA 2003h). Given the similarities in the distribution of large and medium systems using each type of surface water, the Subgroup expected to find only minor differences in source water quality. Exhibits A.18 through A.20, which compare source water TOC, turbidity, and alkalinity, respectively, confirm this hypothesis.

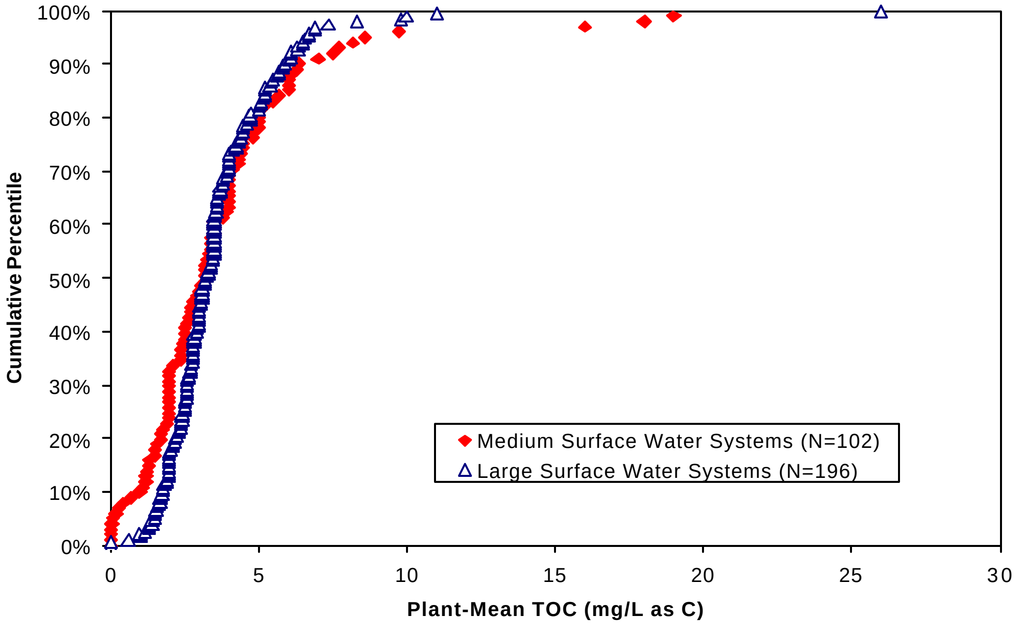
Exhibit A.21 shows that the disinfectant usage of medium and large systems is similar. Exhibits A.22 and A.23 show that the distribution of TTHM values was similar between large and medium systems for measurements at finished water and distribution system sampling points.

Exhibit A.17 Percentages of Medium and Large Surface Water Systems Using Different Source Water Types



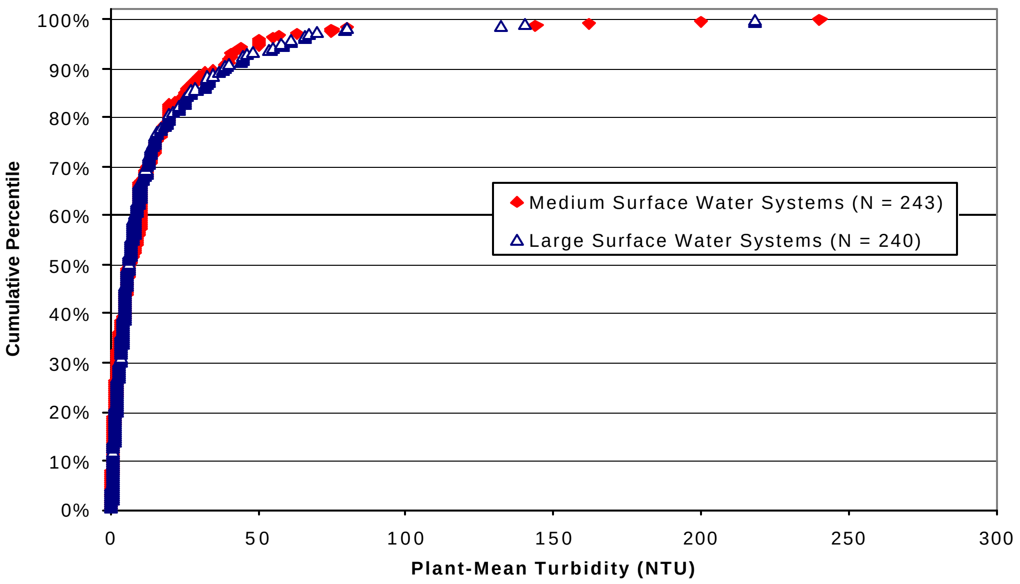
Source: WATER:\STATS (AWWA 2000).

Exhibit A.18 Comparison of Source Water TOC for Medium and Large Surface Water Systems



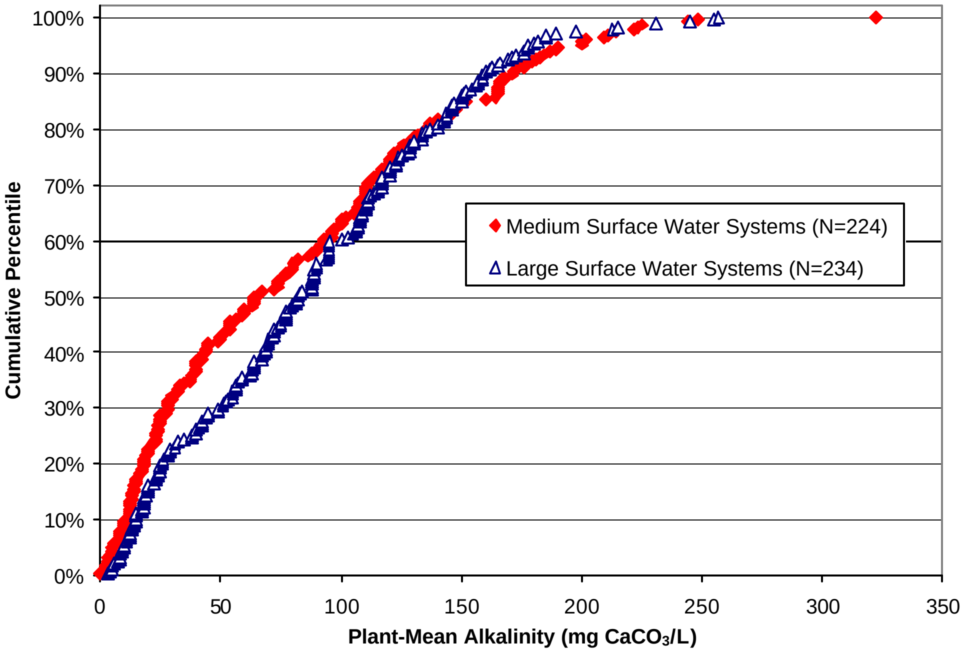
Source: WATER:\STATS (AWWA 2000).

Exhibit A.19 Comparison of Source Water Turbidity For Medium and Large Surface Water Systems



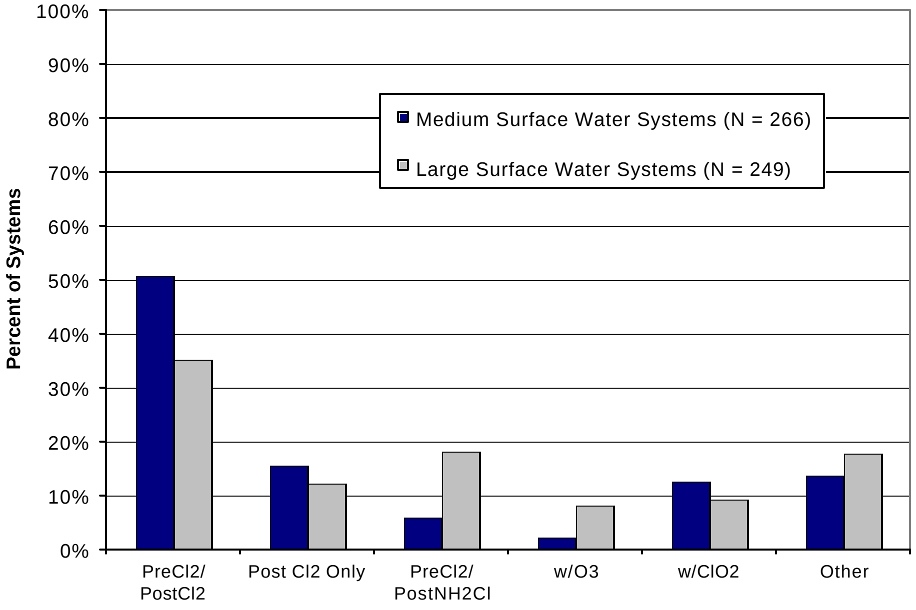
Source: WATER:\STATS (AWWA 2000).

Exhibit A.20 Comparison of Source Water Alkalinity for Medium and Large Surface Water Systems



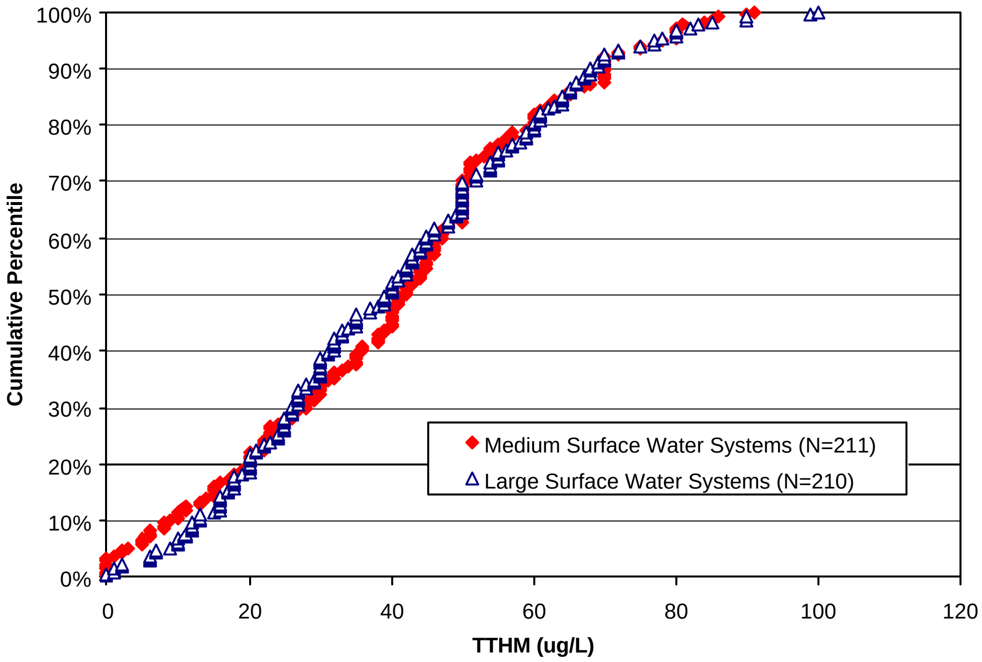
Source: WATER:\STATS (AWWA 2000).

Exhibit A.21 Comparison of Disinfectant Type for Medium and Large Surface Water Systems Using Conventional Filtration



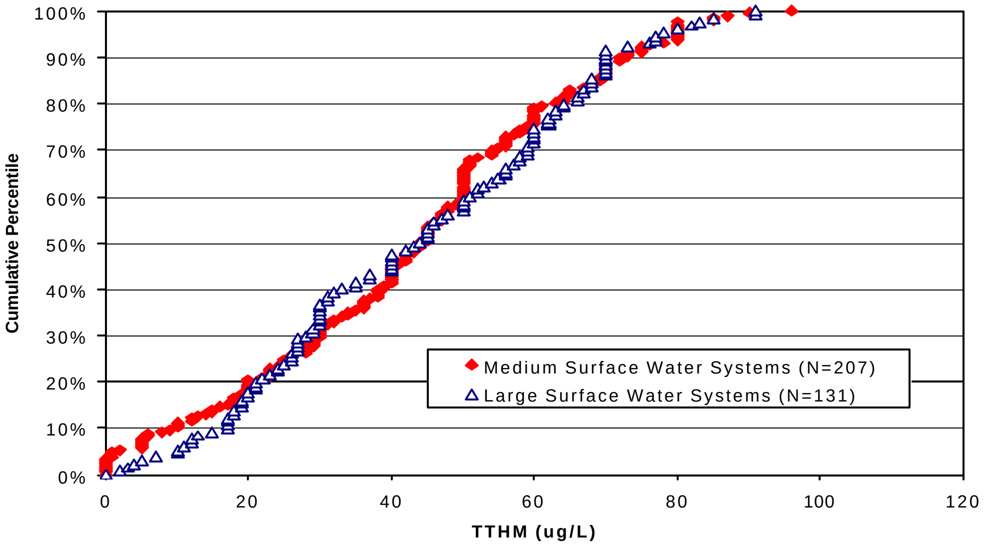
Source: WATER:\STATS (AWWA 2000).

Exhibit A.22 Comparison of Finished Water Annual Average TTHM for Medium and Large Surface Water Systems



Source: WATER:\STATS (AWWA 2000).

Exhibit A.23 Comparison of Distribution System Annual Average TTHM for Medium and Large Surface Water Systems



Source: WATER:\STATS (AWWA 2000).

Because of the similarities between large and medium surface water systems, the Subgroup assumed that ICR data on DBP occurrence and the results of the SWAT analysis were also applicable to medium surface water systems. Thus, the Subgroup assumed that medium surface water systems treatment technology selection was identical to the large surface water system treatment technology selection for pre-Stage 1, Stage 1, and the Stage 2 alternatives.

For this proportional allocation to be valid, some similarity must exist between the nationwide geographical distribution of ICR surface water systems and that of medium surface water systems. The Subgroup compared the distribution of ICR surface water systems by State to the distribution of medium surface water systems by State, using the Baseline Handbook (USEPA 2001c). This effort established that there is no significant difference in overall geographic distribution (as shown in Exhibit A.24), although there is some variation in the distribution of systems in different size categories.

To ensure that the distribution assumptions did not mask differences that may affect DBP formation, additional analyses were performed. In particular, the distribution of systems with high levels of DBP precursors (TOC in Florida, bromide in Texas; based on State data and ICR data analysis) within certain States was examined. No significant difference was found between the percentages of medium and large systems having high precursor levels. The Subgroup concluded that SWAT predictions of occurrence for large systems could be directly applied to the universe of medium surface water plants.

Exhibit A.24 Distribution of Large and Medium Surface Water Plants by EPA Region

EPA Region	Percent of Large Systems	Percent of Medium Systems
1	5.83%	9.00%
2	12.55	6.35
3	11.22	12.60
4	16.60	25.20
5	13.46	14.22
6	11.67	12.51
7	5.38	4.14
8	4.93	6.06
9	14.80	7.48
10	3.60	3.22
Total	100%	100%

Note: Detail may not add due to independent rounding.

Source: Baseline Handbook (USEPA 2001c).

A.9 SWAT based Compliance Forecasts for Small Surface Water Systems

Small surface water systems differ in many ways from medium and large surface water systems. Small systems are exempt from the 1979 Total Trihalomethane Rule, which set the TTHM MCL at 100 µg/L. Source water quality is somewhat better in small systems than in larger systems, as demonstrated by the ICR Supplemental and National Rural Water Association (NRWA) Survey data, discussed below, and the Stage 2 DBPR Occurrence and Exposure Assessment (USEPA 2003h). Unit cost estimates for new treatment technologies are higher in small systems than larger systems, which may drive small systems to take different treatment approaches. In addition, some treatment technologies predicted for use in large and medium systems may not be feasible in small systems.

Due to these considerations, the Technical Workgroup used an expert review process to extract the predicted compliance forecast for large systems to small system subgroups. The method, or the Delphi Poll process, consisted of a group of experts who provided their best professional judgement to identify likely treatment technologies for affected plants. The expert opinions were consolidated for a best estimate of the treatment technology selection response of compliance affected systems. This provided a compliance forecast for a given regulatory option.

The participating experts included members of the NRWA (a federation of 45 State rural water associations, representing over 19,000 water and wastewater utilities), EPA staff, and consulting engineers with many years of experience in small surface water systems. The review process for small surface water systems integrated technical analyses of source water characteristics and experts' predictions of anticipated treatment technologies changes and DBP formation. The experts' responses were then aggregated for further analysis.

A.9.1 Data Sources and Uncertainties

Because the small surface water system compliance forecast is extracted from SWAT model runs, many of the uncertainties in the SWAT model as discussed in Section A.6 apply to the small surface water system compliance forecast. One of the key areas of uncertainty, uncertainty in SWAT predictive equations, is quantified for small surface water systems as it is for large surface water systems. The derivation of alternative compliance forecasts to quantify uncertainty in SWAT predictive equations are presented in Chapter 5.

The ICR Supplemental Survey is a survey meant to compliment the ICR data set. It is a survey of raw source water quality and DBP concentrations from 40 random plants each from the small, medium, and large size categories. This is a small data set when compared to the nearly 4,000 small surface water system. The same is true of the NRWA data set, which consists of 117 randomly surveyed small plants nationwide to determined treatment process, source water quality, and DBP concentrations. Thus, adjustments to the large compliance forecast based on these data sets are uncertain.

The compliance forecasts of small systems are not adjusted to account for the IDSE. Small systems typically have distribution systems that are less complex than those of large surface water systems. As a result, they are more likely to already know the maximum residence time location in their distribution system.

A.9.2 Decisions from the Delphi Poll Process

For the expert review process, small surface water systems were subdivided into three size categories: systems serving fewer than 100 people, systems serving 100 to 999 people, and systems serving between 1,000 and 9,999 people. The Subgroup expected systems in each category to make different treatment choices.

The following sections detail the results of the Subgroup's deliberation of specific treatment technologies. The flowchart describing the analytical process is shown in Exhibit A.25.

Systems Serving 1,000 to 9,999 People

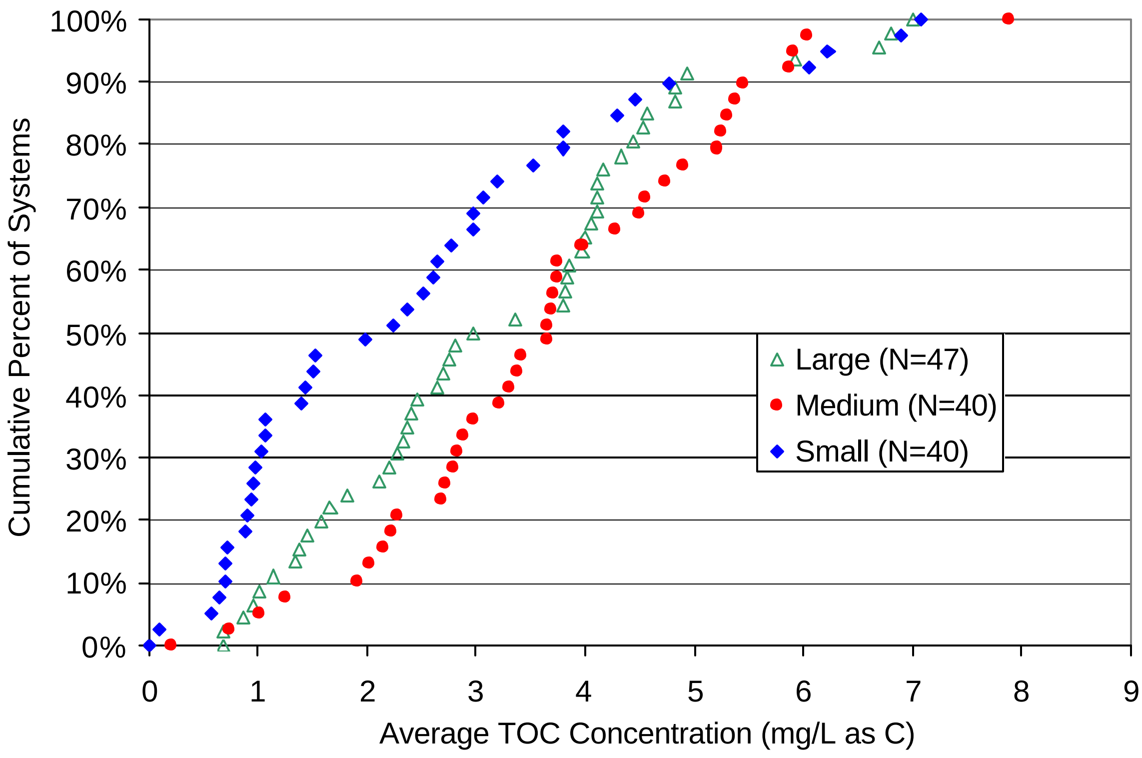
A review of ICR Supplemental Survey and NRWA Survey data indicated that source water quality at small systems was better than that at large systems. NRWA Survey results showed slightly higher TOC concentrations; however, NRWA results may be biased, as discussed in Section A.9.1. Based on Supplemental Survey data shown in Exhibit A.25, the Subgroup predicted that a smaller proportion of small systems would change to advanced treatment technologies as a result of the Stage 1 and Stage 2 DBPRs than the proportion of large systems predicted by SWAT.

The Subgroup adjusted the percentage of small systems using conventional or nonconventional treatment (i.e., not switching to advanced treatment) in the following manner:

- If the percentage of large systems employing conventional and nonconventional treatment technologies, as predicted by SWAT, exceeded or equaled 65 percent, then the corresponding percentage for small systems were to be adjusted upward to 75 percent.

- If the percentage of systems employing conventional and nonconventional treatment technologies was predicted to be less than 65 percent, then the corresponding percentage for small systems were to be adjusted by adding 10 percent to the SWAT output.

Exhibit A.25 Average TOC Levels in Surface Water Systems



Source: 12 months from the ICR Supplemental Survey Data (USEPA 2000b).

SWAT predicted that the percentage of large systems using conventional or nonconventional treatment would exceed 65 percent, so the percentage for small systems was increased to 75. The Subgroup correspondingly removed systems from other treatment categories, including chlorine dioxide, UV, and ozone. The Subgroup assumed that the conventional treatment category included some systems modifying treatment by increasing coagulant dose, installing a pre-sedimentation basin, or moving the point of chlorination. While these activities pose a smaller cost impact to large systems than implementing an advanced treatment technology does, some of these modifications (e.g., installing a pre-sedimentation basin) could constitute a substantial burden for a few small systems. However, the Subgroup was of the opinion that on a national scale the effects would not be significant, and hence did not account for it.

The Subgroup then imposed additional constraints that further affected the Stage 1 and 2 DBPR analyses and increased the number of systems predicted to change to advanced treatment technologies.

Because SWAT predictions are based on large systems, they do not account for small systems that were known to be using microfiltration or ultrafiltration before the Stage 1 DBPR was implemented (no large systems were using these treatment technologies during the ICR period). According to the NRWA Survey, microfiltration and ultrafiltration were used by 3.6 percent of small systems before the Stage 1 DBPR went into effect. As a result, the experts added 3.6 percent to the percentage of small systems predicted to be using microfiltration and ultrafiltration after the Stage 1 and Stage 2 DBPRs. These extra systems were subtracted from the systems predicted to use chlorine dioxide, ozone, and UV, as predicted by SWAT.

The SWAT model includes four options for systems using GAC:

- GAC10 (10-minute empty bed contact time)
- GAC10 plus advanced disinfectants
- GAC20 (20-minute empty bed contact time)
- GAC20 plus advanced disinfectants

Costs for GAC systems include frequent replacement or regeneration of the carbon media. The Subgroup believed that surface water systems serving more than 1,000 people would choose to replace rather than regenerate their GAC media. Because unit costs for GAC20 with replacement are lower than unit costs for GAC10 with regeneration of the media (for small systems), the Subgroup assumed that the systems using GAC10 or GAC10 plus advanced oxidants, based on the large system prediction, would instead use GAC20 or GAC20 plus advanced disinfectants, respectively.

Systems Serving 100 to 999 People

For systems serving 100 to 999 people, the starting point for treatment technology selection was the treatment technology distribution predicted for systems serving 1,000 to 9,999 people. These predictions were further modified to account for the difficulties systems of this size might have with disinfectants such as ozone, chlorine dioxide, and chloramines. Predictions for systems using GAC20 were adjusted as well.

In general, the Subgroup established that many small systems would probably not use chlorine dioxide, because it is difficult to handle and must be generated on site. The application of chlorine dioxide also requires daily testing for chlorite, a regulated DBP. The effort or expertise required for this testing may be beyond the capability of many small systems. Therefore, the Subgroup constrained chlorine dioxide use in the 100-999 size category to half that of the 1,000 to 9,999 category, allocating the rest to UV, ozone, and MF/UF in proportion to the existing numbers for these treatment technologies.

The preceding constraints on the treatment technologies available to small systems necessitated predicting the treatment technology to which each small system will switch. The only difference between the SWAT Decision Tree and the one used for small surface water systems is that GAC10 is not an option for the small surface water systems. The Subgroup also assumed that systems predicted to modify their primary treatment would continue to use the same residual disinfectant.

The Subgroup next adjusted the compliance forecast to account for a small portion of smaller systems that may not be able to apply GAC20 treatment technologies. The Subgroup subtracted 10 percent from the percentage of systems predicted to use GAC20. The systems removed from GAC20 were then added to NF (microfiltration followed by nanofiltration), the next available treatment technology on the decision tree.

Chloramine use may be difficult for some small systems, especially if an operator is not always present. Chloramine use was adjusted in a two-step process. First, the percentage of systems predicted to use chloramine as a residual disinfectant was reduced to 90 percent of the value predicted for systems serving 1,000 to 9,999 people. These systems instead were predicted to use chlorine as a residual disinfectant. Second, the Subgroup predicted that systems using chlorine would switch to different primary treatment technologies. This reallocation was necessary because chlorine contributes more to DBP formation than chloramine does, thereby forcing systems to use a higher cost treatment technology in order to meet the DBP standards of the Stage 2 DBPR.

Systems Serving Fewer than 100 People

For systems serving 100 or fewer people, the starting point for treatment technology selection was the treatment technology distribution predicted for systems serving 100 to 999 people. These predictions were modified to account for the additional difficulties systems of this size might have with disinfectants such as ozone, chlorine dioxide, and chloramine. Predictions for systems using GAC20 were adjusted as well.

The Subgroup assumed that no systems in this size category would use chlorine dioxide or ozone. Consequently, the Subgroup allocated to conventional treatment two-thirds of the systems that were predicted to use chlorine dioxide and ozone. The remaining one-third of chlorine dioxide systems were allocated to UV, MF/UF, GAC20, GAC20 with UV, and NF, and the remaining one-third of ozone systems were allocated to MF/UF, GAC20, GAC20 with UV, and NF, all in proportion to existing numbers for these treatment technologies.

As with systems serving 100 to 999 people, the percentage of systems predicted to use GAC20 was decreased by 10. The systems removed from GAC20 were then added to NF, the next available treatment technology on the decision tree.

The Subgroup adjusted chloramine usage using the same process as it did for systems serving 100 to 999 people, except that the percentage of systems predicted to use chloramine as a residual disinfectant was reduced to 75 percent, rather than 90 percent.

The most significant effect of the chloramine constraint was that systems using less expensive treatment technologies were predicted to move toward more expensive treatment technologies. This effectively neutralizes the cost savings small systems might have achieved through better source water quality. A review of the compliance forecasts shows that when the Stage 1 DBPR predictions for both large and small surface water systems are compared, there is no significant difference in the percentage of systems using advanced treatment technologies to comply with the Stage 1 DBPR. Small systems have better source water quality than large systems do, but this is outweighed by the fact that they must install more expensive treatment technologies to comply with DBP regulations and by the fact that large systems are already complying with the 1979 TTHM Rule.

Adjustments for the Stage 1 DBPR

To account for the effect of less expensive treatment technologies becoming available to meet the Stage 2 DBPR requirements for small surface water systems, the following adjustments were made to the Stage 2 ending treatment technology predictions made by the Delphi subgroup:

- Start with SWAT/Delphi subgroup treatment technology selection predictions for the Stage 1 DBPR and Stage 2 DBPR options (with and without UV) for the small surface water systems.

- Check the Stage 2 small surface water predictions for NF (i.e., the most expensive treatment technology). Use the Stage 1 DBPR estimates for NF usage if they are higher than the Stage 2 NF usage estimates. This is because systems predicted to use NF for Stage 1 will not remove it to shift to a lower-performing treatment technology, even if the actual Stage 2 predictions specify the latter.

- Repeat the above step with the next most expensive treatment technology (i.e., GAC20 & UV or advanced oxidants (AO)). Continue this procedure for each succeeding treatment technology, moving all the way down to chlorine dioxide.

These steps are outlined in Exhibit A.26 (see “Adjusting for Stage 1 Baseline"), and an example of the adjustments made for each size category is presented in Exhibit A.27.

In addition to the treatment technology abbreviations commonly used in this EA, the following acronyms are used in Exhibit A.26:

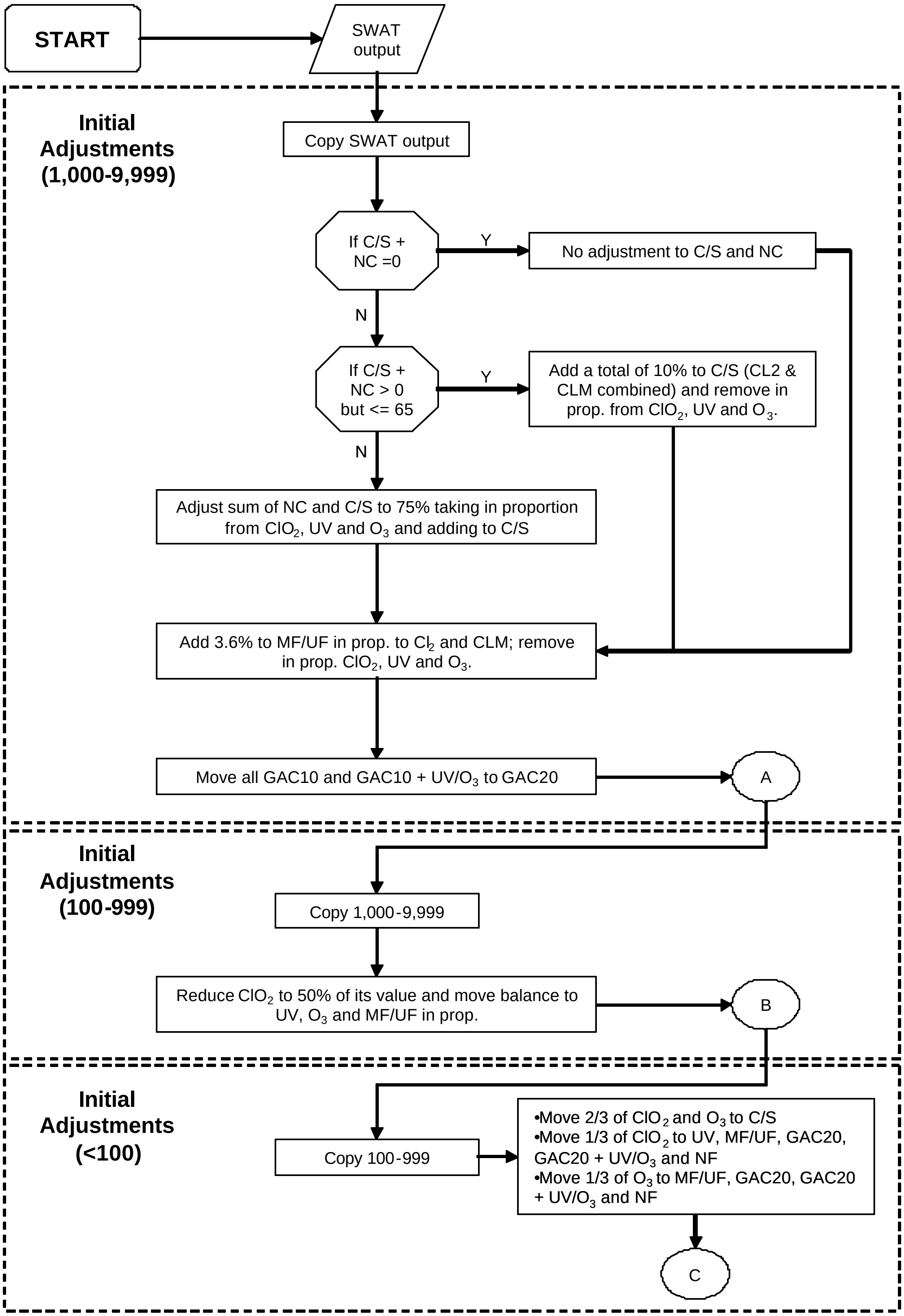
- C/S - Conventional filtration with softening

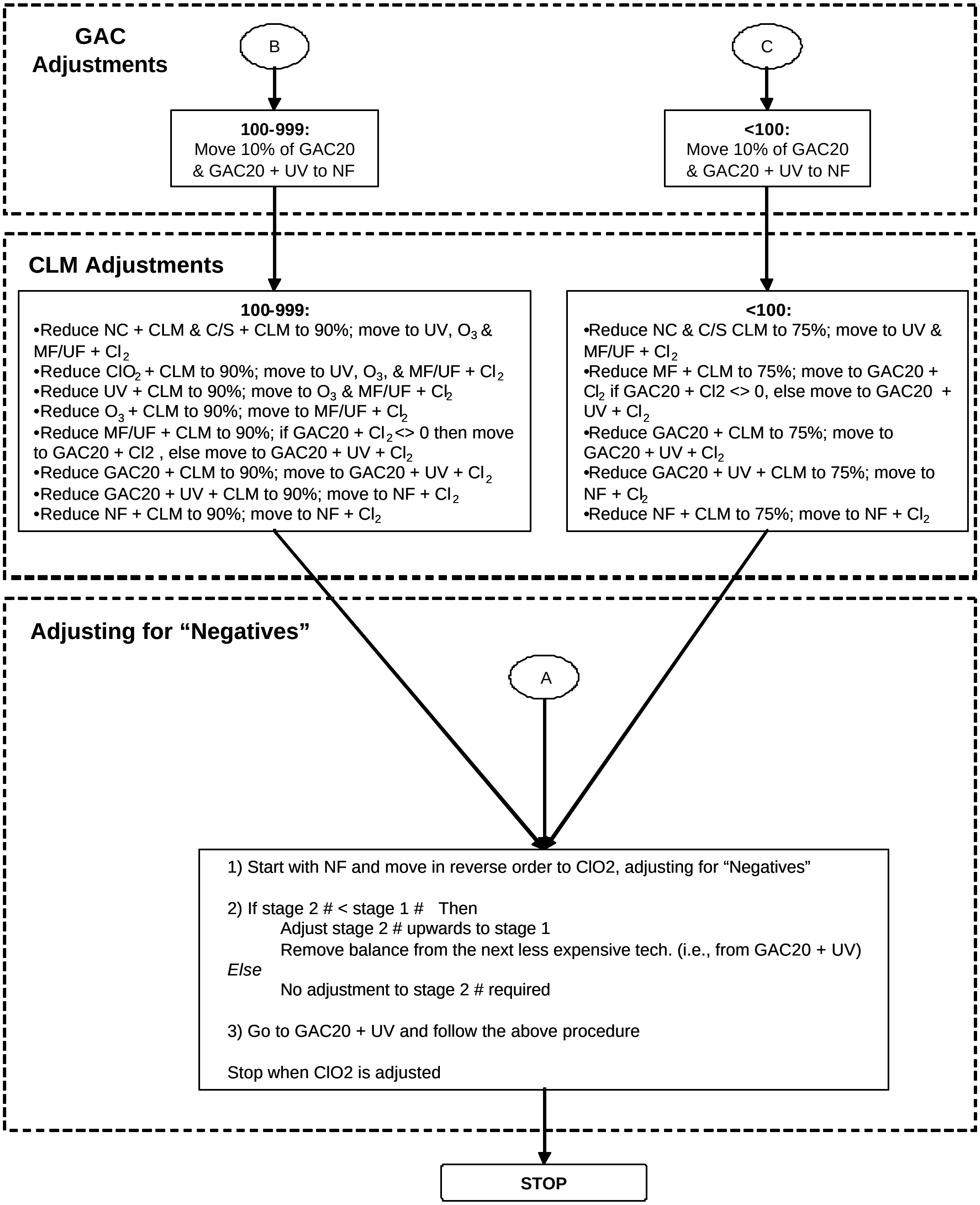
- NC - Nonconventional filtration

A.9.3 Results

Exhibits A.28a, A.28b, and A.28c summarize the treatment technology selection results for small surface water systems, for all Stage 2 DBPR regulatory alternatives and sensitivity options.

Exhibit A.26 Small Surface Water Forecast Flowchart





100-999:
Move 10% of GAC20 & GAC20 + UV to NF

<100:
Move 10% of GAC20 & GAC20 + UV to NF

100-999:
- Reduce NC + CLM & C/S + CLM to 90%; move to UV, O_3 & MF/UF + Cl_2
- Reduce ClO_2 + CLM to 90%; move to UV, O_3, & MF/UF + Cl_2
- Reduce UV + CLM to 90%; move to O_3 & MF/UF + Cl_2
- Reduce O_3 + CLM to 90%; move to MF/UF + Cl_2
- Reduce MF/UF + CLM to 90%; if GAC20 + Cl_2 <> 0 then move to GAC20 + Cl2 , else move to GAC20 + UV + Cl_2
- Reduce GAC20 + CLM to 90%; move to GAC20 + UV + Cl_2
- Reduce GAC20 + UV + CLM to 90%; move to NF + Cl_2
- Reduce NF + CLM to 90%; move to NF + Cl_2

<100:
- Reduce NC & C/S CLM to 75%; move to UV & MF/UF + Cl_2
- Reduce MF + CLM to 75%; move to GAC20 + Cl_2 if GAC20 + Cl2 <> 0, else move to GAC20 + UV + Cl_2
- Reduce GAC20 + CLM to 75%; move to GAC20 + UV + Cl_2
- Reduce GAC20 + UV + CLM to 75%; move to NF + Cl_2
- Reduce NF + CLM to 75%; move to NF + Cl_2

1) Start with NF and move in reverse order to ClO2, adjusting for “Negatives”

2) If stage 2 # < stage 1 # Then
Adjust stage 2 # upwards to stage 1
Remove balance from the next less expensive tech. (i.e., from GAC20 + UV)
Else
No adjustment to stage 2 # required

3) Go to GAC20 + UV and follow the above procedure

Stop when ClO2 is adjusted

Exhibit A.27 Small Surface Water Adjustments Example

Initial Adjustments

SWAT for ICR Systems

	CL2	CLM
Nonconventional	A1	B1
Conventional/Softening	A2	B2
ClO$_2$	A3	B3
UV	A4	B4
Ozone	A5	B5
MF/UF	A6	B6
GAC10	A7	B7
GAC10 & UV	A8	B8
GAC20	A9	B9
GAC20 & UV	A10	B10
Membranes (NF)	A11	B11

Serving 1,000 - 9,999

CL2	CLM
C1 = A1	D1 = B1
C2 = If A1+A2+B1+B2=0 Then A2 Else If A1+A2+B1+B2 AND A1+A2+B1+B2<0.65 Then A2+(A2/(A2+B2))*0.1 Else If A1+A2+B1+B2>0.65 AND A1+A2+B1+B2<0.75 Then A2+(0.75-(A1+A2+B1+B2))*(A2/(A2+B2))) Else A2	D2 = If A1+A2+B1+B2=0 Then B2 Else If A1+A2+B1+B2 AND A1+A2+B1+B2<0.65 Then B2+(B2/(A2+B2))*0.1Else If A1+A2+B1+B2>0.65 AND A1+A2+B1+B2<0.75 Then B2+(0.75-(A1+A2+B1+B2))*(B2/(A2+B2))) Else B2
C3 = (A3-((C2-A3)*(A3/(A3+A4+A5)))-(0.036*(A6/(A6+B6))*(A3/(A3+A4+A5))))	D3 = (B3-((D2-B3)*(B3/(B3+B4+B5)))-(0.036*(B6/(A6+B6))*(B3/(B3+B4+B5))))
C4 = (A4-((C2-A4)*(A4/(A3+A4+A5)))-(0.036*(A6/(A6+B6))*(A4/(A3+A4+A5))))	D4 = (B4-((D2-B4)*(B4/(B3+B4+B5)))-(0.036*(B6/(A6+B6))*(B4/(B3+B4+B5))))
C5 = (A5-((C2-A5)*(A5/(A3+A4+A5)))-(0.036*(A6/(A6+B6))*(A5/(A3+A4+A5))))	D5 = (B5-((D2-B5)*(B5/(B3+B4+B5)))-(0.036*(B6/(A6+B6))*(B5/(B3+B4+B5))))
C6 = A6+0.036*(A6/(A6+B6))	D6 = B6+0.036*(B6/(A6+B6))
C7 = 0	D7 = 0
C8 = 0	D8 = 0
C9 = A9+A7	D9 = B8+B7
C10 = A10+A8	D10 = B10+B8
C11 = A11	D11 = B11

Serving 100 - 999

	CL2	CLM
Nonconventional	E1 = C1	F1 = D1
Conventional/Softening	E2 = C2	F2 = D2
ClO$_2$	E3 = 50%*C3	F3 = 50%*D3
UV	E4 = C4+(0.5*C3)* (C4/(C4+C5+C6))	F4 = D4+(0.5*D3)* (D4/(D4+D5+D6))
Ozone	E5 = C5+(0.5*C3)* (C5/(C4+C5+C6))	F5 = D5+(0.5*D3)* (D5/(D4+D5+D6))
MF/UF	E6 = C6+(0.5*C3)* (C6/(C4+C5+C6))	F6 = D6+(0.5*D3)* (D6/(D4+D5+D6))
GAC10	E7 = C7	F7 = D7
GAC10 & UV	E8 = C8	F8 = D8
GAC20	E9 = C9	F9 = D9
GAC20 & UV	E10 = C10	F10 = D10
Membranes (NF)	E11 = C11	F11 = D11

Serving <100

CL2	CLM
G1 = E1	H1 = F1
G2 = E2+0.67*(E3+E5)	H2 = F2+0.67*(F3+F5)
G3 = 0	H3 = 0
G4 = E4+0.33*E3*(E4/(E4+E6+E9+E10+E11))	H4 = F4+0.33*F3*(F4/(F4+F6+F9+F10+F11))
G5 = 0	H5 = 0
G6 = E6+0.33*E5*(E6/(E6+E9+E10+E11))+ 0.33*E3*(E6/(E4+E6+E9+E10+E11))	H6 = F6+0.33*F5*(F6/(F6+F9+F10+F11))+ 0.33*F3*(F6/(F4+F6+F9+F10+F11))
G7 = 0	H7 = 0
G8 = 0	H8 = 0
G9 = E9+0.33*E5*(E9/(E6+E9+E10+E11))+ 0.33*E3*(E9/(E4+E6+E9+E10+E11))	H9 = F9+0.33*F5*(F9/(F6+F9+F10+F11))+ 0.33*F3*(F9/(F4+F6+F9+F10+F11))
G10 = E10+0.33*E5*(E10/(E6+E9+E10+E11))+ 0.33*E3*(E10/(E4+E6+E9+E10+E11))	H10 = F10+0.33*F5*(F10/(F6+F9+F10+F11))+ 0.33*F3*(F10/(F4+F6+F9+F10+F11))
G11 = E11+0.33*E5*(E11/(E6+E9+E10+E11))+ 0.33*E3*(E11/(E4+E6+E9+E10+E11))	H11 = F11+0.33*F5*(F11/(F6+F9+F10+F11))+ 0.33*F3*(F11/(F4+F6+F9+F10+F11))

Exhibit A.27 Small Surface Water Adjustments Example (Continued)

GAC20 Adjustments

Serving 100 - 999

	CL2	CLM
Nonconventional	E1	F1
Conventional/Softening	E2	F2
ClO_2	E3	F3
UV	E4	F4
Ozone	E5	F5
MF/UF	E6	F6
GAC10	E7	F7
GAC10 & UV	E8	F8
GAC20	I9 = 90%*E9	J9 = 90%*F9
GAC20 & UV	I10 = 90%*E10	J10 = 90%*F10
Membranes (NF)	I11 = E11+10%*(E9+E10)	J11 = F11 + 10%*(F9+F10)

Serving <100

CL2	CLM
G1	H1
G2	H2
G3	H3
G4	H4
G5	H5
G6	H6
G7	H7
G8	H8
K9 = 90%*G9	L9 = 90%*H9
K10 = 90%*G10	L10 = 90%*H10
K11 = G11+10%*(G9+G10)	L11 = H11+10%*(H9+H10)

CLM Adjustments

Serving 100 - 999

	CL2	CLM
Nonconventional	E1	N1 = 90%*F1
Conventional/Softening	E2	N2 = 90%*F2
ClO_2	E3	N3 = 90%*F3
UV	M4 = E4+10%*(F1+F2)*(E4/(E4+E5+E6))+10%*F3*(E4/(E4+E5+E6))	N4 = 90%*F4
Ozone	M5 = E5+10%*(F1+F2)*(E5/(E4+E5+E6))+10%*F3*(E5/(E4+E5+E6))+10%*F4*(E5/(E5+E6))	N5 = 90%*F5
MF/UF	M6 = E6+10%*(F1+F2)*(E6/SUM(E4+E5+E6))+10%*F3*(E6/(E4+E5+E6))+10%*F4*(E6/(E5+E6))+ 10%*F5	N6 = 90%*F6
GAC10	E7	F7
GAC10 & UV	E8	F8
GAC20	M9 = If I9=0 Then 0 Else I9+10%*F6	N9 = 90%*J9
GAC20 & UV	M10 = IF I9=0 Then I10+10%*J9+10%*F6 Else I10+10%*J9	N10 = 90%*J10
Membranes (NF)	M11 = I11+10%*(J10+J11)	N11 = 90%*J11

Serving <100

CL2	CLM
G1	P1 = 75%*H1
G2	P2 = 75%*H2
G3	H3
O4 = G4+25%*(H1+H2)*(G4/(G4+G6))	P4 = 75%*H4
G5	H5
O6 = G6+25%*(H1+H2)*(G6/(G4+G6))+25%*H4	P6 = 75%*H6
G7	H7
G8	H8
O9 = If K9=0 Then 0 Else K9+25%*H6	P9 = 75%*H9
O10 = If K9=0 Then K10+25%*H6+25%*L9 Else K10+25%*L9	P10 = 75%*H10
O11 = K11+25%*(L10+L11)	P11 = 75%*H11

Exhibit A.27 Small Surface Water Adjustments Example (Continued)

Adjusting for "Negatives"

Check if NF is below Stage 1

	Stage 1 Baseline		Stage 2 Alternative		Stage 2 Alternative, after Adjustment	
	CL2	CLM	CL2	CLM	CL2	CLM
Nonconventional	A1	B1	C1	D1	C1	D1
Conventional/Softening	A2	B2	C2	D2	C2	D2
ClO_2	A3	B3	C3	D3	C3	D3
UV	A4	B4	C4	D4	C4	D4
Ozone	A5	B5	C5	D5	C5	D5
MF/UF	A6	B6	C6	D6	C6	D6
GAC10	A7	B7	C7	D7	C7	D7
GAC10 & UV	A8	B8	C8	D8	C8	D8
GAC20	A9	B9	C9	D9	C9	D9
GAC20 & UV	A10	B10	C10	D10	E10 = If C11<A11 Then C10-ABS(A11-C11) Else C10	F10 = If D11<B11 Then D10-ABS(B11-D11) Else D10
Membranes (NF)	A11	B11	C11	D11	E11 = If C11<A11 Then A11 Else C11	F11 = If D11<B11 Then B11 Else D11

Check if GAC20 & UV is below Stage 1

	Stage 1 Baseline		Stage 2 Alternative		Stage 2 Alternative, after Adjustment	
	CL2	CLM	CL2	CLM	CL2	CLM
Nonconventional	A1	B1	C1	D1	C1	D1
Conventional/Softening	A2	B2	C2	D2	C2	D2
ClO_2	A3	B3	C3	D3	C3	D3
UV	A4	B4	C4	D4	C4	D4
Ozone	A5	B5	C5	D5	C5	D5
MF/UF	A6	B6	C6	D6	C6	D6
GAC10	A7	B7	C7	D7	C7	D7
GAC10 & UV	A8	B8	C8	D8	C8	D8
GAC20	A9	B9	C9	D9	G9 = If E10<A10 Then C9-ABS(A10-E10) Else C9	H9 = If F10<B10 Then D9-ABS(B10-F10) Else D9
GAC20 & UV	A10	B10	E10	F10	G10 = If E10<A10 Then A10 Else E10	H10 = If F10<B10 Then B10 Else F10
Membranes (NF)	A11	B11	E11	F11	E11	F11

Check if GAC20 is below Stage 1

	Stage 1 Baseline		Stage 2 Alternative		Stage 2 Alternative, after Adjustment	
	CL2	CLM	CL2	CLM	CL2	CLM
Nonconventional	A1	B1	C1	D1	C1	D1
Conventional/Softening	A2	B2	C2	D2	C2	D2
ClO_2	A3	B3	C3	D3	C3	D3
UV	A4	B4	C4	D4	C4	D4
Ozone	A5	B5	C5	D5	C5	D5
MF/UF	A6	B6	C6	D6	I6 = If G9<A9 Then C6-ABS(A9-G9) Else C6	J6 = If H9<B9 Then D6-ABS(B9-H9) Else D6
GAC10	A7	B7	C7	D7	C7	D7
GAC10 & UV	A8	B8	C8	D8	C8	D8
GAC20	A9	B9	C9	D9	I9 = If G9<A9 Then A9 Else G9	J9 = If H9<B9 Then B9 Else H9
GAC20 & UV	A10	B10	E10	F10	G10	H10
Membranes (NF)	A11	B11	E11	F11	E11	F11

Exhibit A.27 Small Surface Water Adjustments Example (Continued)

Check if MF/UF is below Stage 1

	Stage 1 Baseline		Stage 2 Alternative		Stage 2 Alternative, after Adjustment	
	CL2	**CLM**	**CL2**	**CLM**	**CL2**	**CLM**
Nonconventional	A1	B1	C1	D1	C1	D1
Conventional/Softening	A2	B2	C2	D2	C2	D2
ClO$_2$	A3	B3	C3	D3	C3	D3
UV	A4	B4	C4	D4	C4	D4
Ozone	A5	B5	C5	D5	K5 = If I6<A6 Then C5-ABS(A6-I6) Else C5	L5 = If J6<B6 Then D5-ABS(B6-J6) Else D5
MF/UF	A6	B6	C6	D6	K6 = If I6<A6 Then A6 Else I6	L6 = If J6<B6 Then B6 Else J6
GAC10	A7	B7	C7	D7	C7	D7
GAC10 & UV	A8	B8	C8	D8	C8	D8
GAC20	A9	B9	C9	D9	I9	J9
GAC20 & UV	A10	B10	E10	F10	G10	H10
Membranes (NF)	A11	B11	E11	F11	E11	F11

Check if Ozone is below Stage 1

	Stage 1 Baseline		Stage 2 Alternative		Stage 2 Alternative, after Adjustment	
	CL2	**CLM**	**CL2**	**CLM**	**CL2**	**CLM**
Nonconventional	A1	B1	C1	D1	C1	D1
Conventional/Softening	A2	B2	C2	D2	C2	D2
ClO$_2$	A3	B3	C3	D3	C3	D3
UV	A4	B4	C4	D4	M4 = If K5<A5 Then C4-ABS(A5-K5) Else C4	N4 = If L5<B5 Then B4-ABS(B5-L5) Else D4
Ozone	A5	B5	C5	D5	M5 = If K5<A5 Then A5 Else K5	N5 = If L5<B5 Then B5 Else L5
MF/UF	A6	B6	C6	D6	K6	L6
GAC10	A7	B7	C7	D7	C7	D7
GAC10 & UV	A8	B8	C8	D8	C8	D8
GAC20	A9	B9	C9	D9	I9	J9
GAC20 & UV	A10	B10	C10	D10	G10	H10
Membranes (NF)	A11	B11	C11	D11	E11	F11

Check if UV is below Stage 1

	Stage 1 Baseline		Stage 2 Alternative		Stage 2 Alternative, after Adjustment	
	CL2	**CLM**	**CL2**	**CLM**	**CL2**	**CLM**
Nonconventional	A1	B1	C1	D1	C1	D1
Conventional/Softening	A2	B2	C2	D2	C2	D2
ClO$_2$	A3	B3	C3	D3	O3 = If M4<A4 Then C3-ABS(A4-M4) Else C3	P3 = If N4<B4 Then D3-ABS(B4-N4) Else D4
UV	A4	B4	C4	D4	O4 = If M4<A4 Then A4 Else M4	P4 = If N4<B4 Then B4 Else N4
Ozone	A5	B5	C5	D5	M5	N5
MF/UF	A6	B6	C6	D6	K6	L6
GAC10	A7	B7	C7	D7	C7	D7
GAC10 & UV	A8	B8	C8	D8	C8	D8
GAC20	A9	B9	C9	D9	I9	J9
GAC20 & UV	A10	B10	C10	D10	G10	H10
Membranes (NF)	A11	B11	C11	D11	E11	F11

Exhibit A.27 Small Surface Water Adjustments Example (Continued)

Check if ClO2 is below Stage 1

	Stage 1 Baseline		Stage 2 Alternative		Stage 2 Alternative, after Adjustment	
	CL2	**CLM**	**CL2**	**CLM**	**CL2**	**CLM**
Nonconventional	A1	B1	C1	D1	Q1 = If O3<A3 Then C1-ABS(A3-O3)*(C1/(C1+C2)) Else C1	R1 = If P3<B3 Then D1-ABS(B3-P3)*(D1/(D1+D2)) Else D1
Conventional/Softening	A2	B2	C2	D2	Q2 = If O3<A3 Then C2-ABS(A3-O3)*(C2/(C1+C2)) Else C2	R2 = If P3<B3 Then D2-ABS(B3-P3)*(D2/(D1+D2)) Else D2
ClO_2	A3	B3	C3	D3	Q3 = If O3<A3 Then A3 Else O3	R3 = If P3<B3 Then B3 Else P3
UV	A4	B4	C4	D4	O4	P4
Ozone	A5	B5	C5	D5	M5	N5
MF/UF	A6	B6	C6	D6	K6	L6
GAC10	A7	B7	C7	D7	C7	D7
GAC10 & UV	A8	B8	C8	D8	C8	D8
GAC20	A9	B9	C9	D9	I9	J9
GAC20 & UV	A10	B10	C10	D10	G10	H10
Membranes (NF)	A11	B11	C11	D11	E11	F11

Exhibit A.28a Small Surface Water Treatment Technology Selection Results (Serving Populations <100)

Rule Option	Description of Rule Option			Cl_2 Converting to CLM	Non Conventional	Conventional/ Softening	ClO_2	UV	Ozone	MF UF	GAC10	GAC10 & UV	GAC20	GAC20 & UV	Membranes
	Compliance Calculation	Bromate MCL	UV Considered?												
Stage 1 Baseline	80/60 RAA	10	No	39.56%	9.98%	65.21%	0.00%	0.00%	0.00%	18.03%	0.00%	0.00%	3.25%	0.00%	3.52%
Stage 2 Preferred, 20% SM	80/60 LRAA	10	Yes	42.58%	9.80%	60.76%	0.00%	3.98%	0.00%	18.03%	0.00%	0.00%	3.25%	0.66%	3.52%
Alternative 1	80/60 LRAA	5	Yes	42.58%	9.80%	60.50%	0.00%	3.32%	0.00%	18.03%	0.00%	0.00%	3.25%	1.41%	3.69%
Alternative 2	80/60 SH	10	Yes	50.55%	6.48%	47.68%	0.00%	2.44%	0.00%	21.25%	0.00%	0.00%	11.39%	6.38%	4.37%
Alternative 3	40/30 RAA	10	Yes	51.10%	4.17%	39.39%	0.00%	3.49%	0.00%	21.93%	0.00%	0.00%	17.87%	7.77%	5.38%

Exhibit A.28b Small Surface Water Treatment Technology Selection Results (Serving Populations 100-999)

Rule Option	Description of Rule Option			Cl_2 Converting to CLM	Non Conventional	Conventional/ Softening	ClO_2	UV	Ozone	MF UF	GAC10	GAC10 & UV	GAC20	GAC20 & UV	Membranes
	Compliance Calculation	Bromate MCL	UV Considered?												
Stage 1 Baseline	80/60 RAA	10	No	47.47%	10.59%	64.03%	1.83%	0.00%	9.65%	10.11%	0.00%	0.00%	2.01%	0.92%	0.86%
Stage 2 Preferred, 20% SM	80/60 LRAA	10	Yes	51.10%	10.51%	61.71%	2.10%	1.40%	9.65%	10.11%	0.00%	0.00%	2.01%	1.62%	0.89%
Alternative 1	80/60 LRAA	5	Yes	51.10%	10.50%	61.33%	2.10%	1.05%	9.65%	10.11%	0.00%	0.00%	2.01%	1.35%	1.90%
Alternative 2	80/60 SH	10	Yes	60.66%	7.24%	47.23%	1.83%	0.00%	9.65%	14.40%	0.00%	0.00%	10.43%	6.00%	3.22%
Alternative 3	40/30 RAA	10	Yes	61.32%	4.73%	39.75%	2.35%	0.00%	9.65%	15.33%	0.00%	0.00%	16.93%	7.02%	4.23%

Exhibit A.28c Small Surface Water Treatment Technology Selection Results (Serving Populations 1,000-9,999)

Rule Option	Description of Rule Option			Cl_2 Converting to CLM	Non Conventional	Conventional/ Softening	ClO_2	UV	Ozone	MF UF	GAC10	GAC10 & UV	GAC20	GAC20 & UV	Membranes
	Compliance Calculation	Bromate MCL	UV Considered?												
Stage 1 Baseline	80/60 RAA	10	No	52.75%	10.99%	67.40%	4.03%	0.00%	8.49%	5.43%	0.00%	0.00%	2.20%	1.10%	0.37%
Stage 2 Preferred, 20% SM	80/60 LRAA	10	Yes	56.78%	10.93%	64.90%	4.63%	1.23%	8.49%	5.43%	0.00%	0.00%	2.20%	1.83%	0.37%
Alternative 1	80/60 LRAA	5	Yes	56.78%	10.93%	64.53%	4.63%	0.87%	8.49%	5.43%	0.00%	0.00%	2.20%	1.47%	1.47%
Alternative 2	80/60 SH	10	Yes	67.40%	7.98%	50.96%	4.12%	0.00%	8.49%	9.41%	0.00%	0.00%	11.36%	6.59%	1.10%
Alternative 3	40/30 RAA	10	Yes	68.13%	5.14%	43.05%	5.79%	0.00%	8.49%	10.06%	0.00%	0.00%	18.68%	7.69%	1.10%

Appendix B

Ground Water Plant Compliance Forecasts

Appendix B
Ground Water Plant Compliance Forecasts

B.1 Introduction

This appendix documents the derivation of the compliance forecasts for ground water plants. These forecasts are used in the Economic Analysis (EA) for the Stage 2 Disinfectants and Disinfection Byproducts Rule (DBPR). The forecast for large ground water plants was generated using the Information Collection Rule (ICR) Ground Water Delphi process, which convened a group of ground water system experts. Medium plants were evaluated in a similar manner as large plants. Forecasts for small plants were developed under the small ground water system expert review process. The following sections provide the methodology for developing compliance forecasts for all ground water plants.

B.2 Compliance Forecast for Large and Medium Ground Water Plants

Unlike the compliance forecast for surface water plants generated by the Surface Water Analytical Tool (SWAT), the forecast for ground water plants in large and medium systems (those serving over 10,000 people) was developed in two steps described below (and summarized in Exhibit B.1).

- Estimate the percentage of plants not in compliance: First, the ICR Ground Water Delphi Group used ICR data to evaluate each plant for compliance under various regulatory alternatives. However, most of the large plants predicted to be out of compliance were located in Florida. Florida systems make up a significantly larger proportion of ICR data than is the proportion of all United States ground water systems made up by Florida. Therefore, the Environmental Protection Agency (EPA) applied a “Florida/Non-Florida” stratification when extrapolating the results of the Delphi Group to the universe of ground water systems.

- Apply treatment technology selection forecasts to the plants not in compliance: The Delphi Group predicted treatment technology selection for each non-compliant large ground water plant. These plant-level analyses were aggregated into national-level compliance treatment technology forecasts, which were then applied to the percent of medium and large systems not in compliance.

Section B.2.1 explains the rationale for using ICR Delphi results for medium ground water systems.

At the time of the Delphi process, EPA was still evaluating a large number of regulatory alternatives and had not been advised by the Federal Advisory Committees Act (FACA) on the Preferred Regulatory Alternative. Therefore, the Delphi group analyzed four "bounding" alternatives to address the variety in the MCL levels (80 micrograms per liter (μg/L) for total trihalomethanes (TTHM), 60 μg/L for haloacetic acids (HAA5), and 40 μg/L for TTHM, 30 μg/L for HAA5), and measurement methods (running annual average (RAA), single highest (SH) values, and locational running annual average (LRAA)) being considered. The original bounding alternatives considered by the Delphi group were
:

- 80/60 μg/LRAA (The Stage 1 DBPR)
- 80/60 μg/L SH (Alternative 2)
- 40/30 μg/L RAA (Alternative 3)
- 40/30 μg/L SH (Bounding Alternative 4, not considered in this EA)

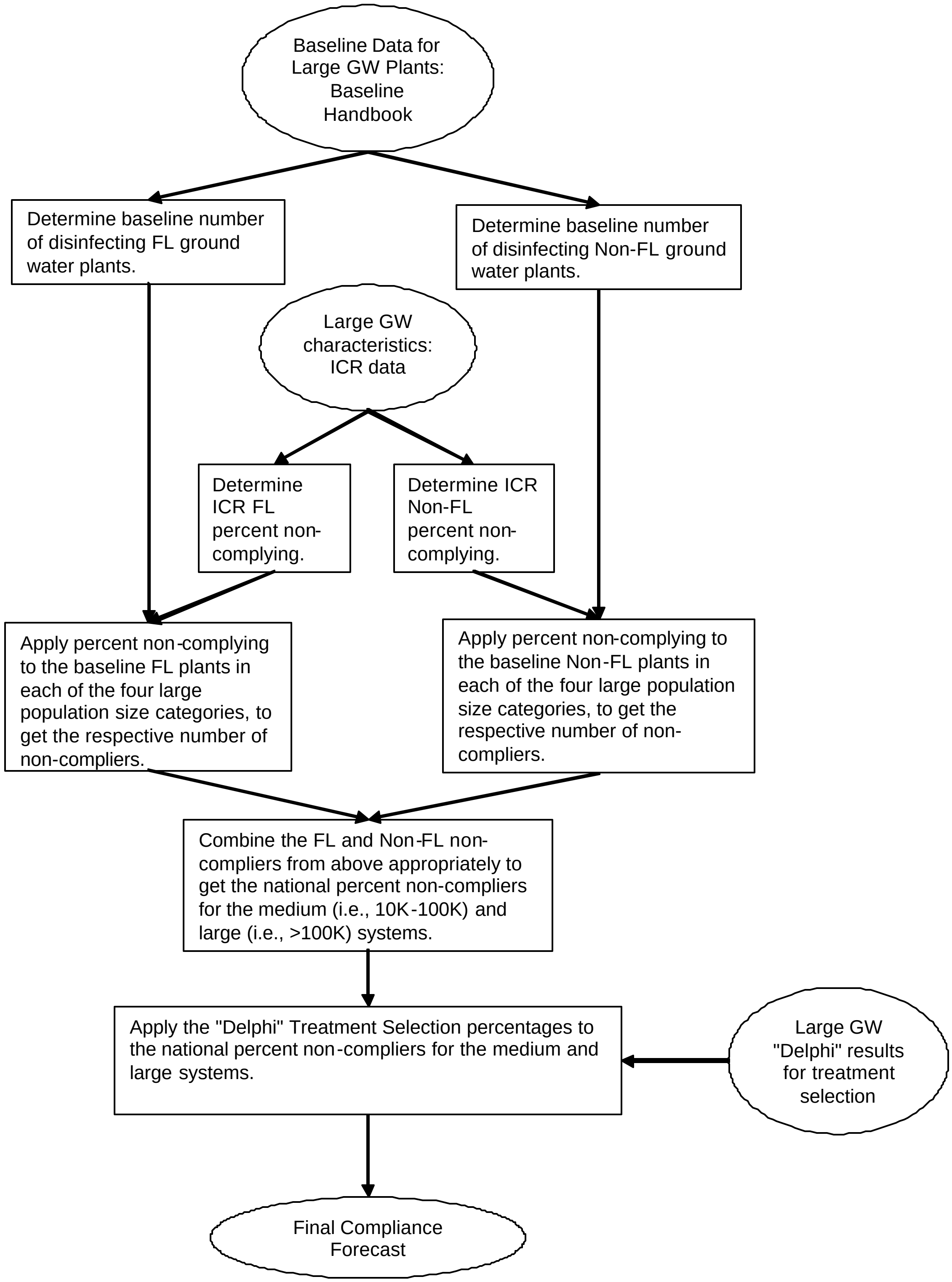
Two additional regulatory alternatives were identified after the original Delphi group analysis was completed:

- 80/60 μg/L LRAA (The Preferred Alternative)
- 80/60 μg/L LRAA with reduced Bromate maximum contaminant level (MCL) of 5 μg/L (Alternative 1)

Unlike the large surface water systems, no sensitivity analysis was performed to quantify the potential effects of the Initial Distribution System Evaluation (IDSE) on the Preferred Alternative. Ground water sources have more stable water quality than surface water systems. As a result, ground water systems will more likely operate their treatment with a much lower safety margin than 20 percent. Therefore, the ground water system compliance forecasts are conservative enough to estimate the potential effects of the IDSE.

Sections B.2.2 and B.2.3 provide the detailed process for estimating the percent of plants not in compliance for each of the 4 alternatives described above and predicting the treatment technologies they may select to meet compliance.

Exhibit B.1 Compliance Forecast for Medium and Large Ground Water Plants

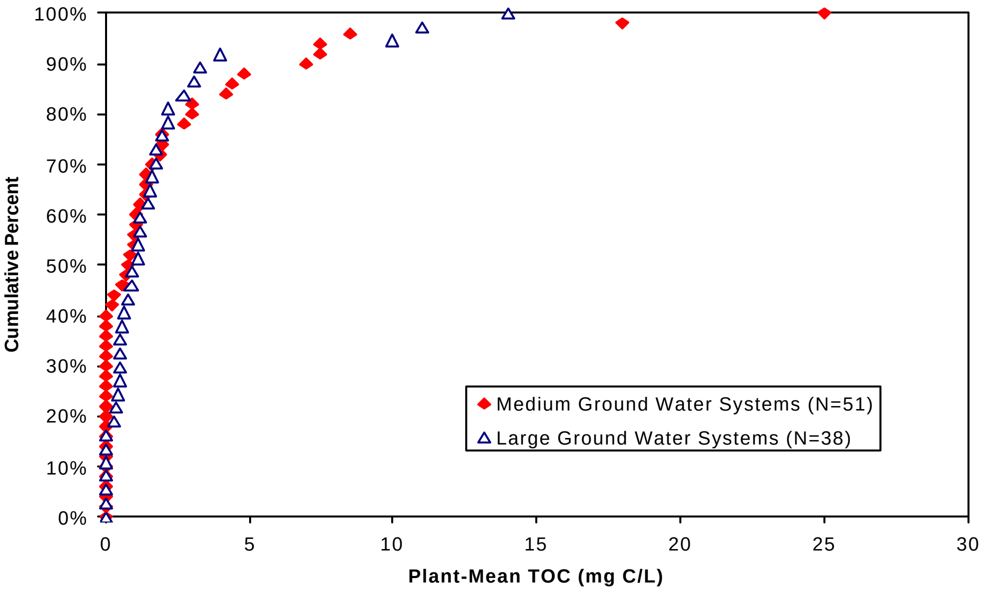


B.2.1 Rationale for Using ICR Delphi Results for Medium Ground Water Systems

To determine if results from the ICR Ground Water Delphi Group could be used for medium ground water systems, EPA compared data on disinfection byproducts (DBPs) and DBP precursors from large ground water systems to data from medium ground water systems. The most relevant information for assessing precursor and byproduct occurrence and treatment technology distribution in medium ground water systems is that provided in the WATER:\STATS database (AWWA 2000). Exhibits B.2 to B.4 provide comparisons of average influent total organic carbon (TOC) levels, treatment technology used, and average TTHM levels for medium and large ground water systems in the WATER:\STATS data set. Based on this data, the treatment technology configurations and well fields of large and medium ground water systems are believed to be similar. Therefore, the percent of plants not in compliance (stratified by Florida/Non-Florida) and compliance treatment technology selections projected for the large ground water plants were used for the medium ground water plants.

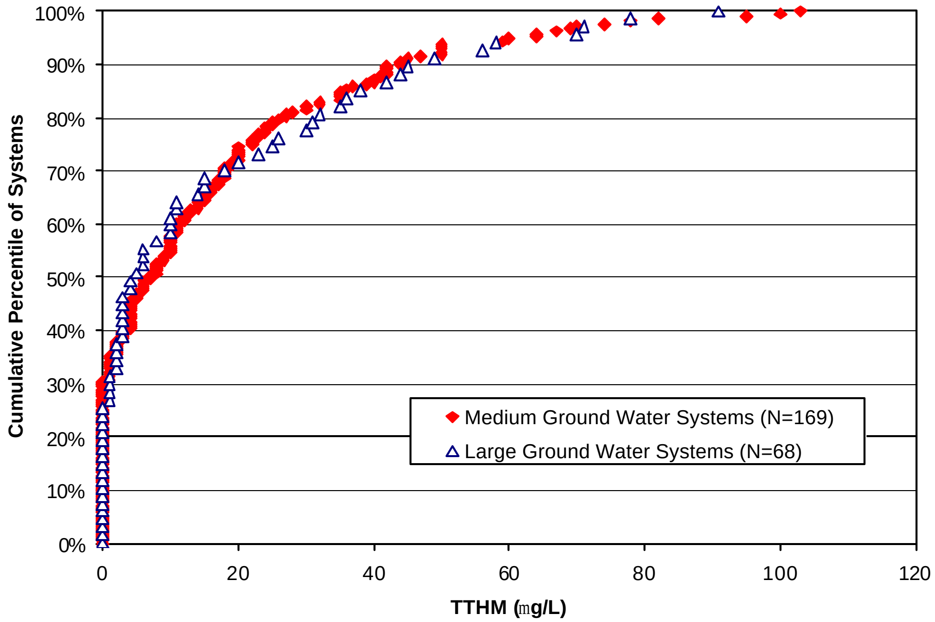
For more details on medium ground water systems, refer to Chapter 3 of *Stage 2 Occurrence Assessment for Disinfectants and Disinfection Byproducts* (USEPA 2005k).

Exhibit B.2 Annual Average Raw Water TOC for Medium and Large Ground Water Systems



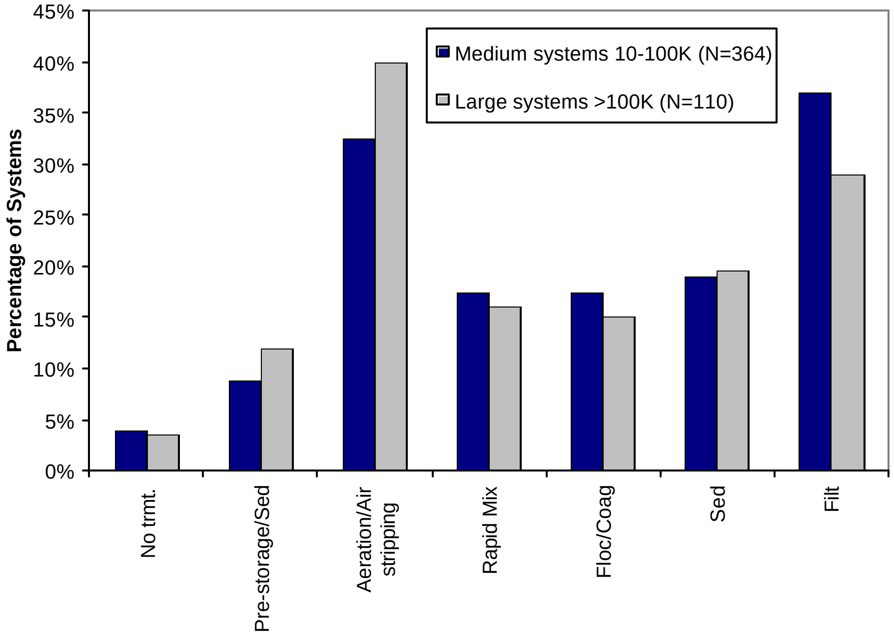
Source: WATER:\STATS (AWWA 2000).

Exhibit B.3 Annual Average Finished Water TTHM for Medium and Large Ground Water Systems



Source: WATER:\STATS (AWWA 2000).

Exhibit B.4 Treatment Technology Summary for Medium and Large Ground Water Systems (Chlorinating and Non-Chlorinating)



Source: WATER:\STATS (AWWA 2000).

B.2.2 Uncertainties in Compliance Forecasts for Medium and Large Ground Water Systems

There are uncertainties in the ground water compliance forecast. Only 130 ICR ground water plants were used for the Ground Water Delphi process. This only 2 percent of the roughly 8,400 medium and large disinfection ground water systems to which these estimates directly apply. In addition, the Ground Water Delphi is based on expert opinion, and is not as reproducible as the SWAT predictions used for the surface water compliance forecast. It is unknown as to whether expert opinion is more or less accurate than a model, although independent Delphi Polls for the surface water systems found agreement between the two methods.

B.2.3 Estimating the Percentage of Systems Not in Compliance

Total Percent Plants not in Compliance from ICR Data

ICR data (USEPA 2000h) were evaluated to estimate the number of plants that would currently exceed MCL requirements of the Stage 1 DBPR and each of the Stage 2 DBPR regulatory alternatives.[1] Plants were initially classified as not in compliance if ICR data showed that they exceeded the MCLs, taking into account a 20 percent safety margin for all alternatives. For example, the Preferred Alternative for the Stage 2 DBPR is 80 µg/L measured as an LRAA for TTHM and 60 µg/L measured as an LRAA for HAA5. Compliance, therefore, is evaluated at 64 µg/L for TTHM and 48 µg/L for HAA5, both measured as LRAAs.

Next, EPA checked to see if water from ground water plants was being blended with water from surface water plants in the distribution system. This may have resulted in higher TTHM and HAA5 concentrations than would normally be associated with an individual ground water plant. If plants with blended water were included in the compliance forecast assessment, the percent of ground water plants not in compliance may be overstated. Therefore, ground water plants that had a surface water plant with the same public water system ID number were considered in compliance for all regulatory alternatives (i.e., compliance would most likely be achieved by modifying the surface water plant rather than the ground water plant).

For regulatory alternatives based on LRAA and RAA calculations, EPA further reviewed ICR data to evaluate the variance in individual distribution system measurements. Influent water quality does not typically fluctuate in ground water systems as much as it does in surface water systems. Distribution system TTHM and HAA5 concentrations may not vary much, and, thus, some ground water systems may not need a safety margin as large a 20 percent. EPA evaluated the SH value of each system predicted to be out of compliance. If the SH value was below the true regulatory limit (without the safety margin), EPA assumed that it was unlikely that the ground water plant would add a treatment technology to comply with the rule. These plants were considered in compliance for all regulatory alternatives. Exhibit B.5 shows an example of two plants (ICR plants 281 and 287) that were initially considered not in

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[1] A total of 130 large ground water plants were evaluated using the last 12 months of ICR data. Based on data in the ICR applicability database, there is a higher total number of ground water plants in large systems than contained in the ICR (see Chapter 4 for the baseline number of large plants used in this analysis). These plants were not included in the ICR as they were medium or small plants (serving fewer than 100,000 people). The EA accounted for this discrepancy by using the total plant estimate from the ICR applicability database to adjust the flow per plant for large ground water systems.

compliance (based on 20 percent safety margin), but were changed to in compliance based on their SH values.

Exhibit B.5 Evaluation of RAA, LRAA and SH (µg/L)

ICR	RAA*		LRAA*		SH*	
WTPID	TTHM	HAA5	TTHM	HAA5	TTHM	HAA5
281	54.4	10.8	64.6	11.5	75.4	16.0
287	59.8	37.4	66.3	44.6	75.7	46.5

Source: ICR Aux 1 (USEPA 2000h), 12 months of data.

Florida/Non-Florida Stratification

EPA evaluated the regional characteristics of those plants exceeding MCLs for each alternative. Large ground water plants in Florida comprise the majority of large ground water plants predicted to be out of compliance with all regulatory scenarios. However, the national proportion of ground water systems in Florida is lower than in the ICR data. This is because Florida requires their ground water systems to disinfect their water due to the high influent TOC concentrations (see Chapter 3 for a discussion of regional impacts). To avoid inappropriately extrapolating national estimates of non-compliance from the heavily Florida-weighted ICR results, EPA evaluated Florida and Non-Florida plants separately and then aggregated the results together to produce national estimates. Below is a step-by-step explanation of how the percent of plants not in compliance was calculated using the Florida/Non-Florida stratification.

Step 1: Determine the baseline number of Florida and Non-Florida ground water plants

Exhibit B.6 shows the number of plants by size category, presented separately for Florida and Non-Florida plants. The total number of Florida ground water systems was derived from SDWIS (USEPA 2003t). EPA assumes that all Florida ground water systems disinfect (USEPA 1996a). Also, surface water systems in Florida that derive the majority of their flow from ground water were moved to the Florida primarily ground water source category (see Chapter 3 for an explanation of how EPA altered system inventories so that they are classified by primary water source). Numbers of systems were converted to numbers of plants using plant per system ratios presented in Chapter 3, with the exception of the systems serving 100,000 to 1 million people. The ICR Applicability database was used to determine the relative plants per system ratio for Florida/Non-Florida systems. The analysis showed that Florida systems had a lower plant per system ratio than Non-Florida systems. The national plant per system number was weighted to incorporate this difference.

Step 2 : Estimate the percent of plants not in compliance in Florida

The percent of plants not in compliance in Florida was based on an evaluation of ICR ground water plant data for non-surface water influenced plants (as previously noted, ground water distribution systems were determined to be potentially under the influence of surface water if systems included a surface water plant). The percent not in compliance is applied to the baseline of both large and medium plants.

Step 3: *Estimate the percent of plants not in compliance outside of Florida*

The percent of non-Florida plants not in compliance was based on an evaluation of ICR ground water plant data for non-surface water influenced plants. The same methodology was used, as described in Step 2, to obtain the percent plants not in compliance for Non-Florida plants. This percentage was applied to both medium and large plants.

Step 4: Estimate the total national percent of plants not in compliance

For each medium and large size category, the total number of plants not in compliance was estimated by multiplying the percentages in Steps 2 and 3 by the baseline numbers from Exhibit B.6 of Florida and non-Florida plants, respectively. The Florida and non-Florida plants not in compliance were then summed and divided by the total number of plants (Florida plus non-Florida). By using this method, EPA was able to estimate a more accurate national percentage of plants out of compliance with the Stage 2 DBPR.

Exhibits B.7 through B.11 present a summary of the Florida/non-Florida stratification described above for the Stage 1 DBPR, Stage 2 DBPR Preferred Alternative for 20 percent safety margin, Alternatives 2 and 3, and the Bounding Alternative 4, respectively. Results are presented for both large and medium ground water systems. Regulatory Alternative 1 (80/60 µg/L LRAA with reduced Bromate MCL of 5 µg/L) is not presented separately; the results for that case are equivalent to the Preferred Alternative (Exhibit B.8), because the Delphi Group assumed that no ground water plants would use ozone with an MCL of 5 ppb.

Exhibit B.6a Baseline Number of Florida and Non-Florida Plants, CWSs

System Size (Population Served)	Florida						Non-Florida		
	Number of Disinfecting GW Systems	Number of SW/GWUDI Systems	Percent SW/GWUDI that are Primarily Ground Water	Number of Disinfecting Systems, Primarily GW	Plants Per System	Number of Plants	Number of Disinfecting Systems, Primarily GW	Plants Per System	Number of Plants
	A	B	C	D = A+B*C	E	F = D*E	G	H	I = G*H
<100	416	2	3.70%	416	1.0	424	5,881	1.0	5,999
100-499	650	2	9.60%	650	1.3	858	10,897	1.3	14,384
500-999	184	2	0.00%	184	1.5	276	3,878	1.5	5,817
1,000-3,299	258	7	5.90%	258	1.6	413	4,484	1.6	7,174
3,300-9,999	135	6	12.00%	136	2.1	280	2,306	2.1	4,750
10,000-49,999	147	8	10.00%	148	4.0	591	1,198	4.0	4,791
50,000-99,999	39	1	8.90%	39	4.9	192	107	4.9	525
100,000-999,999	21	8	14.00%	22	4.6	101	79	10.4	817
≥1,000,000	1	0	0.00%	1	9.1	9	2	9.1	18
Total	1,851	36		1,854	1.7	3,145	28,831	1.5	44,275

Exhibit B.6b Baseline Number of Florida and Non-Florida Plants, NTNCWSs

System Size (Population Served)	Florida						Non-Florida		
	Number of Disinfecting GW Systems	Number of SW/GWUDI Systems	Percent SW/GWUDI that are Primarily Ground Water	Number of Disinfecting Systems, Primarily GW	Plants Per System	Number of Plants	Number of Disinfecting Systems, Primarily GW	Plants Per System	Number of Plants
	A	B	C	D = A+B*C	E	F = D*E	G	H	I = G*H
<100	626	0	0.00%	626	1.0	626	1,867	1.0	1,867
100-499	298	0	0.00%	298	1.0	298	1,831	1.0	1,831
500-999	81	1	0.00%	81	1.0	81	508	1.0	508
1,000-3,299	32	0	0.00%	32	1.0	32	215	1.0	215
3,300-9,999	5	0	0.00%	5	1.0	5	16	1.0	16
10,000-49,999	2	0	0.00%	2	1.0	2	1	1.0	1
50,000-99,999	0	0	0.00%	0	1.0	0	0	1.0	0
100,000-999,999	0	0	0.00%	0	1.0	0	0	1.0	0
≥1,000,000	0	0	0.00%	0	1.0	0	0	1.0	0
Total	1,044	1		1,044	1.0	1,044	4,439	1.0	4,439

Note: Detail may not add due to independent rounding.

Sources:

(A & B) SDWIS 4th quarter freeze (2003).

(C) Florida surface water systems are moved to the Florida GW system category if > 50% of their flow comes from GW. The percentages from Exhibit 3.4, Column F were used to approximate percentages for Florida.

(E & H) Plants per system for Florida were assumed to be equal to plants per system found in Exhibit 3.4, Column L, except for systems serving ≥100,000. For large systems, ICR data was evaluated to determine if the number of GW plants/system was lower in Florida because they have so many large ground water plants. The relationship of plants/system from ICR data was maintained for the national analysis (in other words, the ratio of plants per system of Florida systems to non-Florida systems was used to adjust the entry point estimates.

(G) The number of disinfecting, primarily GW systems is from the Exhibit 3.4, minus the number of disinfecting ground water systems in Florida from Column A.

Exhibit B.7 Percentage of Plants Not In Compliance with the Stage 1 DBPR (80/60 RAA)

Stage 1
80 µg/L TTHM RAA, 60 µg/L HAA5 RAA,
10 µg/L Bromate RAA

Florida

System Size (Population Served)	Number of Plants	Number of ICR Plants Not Complying with Stage 1	Percent of Florida Plants Not Complying with Stage 1	
	A	**B**	**C = B/33**	
10,000-49,999	591	8	24%	
50,000-99,999	192	8	24%	
100,000-999,999	101	8	24%	
>=1,000,000	9	8	24%	

Non-Florida

System Size (Population Served)	Number of Plants	Number of ICR Plants Not Complying with Stage 1	Percent of Non-Florida Plants Not Complying with Stage 1	
	D	**E**	**F = E/97**	
10,000-49,999	4791	0	0%	
50,000-99,999	525	0	0%	
100,000-999,999	817	0	0%	
>=1,000,000	18	0	0%	

National

System Size (Population Served)	Number of All Plants	Number of ICR Plants Not Complying with Stage 1	Percent of All Plants Not Complying with Stage 1	**Total Percentage Not Complying**
	G=A+D	**H = B+E**	**I=((A*C)+(D*F))/G**	**J =SumProduct(G*I)/Sum(G)**
10,000-49,999	5,382	8	3%	**3.1%**
50,000-99,999	716	8	6%	
100,000-999,999	918	8	3%	**2.8%**
>=1,000,000	27	8	8%	

Note: Totals may not add due to independent rounding.

Sources: A & D from Exhibit B.6.
B, C, E, & F are based on evaluation of ICR data for ground water plants without surface water influence. Note that a total of 33 ICR Florida plants and 97 ICR non-Florida plants were evaluated.

Exhibit B.8 Percentage of Plants Not In Compliance with the Preferred Alternative, 20 Percent Safety Margin (80/60 LRAA)

Stage 2, Preferred Option
80 µg/L TTHM LRAA, 60 µg/L HAA5 LRAA,
10 µg/L Bromate RAA

Florida

System Size (Population Served)	Number of Plants	Number of ICR Plants Not Complying with Stage 2	Percent of Florida Plants Not Complying with Stage 2
	A	**B**	**C = B/33**
10,000-49,999	591	11	33%
50,000-99,999	192	11	33%
100,000-999,999	101	11	33%
>=1,000,000	9	11	33%

Non-Florida

System Size (Population Served)	Number of Plants	Number of ICR Plants Not Complying with Stage 2	Percent of Non-Florida Plants Not Complying with Stage 2
	D	**E**	**F = E/97**
10,000-49,999	4791	1	1%
50,000-99,999	525	1	1%
100,000-999,999	817	1	1%
>=1,000,000	18	1	1%

National

System Size (Population Served)	Number of All Plants	Number of ICR Plants Not Complying with Stage 2	Percent of All Plants Not Complying with Stage 2	**Total Percentage Not Complying**
	G=A+D	**H = B+E**	**I=((A*C)+(D*F))/G**	**J =SumProduct(G*I)/Sum(G)**
10,000-49,999	5,382	12	5%	**5.2%**
50,000-99,999	716	12	10%	
100,000-999,999	918	12	5%	**4.8%**
>=1,000,000	27	12	12%	

Note: Totals may not add due to independent rounding.

Sources: A & D from Exhibit B.6.
B, C, E, & F are based on evaluation of ICR data for ground water plants without surface water influence. Note that a total of 33 ICR Florida plants and 97 ICR non-Florida plants were evaluated.

Exhibit B.9 Percentage of Plants Not In Compliance with Regulatory Alternative 2 (80/60 SH)

Stage 2, Alternative 2 80 µg/L TTHM SH, 60 µg/L HAA5 SH, 10 µg/L Bromate RAA				
Florida				
System Size (Population Served)	Number of Plants	Number of ICR Plants Not Complying with Stage 2	Percent of Florida Plants Not Complying with Stage 2	
	A	**B**	**C = B/33**	
10,000-49,999	591	19	58%	
50,000-99,999	192	19	58%	
100,000-999,999	101	19	58%	
>=1,000,000	9	19	58%	
Non-Florida				
System Size (Population Served)	Number of Plants	Number of ICR Plants Not Complying with Stage 2	Percent of Non-Florida Plants Not Complying with Stage 2	
	D	**E**	**F = E/97**	
10,000-49,999	4791	3	3%	
50,000-99,999	525	3	3%	
100,000-999,999	817	3	3%	
>=1,000,000	18	3	3%	
National				
System Size (Population Served)	Number of All Plants	Number of ICR Plants Not Complying with Stage 2	Percent of All Plants Not Complying with Stage 2	**Total Percentage Not Complying**
	G=A+D	**H = B+E**	**I=((A*C)+(D*F))/G**	**J =SumProduct(G*I)/Sum(G)**
10,000-49,999	5,382	22	9%	**10.1%**
50,000-99,999	716	22	18%	
100,000-999,999	918	22	9%	**9.5%**
>=1,000,000	27	22	21%	

Note: Totals may not add due to independent rounding.

Sources: A & D from Exhibit B.6.
B, C, E, & F are based on evaluation of ICR data for ground water plants without surface water influence. Note that a total of 33 ICR Florida plants and 97 ICR non-Florida plants were evaluated.

Exhibit B.10 Percentage of Plants Not In Compliance with Regulatory Alternative 3 (40/30 RAA)

Stage 2, Alternative 3
40 µg/L TTHM RAA, 30 µg/L HAA5 RAA,
10 µg/L Bromate RAA

Florida

System Size (Population Served)	Number of Plants	Number of ICR Plants Not Complying with Stage 2	Percent of Florida Plants Not Complying with Stage 2
	A	**B**	**C = B/33**
10,000-49,999	591	18	55%
50,000-99,999	192	18	55%
100,000-999,999	101	18	55%
>=1,000,000	9	18	55%

Non-Florida

System Size (Population Served)	Number of Plants	Number of ICR Plants Not Complying with Stage 2	Percent of Non-Florida Plants Not Complying with Stage 2
	D	**E**	**F = E/97**
10,000-49,999	4791	1	1%
50,000-99,999	525	1	1%
100,000-999,999	817	1	1%
>=1,000,000	18	1	1%

National

System Size (Population Served)	Number of All Plants	Number of ICR Plants Not Complying with Stage 2	Percent of All Plants Not Complying with Stage 2	**Total Percentage Not Complying**
	G=A+D	**H = B+E**	**I=((A*C)+(D*F))/G**	**J =SumProduct(G*I)/Sum(G)**
10,000-49,999	5,382	19	7%	**7.9%**
50,000-99,999	716	19	15%	
100,000-999,999	918	19	7%	**7.3%**
>=1,000,000	27	19	19%	

Note: Totals may not add due to independent rounding.

Sources: A & D from Exhibit B.6.
B, C, E, & F are based on evaluation of ICR data for ground water plants without surface water influence. Note that a total of 33 ICR Florida plants and 97 ICR non-Florida plants were evaluated.

Exhibit B.11 Percentage of Plants Not In Compliance with Bounding Alternative 4 (40/30 SH)

Stage 2, Alternative 4 40 µg/L TTHM SH, 30 µg/L HAA5 SH, 10 µg/L Bromate RAA				
Florida				
System Size (Population Served)	Number of Plants	Number of ICR Plants Not Complying with Stage 2	Percent of Florida Plants Not Complying with Stage 2	
	A	**B**	**C = B/33**	
10,000-49,999	591	27	82%	
50,000-99,999	192	27	82%	
100,000-999,999	101	27	82%	
>=1,000,000	9	27	82%	
Non-Florida				
System Size (Population Served)	Number of Plants	Number of ICR Plants Not Complying with Stage 2	Percent of Non-Florida Plants Not Complying with Stage 2	
	D	**E**	**F = E/97**	
10,000-49,999	4791	8	8%	
50,000-99,999	525	8	8%	
100,000-999,999	817	8	8%	
>=1,000,000	18	8	8%	
National				
System Size (Population Served)	Number of All Plants	Number of ICR Plants Not Complying with Stage 2	Percent of All Plants Not Complying with Stage 2	**Total Percentage Not Complying**
	G=A+D	**H = B+E**	**I=((A*C)+(D*F))/G**	**J =SumProduct(G*I)/Sum(G)**
10,000-49,999	5,382	35	16%	**17.7%**
50,000-99,999	716	35	28%	
100,000-999,999	918	35	16%	**16.8%**
>=1,000,000	27	35	33%	

Note: Totals may not add due to independent rounding.

Sources: A & D from Exhibit B.6.
B, C, E, & F are based on evaluation of ICR data for ground water plants without surface water influence. Note that a total of 33 ICR Florida plants and 97 ICR non-Florida plants were evaluated.

B.2.4 Treatment Technology Selection

Original "Bounding" Alternatives

The Delphi Group used a multi-step process to develop the compliance forecasts for those large ground water plants out of compliance with the four original regulatory alternatives.

First, the Delphi participants were given ICR data (such as plant type, residual disinfectant, and water quality) for ground water plants unable to meet the MCLs of each alternative. Second, Delphi participants selected a treatment technology from a list of 16 treatment technologies and a residual disinfectant (chlorine or chloramines) for each plant and rated their confidence in their treatment technology selections. Judging by the response provided, it appears that each participant focused on different information to select the treatment technology required by each plant. Some participants gave greater importance to water quality aspects, while others emphasized design issues. There were four general approaches that appear to have guided the participants selections:

- Assess the use of chloramines–If the use of chloramines is not feasible, then look for another treatment technology that better addresses ground water-specific needs, such as multiple small entry points. Evaluate whether these entry points would be best served by treatment technologies such as nanofiltration (NF) and Granular Activated Carbon (GAC) rather than an advanced oxidant (ozone).

- Always maintain a consistent residual in the distribution system–If other plants in the system use chlorine as a residual, the plant cannot select chloramines as its treatment technology. In addition, chloramines cannot be selected when TOC is above a certain level.

- Microfiltration/ultrafiltration (MF/UF) cannot be selected as a treatment technology because ground water plants are not subject to the high removal or inactivation requirements of surface water plants. Other treatment technologies are selected as needed.

- Assess how far the plant is from compliance with the MCLs. Determine whether the plant already uses chloramines. If chloramines are not used, and up to a 20 to 30 percent reduction of DBPs results in compliance, select chloramines as the final treatment technology. If chloramines cannot be used based on specific water quality conditions, eliminate treatment technologies that are not feasible and select the least expensive treatment technology that meets the compliance criteria.

Third, the completed treatment technology selection results from each participant were aggregated. Quality control and quality assurance steps were performed to ensure a consistent and usable data entry format. For example, notes provided by each participant were checked against the treatment technologies they selected to ensure they were consistent. In many cases, multiple treatment technologies were selected by a participant for one plant. In these circumstances, most expensive treatment technology was chosen as a conservative estimate. A Microsoft Access™ database was used to consolidate the participants' responses. Finally, the results were weighted, with higher confidence responses receiving an additional weighting of 25 percent.

The Delphi process concluded that ground water systems that could not comply with the levels specified in the Regulatory Alternative would choose primarily from four advanced treatment technologies:

- Conventional treatment (with chloramines)
- Advanced disinfectants (ozone)
- GAC with an empty bed contact time of 20 minutes (GAC20)
- NF

The use of chloramines with each treatment technology also was calculated for these four advanced treatment technologies. Exhibit B.12 presents the proportion of treatment technologies predicted by the Delphi Group to be selected for the four bounding alternatives. The Delphi results from the bounding alternatives were also used to develop treatment technology selections for the additional regulatory alternatives (discussed later in this appendix).

Additional Regulatory Alternatives

Following the initial Delphi process, the Microbial-Disinfectants and Disinfection Byproducts Advisory Committee (M-DBP Advisory Committee) asked the Delphi group to consider regulatory alternatives in addition to the original “bounding” alternatives. These new alternatives considered a bromate MCL, as well as TTHM and HAA5 MCLs. Two of these new alternatives were considered in this EA (the Preferred Regulatory Alternative and Alternative 1).

Because these alternatives were identified late in the process, the Delphi group decided not to repeat the full evaluation to develop new treatment technology selections (a time-consuming process), but instead evaluated the new alternatives using the treatment technology selections for the original four alternatives. A straight interpolation between the 80/60 RAA (the Stage 1 DBPR) and the 40/30 RAA (Regulatory Alternative 3) was originally used to estimate the treatment technology selection for the 80/60 LRAA alternative. However, EPA later estimated that because water quality in ground water plants does not generally fluctuate as much as it does in surface water plants and they monitor at only one point for Stage 1, treatment technologies identified for the 80/60 RAA would most likely be appropriate for maintaining an 80/60 LRAA. Therefore, the treatment technology selection for the subset of plants not in compliance with the 80/60 RAA was maintained for the 80/60 LRAA alternative. A straight interpolation between the 80/60 RAA and the 40/30 RAA regulatory alternatives was used to estimate the treatment technology selection for all other alternatives (i.e., those complying with 80/60 RAA but not 80/60 LRAA).

Final Results

The percentage of plants not in compliance (Exhibits B.7 through B.11) is multiplied by the proportion of plants predicted to select various treatment technologies. This gives the final treatment technology selection results for each regulatory alternative and sensitivity analyses (Bounding Alternative 4 is not included). Exhibit B.13a presents results for large ground water plants, and B.13b presents results for medium ground water plants.

For Regulatory Alternative 1, the compliance forecast was adjusted so that the compliance forecast delta from Stage 1 to Stage 2 did not show any systems removing treatment technologies (negative forecasts). This is consistent with the methodology used for surface water system compliance forecasts.

Exhibit B.12 Proportion of Treatment Technologies Selected by Non-compliant Large Ground Water Plants as Predicted by the Delphi Group

Scenario	Converting to CLM only	Advanced Disinfectants	Advanced Disinfectants + CLM	GAC20	GAC20 + CLM	NF	NF + CLM	Total
	A	B	C	D	E	F	G	H = SUM(A:G)
Bounding Alternative 1: RAA 80/60 (Stage 1)	59.3%	2.5%	24.8%	0.0%	1.3%	4.0%	8.2%	100.00%
Bounding Alternative 2: RAA 40/30 (Regulatory Alternative 3)	69.5%	2.6%	7.9%	0.0%	8.5%	0.9%	10.6%	100.00%
Bounding Alternative 3: SH 80/60 (Regulatory Alternative 2)	77.5%	2.1%	7.4%	0.0%	4.5%	0.7%	7.8%	100.00%
Bounding Alternative 4: SH 40/30	63.5%	4.1%	9.5%	1.0%	8.5%	1.9%	11.6%	100.00%
2. Extrapolation for Preferred Alternative and Regulatory Alternative 1								
Alternative 5: LRAA 80/60 (Preferred Regulatory Alternative)	62.7%	2.5%	19.2%	0.0%	3.7%	3.0%	9.0%	100.0%
Alternative 6: LRAA 80/60, reduced Bromate MCL of 5 ug/L (Regulatory Alternative 1)	62.7%	0.0%	0.0%	1.0%	11.5%	4.5%	20.3%	100.0%

Notes: Totals may not add due to rounding.
The original Delphi Group Results were adjusted slightly form the original numbers reported during the Technical Working Group (TWG), to make the total equal to 100 percent.

Sources: ICR Ground Water Delphi Group Results

Exhibit B.13a Final Treatment Technology Selection Results for Large Ground Water Plants
Stage 2 Regulatory Alternatives

Regulatory Alternative	Converting to CLM Only	Advanced Disinfectants	Advanced Disinfectants + CLM	GAC20	GAC20 + CLM	NF	NF + CLM	Total Percent Non-Complying
Stage 1 DBPR 80 µg/L TTHM RAA 60 µg/L HAA5 RAA	1.68%	0.07%	0.70%	0.00%	0.04%	0.11%	0.23%	2.83%
Unadjusted Stage 2 Preferred Alternative, 20% Safety Margin 80 µg/L TTHM LRAA 60 µg/L HAA5 LRAA	3.01%	0.12%	0.92%	0.00%	0.18%	0.14%	0.43%	4.80%
Alternative 1 80 µg/L TTHM LRAA 60 µg/L HAA5 LRAA 5 µg/L Bromate MCL	2.24%	0.07%	0.70%	0.05%	0.55%	0.22%	0.97%	4.80%
Alternative 2 80 µg/L TTHM SH 60 µg/L HAA5 SH	7.27%	0.20%	0.70%	0.00%	0.43%	0.11%	0.74%	9.45%
Alternative 3 40 µg/L TTHM RAA 30 µg/L HAA5 RAA	4.88%	0.19%	0.70%	0.00%	0.62%	0.11%	0.77%	7.28%

Sources: Percentage of plant not in compliance derived from Exhibits B.7 through B.12. Percentage of plants adding each treatment technology was calculated by multiplying the percentage of plants not in compliance by the proportion selecting each treatment technology (Exhibit B.13).

Notes:
[1] Totals may not add due to rounding.
[2] The treatment technology selection for Regulatory Alternative 1 was adjusted to ensure that the compliance forecast delta (compliance forecast for Alternative 1 minus the compliance forecast for the Stage 1 DBPR) did not have any negative predictions.
[3] The Preferred Alternative row in Exhibit B.13 is used for both Preferred Alternative safety margin rows in this exhibit.

Exhibit B.13b Final Treatment Technology Selection Results for Medium Ground Water Plants
Stage 2 Regulatory Alternatives

Regulatory Alternative	Converting to CLM Only	Advanced Disinfectants	Advanced Disinfectants + CLM	GAC20	GAC20 + CLM	NF	NF + CLM	Total Percent Non-Complying
Stage 1 DBPR 80 µg/L TTHM RAA 60 µg/L HAA5 RAA	1.84%	0.08%	0.77%	0.00%	0.04%	0.13%	0.26%	3.11%
Unadjusted Stage 2 Preferred Alternative, 20% Safety Margin 80 µg/L TTHM LRAA 60 µg/L HAA5 LRAA	3.24%	0.13%	0.99%	0.00%	0.19%	0.16%	0.47%	5.18%
Alternative 1 80 µg/L TTHM LRAA 60 µg/L HAA5 LRAA 5 µg/L Bromate MCL	2.40%	0.08%	0.77%	0.05%	0.60%	0.23%	1.05%	5.18%
Alternative 2 80 µg/L TTHM SH 60 µg/L HAA5 SH	7.73%	0.21%	0.77%	0.00%	0.45%	0.13%	0.79%	10.09%
Alternative 3 40 µg/L TTHM RAA 30 µg/L HAA5 RAA	5.29%	0.21%	0.77%	0.00%	0.67%	0.13%	0.84%	7.90%

Sources: Percentage of plant not in compliance derived from Exhibits B.7 through B.12. Percentage of plants adding each treatment technology was calculated by multiplying the percentage of plants not in compliance by the proportion selecting each treatment technology (Exhibit B.13).

Notes:
[1] Totals may not add due to rounding.
[2] The treatment technology selection for Regulatory Alternative 1 was adjusted to ensure that the compliance forecast delta (compliance forecast for Alternative 1 minus the compliance forecast for the Stage 1 DBPR) did not have any negative predictions.
[3] The Preferred Alternative row in Exhibit B.13 is used for both Preferred Alternative safety margin rows in this exhibit.

B.3 Compliance Forecast for Small Ground Water Plants

Because of differences in water quality, location, and economies of scale, the compliance treatment technologies predicted for large and medium plants do not represent those that small plants would select (see *Stage 2 Occurrence Assessment for Disinfectants and Disinfection Byproducts* (USEPA 2003l) for a comparison of large and small systems). Instead, EPA and experts on small water systems estimated compliance forecasts by beginning with the compliance forecasts for large plants and making adjustments based on expert knowledge and data evaluation. A discussion of the adjustments made to the large ground water system forecasts to produce the forecasts for small systems is presented in this section.

To further recognize differences in treatment technology use, treatment technology capability, and water quality among the small systems, the small ground water system group prepared compliance forecasts separately for the following size categories:

- Systems serving between 1,000 and 9,999 people

- Systems serving between 100 and 999 people

- Systems serving fewer than 100 people

Exhibit B.14 summarizes the derivation of the small ground water compliance forecast via a flowchart, consisting of two steps:

- Estimation of percent of plants not in compliance

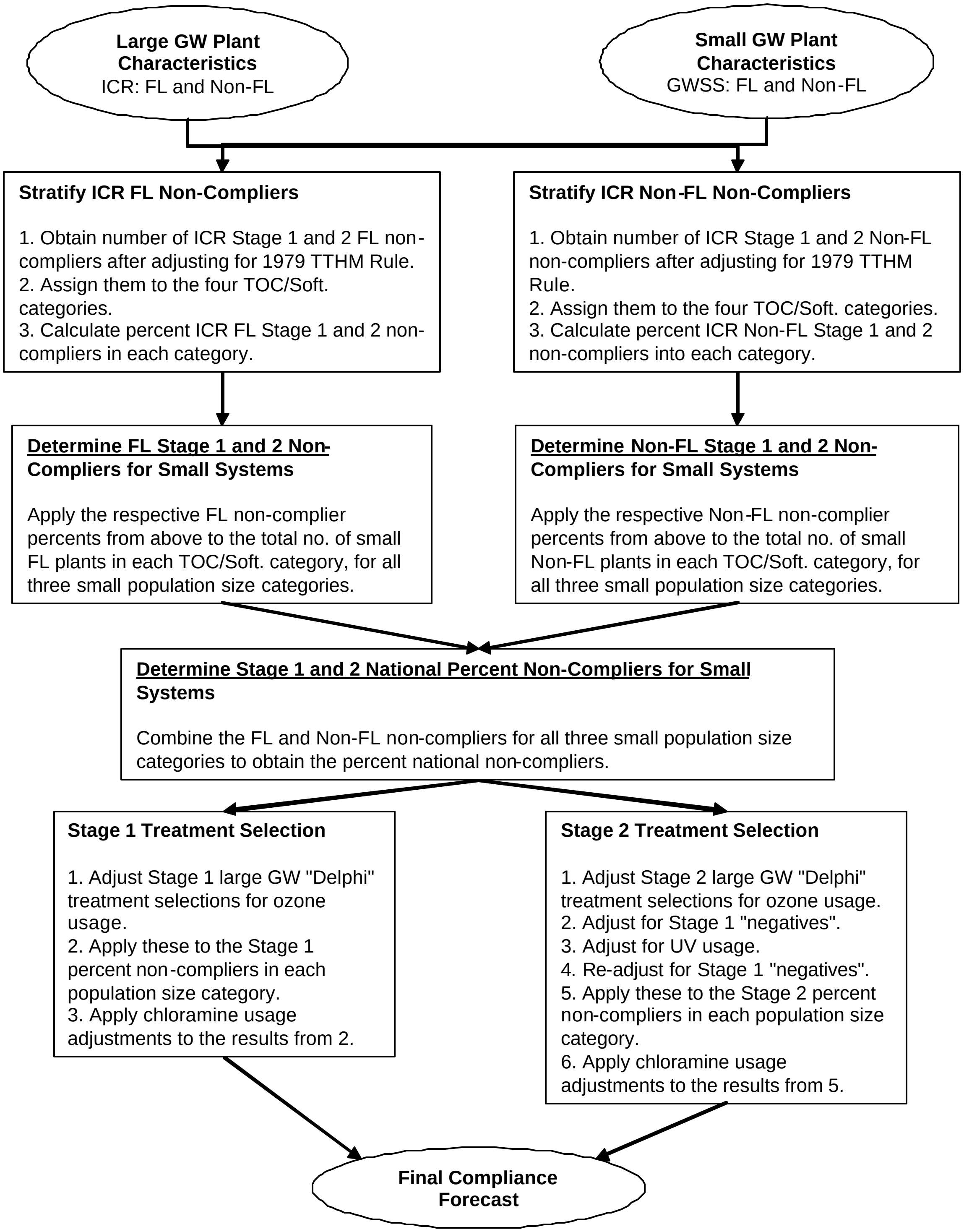
- Treatment technology forecasts for plants not in compliance

B.3.1 Estimation of Percent of Plants Not In Compliance

Exhibits B.7 through B.11 show the percent of large ground water systems that were judged to be not in compliance for each rule alternative, based on the evaluation of ICR data. Several adjustments were made to these estimates to make them applicable to small ground water plants.

Florida and Non-Florida stratification: One of the most significant influences on the regulatory alternatives considered was plant location. Florida systems (which have higher TOC levels than those of other States) account for a substantial fraction of all large ground water systems, whereas the proportion of all small ground water systems located in Florida is much smaller. Without adjusting for this, the national forecast of small ground water system non-compliance would be overstated. The large and small ground water systems were analyzed separately to the mitigate potential biases of the large system compliance and treatment technology forecasts.

Exhibit B.14 Compliance Forecast for Small Ground Water Plants



Large GW Plant Characteristics
ICR: FL and Non-FL

Small GW Plant Characteristics
GWSS: FL and Non-FL

Stratify ICR FL Non-Compliers

1. Obtain number of ICR Stage 1 and 2 FL non-compliers after adjusting for 1979 TTHM Rule.
2. Assign them to the four TOC/Soft. categories.
3. Calculate percent ICR FL Stage 1 and 2 non-compliers in each category.

Stratify ICR Non-FL Non-Compliers

1. Obtain number of ICR Stage 1 and 2 Non-FL non-compliers after adjusting for 1979 TTHM Rule.
2. Assign them to the four TOC/Soft. categories.
3. Calculate percent ICR Non-FL Stage 1 and 2 non-compliers into each category.

Determine FL Stage 1 and 2 Non-Compliers for Small Systems

Apply the respective FL non-complier percents from above to the total no. of small FL plants in each TOC/Soft. category, for all three small population size categories.

Determine Non-FL Stage 1 and 2 Non-Compliers for Small Systems

Apply the respective Non-FL non-complier percents from above to the total no. of small Non-FL plants in each TOC/Soft. category, for all three small population size categories.

Determine Stage 1 and 2 National Percent Non-Compliers for Small Systems

Combine the FL and Non-FL non-compliers for all three small population size categories to obtain the percent national non-compliers.

Stage 1 Treatment Selection

1. Adjust Stage 1 large GW "Delphi" treatment selections for ozone usage.
2. Apply these to the Stage 1 percent non-compliers in each population size category.
3. Apply chloramine usage adjustments to the results from 2.

Stage 2 Treatment Selection

1. Adjust Stage 2 large GW "Delphi" treatment selections for ozone usage.
2. Adjust for Stage 1 "negatives".
3. Adjust for UV usage.
4. Re-adjust for Stage 1 "negatives".
5. Apply these to the Stage 2 percent non-compliers in each population size category.
6. Apply chloramine usage adjustments to the results from 5.

Final Compliance Forecast

The 1979 TTHM Rule Adjustment: The percentage of small ground water plants not in compliance is expected to be greater than the percentage of large plants not in compliance because small plants have not had to meet the 1979 TTHM standards. As a proxy for estimating the additional number of small plants that would currently exceed regulatory targets, EPA assumed that large plants using chloramines and meeting regulatory targets probably would *not* have met the targets without chloramines. The percentage of these large plants (based on ICR data) not meeting the targets (adjusted to remove those plants with surface water influence) was used to obtain a more accurate estimate of the number of small systems not meeting the targets.

TOC/Softening Adjustment: The compliance forecast was further adjusted by taking into the account the differences in source water TOC levels and softening use in small plants compared to large plants.

Exhibit B.15 illustrates the procedure for obtaining the percent of plants not in compliance in small ground water universe using the ICR data for large ground water systems as a starting point. The descriptions of steps 1 through 5 in Exhibit B.15 are presented below.

Step 1) Obtain the number of ICR ground water plants not in compliance with Stage 1 and Stage 2 from Exhibits B.7 through B.11. Using this percentage yields a net increase (delta) of plants changing treatment technology from Stage 1 to Stage 2 of 3.08% for all size categories. However, the ICR data, as stated previously is comprised of a greater proportion of ground water plants from Florida than exist in the nation as a whole, especially when compared to small ground water systems.

Step 2) Next, both the number of ICR ground water plants and small ground water plants are stratified into a Florida or non-Florida category. This step is done because Florida ground waters typically have higher DBP precursor levels compared to other states, and Florida has a proportionately higher number of ICR ground water plants compared to other states. This simple stratification lowers the delta to 1.48 percent, a little more than half of the percentage obtained during Step 1.

Step 3) Next, we need to take in several factors that make small ground water plants unique from medium and large ground water plants. Small ground water plants were not subject to the 1979 TTHM Rule whereas medium and large ground water plants were subject to the rule. In order to adjust for this fact, EPA assumed that large ground water plants that used chloramines did so to meet the 1979 TTHM rule, and thus were added to plants out of compliance with Stage 1 and Stage 2.

Step 4) Next we take into account the differences in treatment and influent water quality between ICR ground water plans and small ground water plants. We do this by stratifying both lare and small plants according to whether or not they have softening, and by TOC concentration (TOC< 1 mg/L, or TOC > 1 mg/L). Softening adjustments increase the delta to 1.82%The inclusion of TOC helps separate plants that have high TOC from those without, as high TOC is a leading factor in increased DBP levels. Adding TOC to the adjustments made in Step 3 raises the delta to 2.35 percent.

Step 5) Finally, all factors (Florida, Chloramine compliers, Softening, TOC) are combined to create the final percent of plants not complying. The delta after this method is 2.90 percent. Exhibit

B.15 also shows the breakout of plants not in compliance for all three population categories combined.

Exhibit B.15 Steps for Estimating National Percentage of Plants Not in Compliance for Small Ground Water Systems

Step 1) Initial ICR GW Non Complying Extrapolation

ICR GW Plants	ICR GW Noncompliers - Stage 1	ICR GW Noncompliers - Stage 2
A	B	C
130	8	12

System Size (Population Served)	# of All Plants	% of All Plants Not Complying with Stage 1	# of All Plants Not Complying with Stage 1	% of All Plants Not Complying with Stage 2	# of All Plants Not Complying with Stage 2	Stage 2 to Stage 1 Delta	
	D	E=B/A	F=D*E	G=C/A	H=D*G	I = G-E	J=I/D
<100	6,423	6.15%	395	9.23%	593	198	3.08%
100-999	21,336	6.15%	1,313	9.23%	1,969	656	3.08%
1,000-9,999	12,617	6.15%	776	9.23%	1,165	388	3.08%
Total	40,376		2,485		3,727	1,242	3.08%

Sources: (A-C) ICR Aux 1 Database.
(D) Exhibit 3.2, Column AB

Step 2) Florida/Non-Florida Stratification (FL)

ICR Plants Total		ICR GW Noncompliers - Stage 1		ICR GW Noncompliers - Stage 2	
Florida	Non-Florida	Florida	Non-Florida	Florida	Non-Florida
A	B	C	D	E	F
33	97	8	0	11	1

System Size (Population Served)	Florida Plants			Non-Florida Plants			Plants Not Complying with Stage 1	Plants Not Complying with Stage 2	Stage 2 to Stage 1 Delta	
	Number of Plants	% Not Complying with Stage 1	% Not Complying with Stage 2	Number of Plants	% Not Complying with Stage 1	% Not Complying with Stage 2				
	G	H=C/A	I=E/A	J	K=D/B	L=F/B	M=G*H+J*K	N=G*I+J*L	O=N-M	P=O/G
<100	424	24.24%	33.33%	5,999	0.00%	1.03%	103	203	100	1.48%
100-999	1,134	24.24%	33.33%	20,201	0.00%	1.03%	275	586	311	
1,000-9,999	693	24.24%	33.33%	11,924	0.00%	1.03%	168	354	186	
Total	2,252			38,124			546	1,144	598	1.48%

Sources: (A-B) ICR Aux 1 Database.
(C) Exhibit B.7, column B.
(D) Exhibit B.7, column E.
(E) Exhibit B.8, column B.
(F) Exhibit B.8, column E.
(G) Exhibit B.6a, Column F
(J) Exhibit B.6a, Column I

Exhibit B.15 Steps for Estimating National Percentage of Plants Not in Compliance for Small Ground Water Systems (continued)

Step 3) Inclusion of ICR GW Compliers using Chloramines

	ICR Plants Total		ICR GW Noncompliers - Stage 1		ICR GW Noncompliers - Stage 2	
	Florida	Non-Florida	Florida	Non-Florida	Florida	Non-Florida
	A	B	C	D	E	F
ICR Noncompliers	33	97	8	0	11	1
ICR CLM Compliers			9	2	9	2

System Size (Population Served)	Florida Plants			Non-Florida Plants			Plants Not Complying with Stage 1	Plants Not Complying with Stage 2	Stage 2 to Stage 1 Delta	
	Number of Plants	% Not Complying with Stage 1	% Not Complying with Stage 2	Number of Plants	% Not Complying with Stage 1	% Not Complying with Stage 2				
	G	H=(C1+C2)/A	I=(E1+E2)/A	J	K=(D1+D2)/B	L=(F1+F2)/B	M=G*H+J*K	N=G*I+J*L	O=N-M	P=O/(G+J)
<100	424	51.52%	60.61%	5,999	2.06%	3.09%	342	443	100	1.56%
100-999	1,134	51.52%	60.61%	20,201	2.06%	3.09%	1001	1312	311	1.46%
1,000-9,999	693	51.52%	60.61%	11,924	2.06%	3.09%	603	789	186	1.47%
Total	2,252			38,124			1,946	2,544	598	1.48%

Sources:
(A-B) ICR Aux 1 Database.
(C) Exhibit B.7, column B for noncompliers, ICR chloramine compliers derived from the ICR database.
(D) Exhibit B.7, column E for noncompliers, ICR chloramine compliers derived from the ICR database.
(E) Exhibit B.8, column B for noncompliers, ICR chloramine compliers derived from the ICR database.
(F) Exhibit B.8, column E for noncompliers, ICR chloramine compliers derived from the ICR database.
(G) Exhibit B.6a, Column F
(J) Exhibit B.6a, Column I

Step 4a) Inclusion of Softening/Non-Softening Stratification Only

Total ICR GW Plants				ICR GW Noncompliers - Stage 1				ICR GW Noncompliers - Stage 2			
Florida		Non-Florida		Florida		Non-Florida		Florida		Non-Florida	
Soft	Non-Softening	Soft	Non-Softening	Soft	Non-Softening	Soft	Non-Softening	Soft	Non-Softening	Soft	Non-Softening
A	B	C	D	E	F	G	H	I	J	K	L
14	19	4	93	12	5	1	1	12	8	1	2

System Size (Population Served)	Florida						Non-Florida						Plants Not Complying		Stage 2 to Stage 1 Delta	
	Total Plants	Percent Softening	% Not Complying with Stage 1		% Not Complying with Stage 2		Total Plants	Percent Softening	% Not Complying with Stage 1		% Not Complying with Stage 2					
			Soft	Non-Softening	Soft	Non-Softening			Soft	Non-Softening	Soft	Non-Softening	Stage 1	Stage 2	Plants	Percent
	M	N	O=E/A	P=F/B	Q=I/A	R=J/B	S	T	U=G/C	V=H/D	W=K/C	X=L/D	Y	Z	AA=Z-Y	AB=AA/(M+S)
<100	424	4.3%	85.71%	26.32%	85.71%	42.11%	5,999	3.9%	25.00%	1.08%	25.00%	2.15%	243	369	126	1.96%
100-999	1,134	4.0%	85.71%	26.32%	85.71%	42.11%	20,201	4.0%	25.00%	1.08%	25.00%	2.15%	737	1,117	380	1.78%
1,000-9,999	693	4.1%	85.71%	26.32%	85.71%	42.11%	11,924	4.1%	25.00%	1.08%	25.00%	2.15%	444	672	228	1.81%
Total	2,252	4.1%					38,124	4.0%					1,425	2,159	734	1.82%

Sources:
(A-L) ICR Aux 1 Database.
(M) Exhibit B.6a, Column F
(N) Derived from the GWSS 1983 data.
(S) Exhibit B.6a, Column I
(T) Derived from the GWSS 1983 data.
(Y) M*N*O + M*(1-N)*P + S*T*U + S*(1-T)*V
(Z) M*N*Q + M*(1-N)*R + S*T*W + S*(1-T)*X

Exhibit B.15 Steps for Estimating National Percentage of Plants Not in Compliance for Small Ground Water Systems (continued)

Step 4b) Inclusion of TOC≤1/TOC>1 Stratification Only (FL+CLM+TOC)

Total ICR GW Plants				ICR GW Noncompliers - Stage 1				ICR GW Noncompliers - Stage 2			
Florida		Non-Florida		Florida		Non-Florida		Florida		Non-Florida	
TOC < 1	TOC > 1	TOC < 1	TOC > 1	TOC < 1	TOC > 1	TOC < 1	TOC > 1	TOC < 1	TOC > 1	TOC < 1	TOC > 1
A	B	C	D	E	F	G	H	I	J	K	L
5	28	78	19	0	17	0	2	0	20	0	3

System Size (Population Served)	Florida						Non-Florida						Total Plants Not Complying		Stage 2 to Stage 1 Delta	
	Total Plants	Percent with TOC <=1	% Not Complying with Stage 1		% Not Complying with Stage 2		Total Plants	Percent with TOC <=1	% Not Complying with Stage 1		% Not Complying with Stage 2					
			TOC ≤ 1	TOC > 1	TOC ≤ 1	TOC > 1			TOC ≤ 1	TOC > 1	TOC ≤ 1	TOC > 1	Stage 1	Stage 2	Plants	Percent
	M	N	O=E/A	P=F/B	Q=I/A	R=J/B	S	T	U=G/C	V=H/D	W=K/C	X=L/D	Y	Z	AA=Z-Y	AB=AA/(M+S)
<100	424	40.0%	0.00%	60.71%	0.00%	71.43%	5,999	69.1%	0.00%	10.53%	0.00%	15.79%	350	474	125	1.94%
100-999	1,134	38.5%	0.00%	60.71%	0.00%	71.43%	20,201	55.5%	0.00%	10.53%	0.00%	15.79%	1,370	1,918	548	2.57%
1,000-9,999	693	41.4%	0.00%	60.71%	0.00%	71.43%	11,924	62.8%	0.00%	10.53%	0.00%	15.79%	714	991	277	2.20%
Total	2,252	39.7%					38,124	59.9%					2,433	3,383	950	2.35%

Sources:
(A-L) ICR Aux 1 Database.
(M) Exhibit B.6a, Column F
(N) Derived from the GWSS 1983 data.
(T) Derived from the GWSS 1983 data.
(Y) M*N*O + M*(1-N)*P + S*T*U + S*(1-T)*V
(Z) M*N*Q + M*(1-N)*R + S*T*W + S*(1-T)*X

Step 5) Final Stratification by Florida/Non-Florida, TOC≤1/TOC>1 & Softening/Non-Softening Stratifications (FL+CLM+TOC+SOFT)

	Florida				Non-Florida			
	TOC ≤ 1		TOC > 1		TOC ≤ 1		TOC > 1	
	Soft	Non-Softening	Soft	Non-Softening	Soft	Non-Softening	Soft	Non-Softening
	A	B	C	D	E	F	G	H
Total ICR GW Plants	1	4	13	15	0	78	4	15
ICR Stage 1 Noncompliers	0	0	12	5	0	0	1	1
ICR Stage 2 Noncompliers	0	0	12	8	0	0	1	2

System Size (Population Served)	Florida												
	Total Plants	Percentages in Bins				% Not Complying with Stage 1				% Not Complying with Stage 2			
		TOC ≤ 1		TOC > 1		TOC ≤ 1		TOC > 1		TOC ≤ 1		TOC > 1	
		Soft	Non-Softening	Soft	Non-Softening	Soft	Non-Softening	Soft	Non-Softening	Soft	Non-Softening	Soft	Non-Softening
	I	J	K	L	M	N=A2/A1	O=B2/B1	P=C2/C1	Q=D2/D1	R=A3/A1	S=B3/B1	T=C3/C1	U=D3/D1
<100	424	0.0%	40.0%	4.3%	55.7%	0.00%	0.00%	92.31%	33.33%	0.00%	0.00%	92.31%	53.33%
100-999	1,134	0.0%	38.5%	4.0%	57.5%	0.00%	0.00%	92.31%	33.33%	0.00%	0.00%	92.31%	53.33%
1,000-9,999	693	0.0%	41.4%	4.1%	54.5%	0.00%	0.00%	92.31%	33.33%	0.00%	0.00%	92.31%	53.33%
	Non-Florida												
	V	W	X	Y	Z	AA=E2/E1	AB=F2/F1	AC=G2/G1	AD=H2/H1	AE=E3/E1	AF=F3/F1	AG=G3/G1	AH=H3/H1
<100	5,999	0.0%	69.1%	3.9%	27.0%	0.00%	0.00%	25.00%	6.67%	0.00%	0.00%	25.00%	13.33%
100-999	20,201	0.0%	55.5%	4.0%	40.5%	0.00%	0.00%	25.00%	6.67%	0.00%	0.00%	25.00%	13.33%
1,000-9,999	11,924	0.0%	62.8%	4.1%	33.1%	0.00%	0.00%	25.00%	6.67%	0.00%	0.00%	25.00%	13.33%

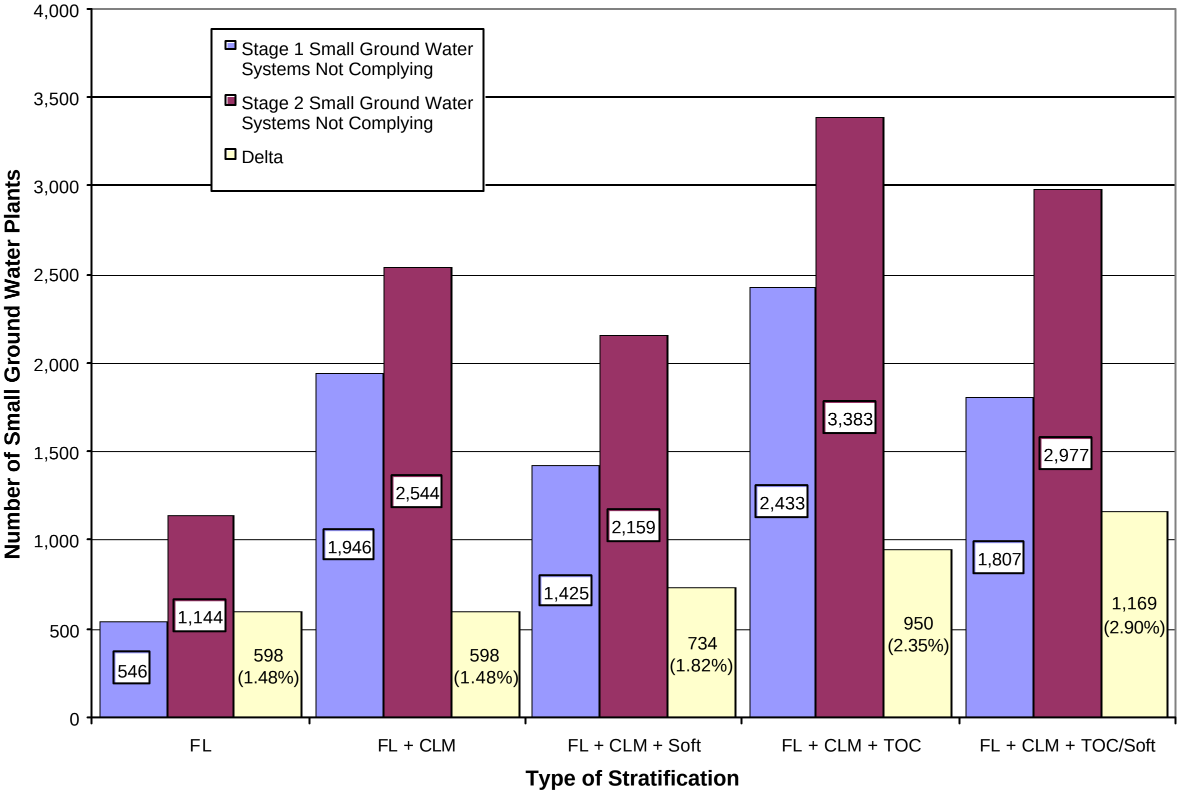
	Plants Not Complying						Stage 2 to Stage 1 Delta	
	Florida		Non-Florida		Total			
	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Plants	Percent
	AI	AJ	AK	AL	AM=AI+AK	AN=AJ+AL	AO=AN-AM	AP=AO/(I+V)
<100	96	143	167	274	262	417	155	2.41%
100-999	259	390	748	1,293	1,007	1,683	676	3.17%
1,000-9,999	152	228	386	649	538	877	339	2.69%
Total	507	760	1,300	2,217	1,807	2,977	1,169	2.90%

Sources:
(A-H) ICR Aux 1 Database.
(I) Exhibit B.6a, Column F
(J-M) Derived from the GWSS 1983 data.
(V) Exhibit B.6a, Column I
(W-Z) Derived from the GWSS 1983 data.
(AI) I*J*N + I*K*O + I*L*P + I*M*Q
(AJ) I*J*R + I*K*S + I*L*T + I*M*U
(AK) V*W*AA + V*X*AB + V*Y*AC + V*Z*AD
(AL) V*W*AE + V*X*AF + V*Y*AG + V*Z*AH

Exhibit B.16 illustrates the individual effect of the three adjustments on the estimate of the number of small ground water plants not in compliance. The first column, "FL," displays the change from Stage 1 to Stage 2 if no adjustments were made from large to small ground water systems. This results in a difference of 1.48 percent. The second column, "FL + CLM," displays the results of adding the large ICR GW systems that are in compliance but use chloramine (CLM). This is a surrogate for the fact that large GW systems were subject to the 1979 TTHM rule but small ground waters are not subject to the 1979 TTHM Rule. Note the change from Stage 1 to Stage 2 is the same, only the total number of plants affected has changed.

The third column, "FL + CLM + Soft," displays the results if systems are stratified based on whether they use softening at their plants. The change from Stage 1 to Stage 2 for this step is 1.79 percent as opposed to 1.48 percent. The fourth column, "FL + CLM + TOC," displays the results if systems are stratified based on whether their TOC is greater than 1 milligrams per liter (mg/L). The difference is now 2.35 percent, almost a full percentage point higher than the softening. Finally, the fifth column, "FL + CLM + TOC/Soft," shows the results if one combines the stratification of softening with TOC. The difference increases again to 2.90 percent. The stratification of small ground water plants results in more plants changing treatment technology, representing the unique situation with regard to EPA regulations and the differences in Florida systems between small and large ground water systems.

Exhibit B.16 Effect of the Adjustment Steps on the Change from Stage 1 to Stage 2



B.3.2 Uncertainties in Compliance Forecasts for Small Ground Water Systems

The biggest source of uncertainty for the compliance forecasts for small ground water systems exists in the extrapolation from the large ground water compliance forecasts. As mentioned previously, the compliance forecasts for medium and large systems is based on a relatively small subset of total plants. The extrapolation does attempt to factor in difference in geography by adjusting for the percentage of systems in Florida.

B.3.3 Treatment Technology Forecasts for Systems Not in Compliance

The treatment technology forecasts for small ground water systems were generated by adjusting the large ground water compliance forecast. As with small surface water systems, chloramine and ozone were assumed to be less feasible treatment technologies for small ground water systems than for large systems. The assumed use of these disinfectants was adjusted for each small system size category. The steps for generating the Stage 1 and Stage 2 forecasts are summarized below.

<u>Adjustments for the Stage 1 treatment technology forecasts:</u>

Step 1: Start with the Stage 1 (i.e., 80/60 RAA, Bromate 10) compliance forecast for large ground water systems from Exhibit B.12.

Step 2: For the two smaller population size categories, adjust the percentage of ozone selected as follows:

- 100-999: 50 percent reduction in ozone use; the remaining 50 percent is allocated to GAC.

- <100: 100 percent reduction in ozone use; the 100 percent is allocated to GAC.

Step 3: Multiply the results from Step 2 by the percent of plants not in compliance for each population category of small ground water systems.

Step 4: Obtain the treatment technology selection showing the CLM use breakout for each treatment technology, for each population category, as follows:

- 1,000-9,999:
  1. Start with results from Step 3.
  2. Converting to chloramine: No change from Step 3.
  3. Ozone: 75 percent of the original ozone shifts to ozone+CLM, 25 percent remains in ozone.
  4. GAC: All original GAC shifts to GAC+CLM.
  5. Membranes: 90 percent of the original membranes shifts to membranes+CLM, 10 percent remains in membranes.

- 100-999:
  1. Start with results from Step 3.
  2. Converting to chloramine: No change from Step 3.
  3. Ozone: 75 percent of the original ozone shifts to ozone+CLM, 25 percent remains in ozone.
  4. GAC: All original GAC shifts to GAC+CLM.

   5. Membranes: 90 percent of the original membranes shifts to membranes+CLM, 10 percent remains in membranes.
   6. Final chloramine adjustment: 10 percent of GAC+CLM shifts to membranes.

- <100:
   1. Start with results from Step 3.
   2. Converting to chloramine: No change from Step 3.
   3. Ozone: Not selected.
   4. GAC: All original GAC shifts to GAC+CLM.
   5. Membranes: 90 percent of the original membranes shifts to membranes+CLM, 10 percent remains in membranes.
   6. Final chloramine adjustment: 25 percent of GAC+CLM shifts to membranes.

Adjustments for the Stage 2 treatment technology forecasts:

Step 1: Start with the Stage 2 (i.e., 80/60 LRAA, Bromate 10) compliance forecast for large ground water systems from Exhibit B.12.

Step 2: For the two smaller population size categories, adjust the percentage of ozone selected as follows:

- 100-999: 50 percent reduction in ozone use; the remaining 50 percent is allocated to GAC.

- <100: 100 percent reduction in ozone use; the 100 percent is allocated to GAC.

Step 3: Adjust the numbers from Step 2 for “negatives”: This ensures that the overall percentages of systems using advanced treatment technologies do not fall below those forecasted for the Stage 1 DBPR.

Step 4: Adjust the numbers from Step 3 for Ultraviolet disinfection (UV): UV is available as a treatment technology option for all Stage 2 DBPR alternatives. Small systems are assumed to be able to achieve 4-logs of virus inactivation by installing 2, 2-log UV reactors in series. Even with the 2 reactor series, UV is less expensive than other advanced treatment technologies. For the Stage 2 DBPR alternatives, EPA assumed that 60 percent of the advanced treatment technology selections of ozone, GAC, and membranes would instead be UV. UV was not included as a viable treatment technology for the Stage 1 DBPR, so EPA assumed that all of the systems adding advanced treatment technology for the Stage 1 DBPR would stay with that treatment technology for the Stage 2 DBPR, while additional systems adding treatment technology for the Stage 2 DBPR can use UV. As a result, EPA apportioned a fraction (i.e., 60 percent) of the systems moving to advanced treatment technologies, to UV.

Step 5: Re-adjust the numbers from Step 4 for “negatives”: This ensures that the overall percentages of systems using advanced treatment technologies do not fall below those forecasted for the Stage 1 DBPR.

Step 6: Multiply the results from Step 2 by the percent of plants not in compliance for each population category of small ground water systems.

Step 7: Chloramine adjustments: Obtain the treatment technology selection showing the chloramine use breakout for each treatment technology, for each population category, as follows:

- 1,001-10,000:
    1. Start with the results from Step 6.
    2. Converting to chloramine: No change from Step 6.
    3. UV: All shift to UV+CLM.
    4. Ozone: 75 percent of the original ozone shifts to ozone+CLM, 25 percent remains in ozone.
    5. GAC: All original GAC shifts to GAC+CLM.
    6. Membranes: 90 percent of the original membranes shifts to membranes+CLM, 10 percent remains in membranes.

- 101-1,000:
    1. Start with the results from Step 6.
    2. Converting to chloramine: No change from Step 6.
    3. UV: 90 percent of the original UV shifts to UV+CLM, 0% remains in UV.
    4. Ozone: 75 percent of the original ozone shifts to ozone+CLM, 25 percent remains in ozone.
    5. GAC: All original GAC shifts to GAC+CLM, 10% of original UV shifts to GAC.
    6. Membranes: 90 percent of the original membranes shifts to membranes+CLM, 10 percent remains in membranes.
    7. Final chloramine adjustment: 10 percent of GAC+CLM shifts to membranes.

- ≤ 100:
    1. Start with the results from Step 6.
    2. Converting to chloramine: No change from Step 6.
    3. UV: 75 percent of the original UV shifts to UV+CLM, 0% remains in UV.
    4. Ozone: Not selected.
    5. GAC: All original GAC shifts to GAC+CLM, 25% of original UV shifts to GAC.
    6. Membranes: 90 percent of the original membranes shifts to membranes+CLM, 10 percent remains in membranes.
    7. Final chloramine adjustment: 25 percent of GAC+CLM shifts to membranes.

B.3.3 Results

Exhibits B.17 and B.18 illustrate the adjustments discussed in section B.3.2. for the Stage 1 (i.e., 80/60 RAA, Bromate 10) and the Stage 2 DBPR Preferred Alternative (i.e., 80/60 LRAA, Bromate 10) respectively. In addition to conducting the above analysis for the Stage 2 DBPR Preferred Alternative, similar analyses were performed for all regulatory alternatives considered during the development of the Stage 2 DBPR. Results are summarized in Chapter 5 and Appendix C for all regulatory alternatives. Exhibit B.19 summarizes the treatment technology selection results for small ground water systems, for all Stage 2 DBPR regulatory alternatives and sensitivity options.

Exhibit B.17 Stage 1 (80/60 RAA, Bromate 10) Treatment Technology Selection Forecasts

Adjustments	% Disinfecting non-compliers	Converting to CLM only	CONV	Ozone	Ozone+ CLM	GAC	GAC+ CLM	MEM	MEM+ CLM	Comments
1,001-10,000 category										
1. Large GW treatment selection for noncompliers (Delphi)	4.26%		59.25%	27.25%		1.25%		12.25%		From large GW delphi.
2. Treatment selection for noncompliers after applying ozone adjustments to 1	4.26%		59.25%	27.25%		1.25%		12.25%		No adjustments to ozone usage in this category.
3. Treatment selection from 2 applied to the percent noncompliers	4.26%	2.52%		1.16%		0.05%		0.52%		All plants predicted to be CONV have to switch to CLM to be compliant. Example calculation (Ozone): 27.25% of 4.26% = 1.16%.
4. **Final** treatment selection showing chloramine use breakout within each technology	4.26%	**2.52%**		**0.29%**	**0.87%**	**0.00%**	**0.26%**	**0.05%**	**0.47%**	(1) Start with results from 3. (2) Convert to CLM: No change. (3) Ozone: 75% to Ozone+CLM, 25% to Ozone. (4) GAC: All go to GAC+CLM. (5) MEM: 90% to MEM+CLM, 10% remains in MEM.
101-1,000 category										
1. Large GW treatment selection for noncompliers (Delphi)	4.72%		59.25%	27.25%		1.25%		12.25%		From large GW delphi.
2. Treatment selection for noncompliers after applying ozone adjustments to 1	4.72%		59.25%	13.63%		14.88%		12.25%		50% reduction in ozone, balance goes to GAC.
3. Treatment selection from 2 applied to the percent noncompliers	4.72%	2.80%		0.64%		0.70%		0.58%		All plants predicted to be CONV have to switch to CLM to be compliant. Example calculation (Ozone): 13.63% of 4.72% = 0.64%.
4. **Final** treatment selection showing chloramine use breakout within each technology	4.72%	**2.80%**		**0.16%**	**0.48%**	**0.22%**	**0.63%**	**0.15%**	**0.70%**	(1) Start with results from 3. (2) Convert to CLM: No change. (2) Ozone: 75% to Ozone+CLM, 25% to Ozone. (3) GAC: All go to GAC+CLM. (4) MEM: 90% to MEM+CLM, 10% remain in MEM. (5) Final CLM adjustment: 10% of GAC+CLM to MEM.
<= 100 category										
1. Large GW treatment selection for noncompliers (Delphi)	4.08%		59.25%	27.25%		1.25%		12.25%		From large GW delphi.
2. Treatment selection for noncompliers after applying ozone adjustments to 1	4.08%		59.25%	0.00%		28.50%		12.25%		100% reduction in ozone, balance goes to GAC.
3. Treatment selection from 2 applied to the percent noncompliers	4.08%	2.42%		0.00%		1.16%		0.50%		All plants predicted to be CONV have to switch to CLM to be compliant. Example calculation (GAC): 28.50% of 4.08% = 1.16%.
4. **Final** treatment selection showing chloramine use breakout within each technology	4.08%	**2.42%**		**0.00%**	**0.00%**	**0.00%**	**0.87%**	**0.34%**	**0.45%**	(1) Start with results from 3. (2) Convert to CLM: No change. (3) Ozone: 0%. (4) GAC: All go to GAC+CLM. (5) MEM: 90% to MEM+CLM, 10% remain in MEM. (6) Final CLM adjustment: 25% of GAC+CLM to MEM.

Exhibit B.18 Stage 2 Preferred Alternative (80/60 LRAA, Bromate 10) Treatment Technology Selection Forecast

Adjustments	% Disinfecting non-compliers	Converting to CLM only	CONV	UV	UV+ CLM	Ozone	Ozone+C LM	GAC	GAC+C LM	MEM	MEM+C LM	Comments
<= 100 category												
1. Large GW treatment selection for noncompliers (Delphi)	6.50%		62.67%			0.00%		25.33%		12.00%		From large GW delphi.
2. Treatment selection for noncompliers after applying ozone adjustments to 1	6.50%		62.67%			0.00%		25.33%		12.00%		100% reduction in ozone, balance goes to GAC.
3. Treatment selection after adjusting 2 for "negatives"	6.50%		62.67%			0.00%		25.33%		12.00%		To ensure that treatment selection for a technology is not below the Stage 1 selection.
4. Treatment selection after UV adjustments to 3	6.50%		62.67%	22.40%		0.00%		10.13%		4.80%		Assumes that 60% of (Ozone+GAC+MEM) switch to UV, the balance 40% is distrbuted among Ozone, GAC, and MEM in their existing proportions.
5. Treatment selection after adjusting 4 for "negatives"	6.50%		51.99%	22.40%		0.00%		17.91%		7.70%		To ensure that treatment selection for a technology is not below the Stage 1 selection.
6. Treatment selection from 5 applied to noncompliers	6.50%	3.38%		1.46%		0.00%		1.16%		0.50%		All plants predicted to be CONV have to switch to CLM to be compliant. Example calculation (GAC): 17.91% of 6.50% = 1.16%.
7. **Final** treatment selection showing chloramine use breakout within each technology	6.50%	**3.03%**		**0.00%**	**1.25%**	**0.00%**	**0.00%**	**0.42%**	**0.87%**	**0.36%**	**0.58%**	(1) Start with results from 6. (2) Convert to CLM: No change. (3) UV: 75% of original UV to UV+CLM, 0% to UV. (4) Ozone: 0%. (5) GAC: All original GAC to GAC+CLM, balance 25% of original UV to GAC. (6) MEM: 90% to MEM+CLM, 10% remains in MEM. (7) Final CLM adjustment: 25% of GAC+CLM to MEM.

Exhibit B.18 Stage 2 Preferred Alternative (80/60 LRAA, Bromate 10) Treatment Technology Selection Forecast (continued)

Adjustments	% Disinfecting non-compliers	Converting to CLM only	CONV	UV	UV+ CLM	Ozone	Ozone+ CLM	GAC	GAC+ CLM	MEM	MEM+ CLM	Comments
1,001-10,000 category												
1. Large GW treatment selection for noncompliers (Delphi)	6.95%		62.67%			21.67%		3.67%		12.00%		From large GW delphi.
2. Treatment selection for noncompliers after applying ozone adjustments to 1	6.95%		62.67%			21.67%		3.67%		12.00%		No adjustments to ozone usage in this category.
3. Treatment selection after adjusting 2 for "negatives"	6.95%		62.67%			21.67%		3.67%		12.00%		To ensure that treatment selection for a technology is not below the Stage 1 selection.
4. Treatment selection after UV adjustments to 3	6.95%		62.67%	22.40%		8.67%		1.47%		4.80%		Assumes that 60% of (Ozone+GAC+MEM) switch to UV, the balance 40% is distrbuted among Ozone, GAC, and MEM in their existing proportions.
5. Treatment selection after adjusting 4 for "negatives"	6.95%		51.90%	22.40%		16.72%		1.47%		7.51%		To ensure that treatment selection for a technology is not below the Stage 1 selection.
6. Treatment selection from 5 applied to noncompliers	6.95%	3.61%		1.56%		1.16%		0.10%		0.52%		All plants predicted to be CONV have to switch to CLM to be compliant. Example calculation (UV): 22.40% of 6.95% = 1.56%.
7. **Final** treatment selection showing chloramine use breakout within each technology	6.95%	**0.00%**		**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	(1) Start with results from 6. (2) Convert to CLM: No change. (3) UV: All go to UV+CLM. (4) Ozone: 75% of original to Ozone+CLM, 25% to Ozone. (5) GAC: All go to GAC+CLM. (6) MEM: 90% to MEM+CLM, 10% remains in MEM.
101-1,000 category												
1. Large GW treatment selection for noncompliers (Delphi)	7.89%		62.67%			10.83%		14.50%		12.00%		From large GW delphi.
2. Treatment selection for noncompliers after applying ozone adjustments to 1	7.89%		62.67%			5.42%		19.92%		12.00%		50% reduction in ozone, balance goes to GAC.
3. Treatment selection after adjusting 2 for "negatives"	7.89%		62.67%			5.42%		19.92%		12.00%		To ensure that treatment selection for a technology is not below the Stage 1 selection.
4. Treatment selection after UV adjustments to 3	7.89%		62.67%	22.40%		2.17%		7.97%		4.80%		Assumes that 60% of (Ozone+GAC+MEM) switch to UV, the balance 40% is distrbuted among Ozone, GAC, and MEM in their existing proportions.
5. Treatment selection after adjusting 4 for "negatives"	7.89%		53.21%	22.40%		8.16%		8.90%		7.33%		To ensure that treatment selection for a technology is not below the Stage 1 selection.
6. Treatment selection from 5 applied to noncompliers	7.89%	4.20%		1.77%		0.64%		0.70%		0.58%		All plants predicted to be CONV have to switch to CLM to be compliant. Example calculation (Ozone): 8.16% of 7.89% = 0.64%.
7. **Final** treatment selection showing chloramine use breakout within each technology	7.89%	**4.90%**		**0.00%**	**1.51%**	**0.16%**	**0.48%**	**0.17%**	**0.63%**	**0.13%**	**0.52%**	(1) Start with results from 6. (2) Convert to CLM: No change. (3) UV: 90% of original UV to UV+CLM, 0% to UV. (4) Ozone: 75% of original to Ozone+CLM, 25% to Ozone. (5) GAC: All original GAC go to GAC+CLM, balance 10% of original UV to GAC. (6) MEM: 90% to MEM+CLM, 10% remains in MEM. (7) Final CLM adjustment:10% of GAC+CLM to MEM.

Exhibit B.19 Small Ground Water Treatment Technology Selection Results Summary

Regulatory Option	Converting to CLM only	UV	UV + CLM	Ozone	Ozone + CLM	GAC20	GAC20 + CLM	NF	NF + CLM	Total % Changing Tech.
1,001-10,000 category										
Stage 1 Baseline, 80/60 RAA, BRO3 = 10, UV = OFF	2.52%	0.00%	0.00%	0.29%	0.87%	0.00%	0.05%	0.05%	0.47%	4.26%
Preferred Alternative, 20% Safety Margin, 80/60 LRAA, BRO3 = 10, UV = ON	3.61%	0.00%	1.56%	0.29%	0.87%	0.00%	0.10%	0.05%	0.47%	6.95%
Stage 2 Alternative 1, 80/60 LRAA, BRO3 = 5, UV = ON	2.50%	0.00%	2.25%	0.29%	0.87%	0.00%	0.35%	0.07%	0.62%	6.95%
Stage 2 Alternative 2, 80/60 SH, BRO3 = 10, UV = ON	6.00%	0.00%	1.42%	0.29%	0.87%	0.00%	0.17%	0.05%	0.47%	9.27%
Stage 2 Alternative 3, 40/30 RAA, BRO3 = 10, UV = ON	4.00%	0.00%	1.60%	0.29%	0.87%	0.00%	0.26%	0.05%	0.47%	7.55%
101-1,000 category										
Stage 1 Baseline, 80/60 RAA, BRO3 = 10, UV = OFF	2.80%	0.00%	0.00%	0.16%	0.48%	0.00%	0.63%	0.13%	0.52%	4.72%
Preferred Alternative, 20% Safety Margin, 80/60 LRAA, BRO3 = 10, UV = ON	4.20%	0.00%	1.59%	0.16%	0.48%	0.18%	0.63%	0.13%	0.52%	7.89%
Stage 2 Alternative 1, 80/60 LRAA, BRO3 = 5, UV = ON	3.61%	0.00%	1.94%	0.16%	0.48%	0.22%	0.63%	0.15%	0.70%	7.89%
Stage 2 Alternative 2, 80/60 SH, BRO3 = 10, UV = ON	6.67%	0.00%	1.31%	0.16%	0.48%	0.15%	0.63%	0.13%	0.52%	10.05%
Stage 2 Alternative 3, 40/30 RAA, BRO3 = 10, UV = ON	4.90%	0.00%	1.51%	0.16%	0.48%	0.17%	0.63%	0.13%	0.52%	8.50%
<= 100 category										
Stage 1 Baseline, 80/60 RAA, BRO3 = 10, UV = OFF	2.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.87%	0.34%	0.45%	4.08%
Preferred Alternative, 20% Safety Margin, 80/60 LRAA, BRO3 = 10, UV = ON	3.38%	0.00%	1.09%	0.00%	0.00%	0.36%	0.87%	0.34%	0.45%	6.50%
Stage 2 Alternative 1, 80/60 LRAA, BRO3 = 5, UV = ON	3.03%	0.00%	1.25%	0.00%	0.00%	0.42%	0.87%	0.36%	0.58%	6.50%
Stage 2 Alternative 2, 80/60 SH, BRO3 = 10, UV = ON	6.24%	0.00%	0.92%	0.00%	0.00%	0.31%	0.87%	0.34%	0.45%	9.13%
Stage 2 Alternative 3, 40/30 RAA, BRO3 = 10, UV = ON	4.25%	0.00%	0.99%	0.00%	0.00%	0.33%	0.87%	0.34%	0.45%	7.23%

Appendix C
Supplemental Compliance Forecasts

Appendix C
Supplemental Compliance Forecasts

This appendix presents the Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts Rule (DBPR) compliance forecast results for both surface water and ground water systems. There are three basic types of compliance forecasts presented:

- **Treatment Technology Selection**—The treatment technology selection tables represent the number and percent of systems that have to add a treatment technology to comply with the rule. These results include only the number of systems that exceed rule maximum contaminant levels (MCLs) and must add treatment technology to comply with the rule. Those plants that are already using a treatment technology prior to the rule and do not have to add an additional treatment technology to comply are not included in this table. The treatment technology selection numbers are based on the pre-Stage 1 treatment technology baseline.

- **Treatment Technology Selection Deltas**—The treatment technology selection delta tables represent the incremental number of plants that must add a treatment technology to meet Stage 2 DBPR regulatory alternatives after predicted changes to meet the Stage 1 DBPR. These tables are calculated by subtracting the Stage 1 DBPR treatment technology selection tables from the Stage 2 DBPR treatment technology selection tables. These tables are used for costing.

- **Treatment Technologies in Place**—The treatment technologies in place tables show the number and percent of systems that are using a treatment technology, once systems are in compliance with the rule. This includes the systems predicted to add a treatment technology to comply with the rule, and those systems that were already using the treatment technology before rule promulgation.

This Appendix presents the treatment technology selection tables for the Stage 1 DBPR and the Stage 2 DBPR, and the treatment technology selection, treatment technology selection deltas, and treatment technologies in place tables for the other regulatory alternatives and the sensitivity analyses. Compliance forecasts are organized as follows (see next page).

Note: Some compliance forecasts are presented in the main body of the Economic Analysis (i.e., Exhibits 3.13a through 3.14b, 7.14a through 7.19b), and are thus not repeated in this Appendix.

Rule Option	Compliance Forecast Type	Source	System Type	Exhibit Number	Page Number
Pre-Stage 1	Treatment Technologies in Place	Surface Water	CWS	Chapter 3, Exhibit 3.13a	
			NTNCWS	Chapter 3, Exhibit 3.13b	
		Ground Water	CWS	Chapter 3, Exhibit 3.14a	
			NTNCWS	Chapter 3, Exhibit 3.14b	
Pre-Stage 2 (Post-Stage 1)	Selection	Surface Water	CWS	Exhibit C.1a	C-3
			NTNCWS	Exhibit C.1b	C-4
		Ground Water	CWS	Exhibit C.2a	C-5
			NTNCWS	Exhibit C.2b	C-6
	Treatment Technologies in Place	Surface Water	CWS	Chapter 7, Exhibit 7.14a	7-41
			NTNCWS	Chapter 7, Exhibit 7.14b	7-41
		Ground Water	CWS	Chapter 7, Exhibit 7.17a	7-46
			NTNCWS	Chapter 7, Exhibit 7.17b	7-46
Stage 2 Preferred Alternative	Delta	Surface Water	CWS	Chapter 7, Exhibit 7.15a & 7.15b	7-42
			NTNCWS	Chapter 7, Exhibit 7.15c & 7.15d	7-43
		Ground Water	CWS	Chapter 7, Exhibit 7.18a & 7.18b	7-47
			NTNCWS	Chapter 7, Exhibit 7.18c & 7.18d	7-48
	Treatment Technologies in Place	Surface Water	CWS	Chapter 7, Exhibit 7.16a & 7.16b	7-44
			NTNCWS	Chapter 7, Exhibit 7.16c & 7.16d	7-45
		Ground Water	CWS	Chapter 7, Exhibit 7.19a & 7.19b	7-49
			NTNCWS	Chapter 7, Exhibit 7.19c & 7.19d	7-50
Stage 2 Alternative 1	Delta	Surface Water	CWS	Exhibits C.3a & C.3b	C-7
			NTNCWS	Exhibits C.3c & C.3d	C-8
		Ground Water	CWS	Exhibits C.4a & C.4b	C-9
			NTNCWS	Exhibits C.4c & C.4d	C-10
	Treatment Technologies in Place	Surface Water	CWS	Exhibits C.5a & C.5b	C-11
			NTNCWS	Exhibits C.5c & C.5d	C-12
		Ground Water	CWS	Exhibits C.6a & C.6b	C-13
			NTNCWS	Exhibits C.6c & C.6d	C-14
Stage 2 Alternative 2	Delta	Surface Water	CWS	Exhibits C.7a & C.7b	C-15
		Ground Water	CWS	Exhibits C.8a & C.8b	C-17
			NTNCWS	Exhibits C.8c & C.8d	C-18
	Treatment Technologies in Place	Surface Water	CWS	Exhibits C.9a & C.9b	C-19
			NTNCWS	Exhibits C.9c & C.9d	C-20
		Ground Water	CWS	Exhibits C.10a & C.10b	C-21
			NTNCWS	Exhibits C.10c & C.10d	C-22
Stage 2 Alternative 3	Delta	Surface Water	CWS	Exhibits C.11a & C.11b	C-23
			NTNCWS	Exhibits C.11c & C.11d	C-24
		Ground Water	CWS	Exhibits C.12a & C.12b	C-25
			NTNCWS	Exhibits C.12c & C.12d	C-26
	Treatment Technologies in Place	Surface Water	CWS	Exhibits C.13a & C.13b	C-27
			NTNCWS	Exhibits C.13c & C.13d	C-28
		Ground Water	CWS	Exhibits C.14a & C.14b	C-29
			NTNCWS	Exhibits C.14c & C.14d	C-30
Stage 2 Preferred Alternative, 20% Safety Margin	Delta	Surface Water	CWS	Exhibits C.15a & C.15b	C-31
			NTNCWS	Exhibits C.15c & C.15d	C-32
		Ground Water	CWS	Exhibits C.16a & C.16b	C-33
			NTNCWS	Exhibits C.16c & C.16d	C-34
	Treatment Technologies in Place	Surface Water	CWS	Exhibits C.17a & C.17b	C-35
			NTNCWS	Exhibits C.17c & C.17d	C-36
		Ground Water	CWS	Exhibits C.18a & C.18b	C-37
			NTNCWS	Exhibits C.18c & C.18d	C-38
Stage 2 Preferred Alternative, 25% Safety Margin	Delta	Surface Water	CWS	Exhibits C.19a & C.19b	C-39
			NTNCWS	Exhibits C.19c & C.19d	C-40
		Ground Water	CWS	Exhibits C.20a & C.20b	C-41
			NTNCWS	Exhibits C.20c & C.20d	C-42
	Treatment Technologies in Place	Surface Water	CWS	Exhibits C.21a & C.21b	C-43
			NTNCWS	Exhibits C.21c & C.21d	C-44
		Ground Water	CWS	Exhibits C.22a & C.22b	C-45
			NTNCWS	Exhibits C.22c & C.22d	C-46

Exhibit C.1a

Stage 1 DBPR Treatment Technology Selection for CWS Surface Water Plants (Percent and Number of Plants by Residual Disinfection Type)

System Size (Population Served)	Conventional Plants Adding CLM only		Adding Advanced Treatment Treatment Technologies																																				Total Converting to CLM		Total Adding Treatment Technology	
			Chlorine Dioxide				UV				Ozone				MF/UF				GAC10				GAC10 + Advanced Disinfectants				GAC20				GAC20 + Advanced Disinfectants				Membranes							
			CL2		CLM		CL2		CLM		CL2		CLM		CL2		CLM		CL2		CLM		CL2		CLM		CL2		CLM		CL2		CLM		CL2		CLM					
	A		B				C				D				E				F				G				H				I				J				K		L = SUM(A:J)	
<100	29.7%	107													10.9%	39	7.1%	26									2.0%	7	1.3%	5	0.0%	0	0.0%	0	2.1%	8	1.4%	5	39.6%	142	54.6%	196
100-499	35.4%	272	1.0%	7	0.9%	7					5.1%	39	4.6%	35	5.3%	41	4.8%	37									1.1%	8	1.0%	7	0.5%	4	0.4%	3	0.5%	3	0.4%	3	47.5%	364	60.8%	466
500-999		171		5		4						24		22		26		23										5		5		2		2		2		2		229		294
1,000-3,300	41.3%	467	1.9%	22	2.1%	24					4.0%	45	4.5%	51	2.6%	29	2.9%	32									1.0%	12	1.2%	13	0.5%	6	0.6%	7	0.2%	2	0.2%	2	52.7%	596	63.0%	711
3,301-9,999		520		24		27						50		56		32		36										13		15		7		7		2		2		664		792
10,000-49,999	10.9%	141	4.4%	57	0.7%	9					9.5%	122	1.5%	20	1.6%	20	0.3%	3	1.6%	20	0.3%	3	0.9%	12	0.2%	2	0.3%	4	0.1%	1	0.0%	0	0.0%	0	0.3%	4	0.1%	1	13.9%	180	32.5%	420
50,000-99,999		63		26		4						55		9		9		1		9		1		5		1		2		0		0		0		2		0		81		188
100,000-999,999	10.9%	67	4.4%	27	0.7%	4					9.5%	58	1.5%	9	1.6%	10	0.3%	2	1.6%	10	0.3%	2	0.9%	6	0.2%	1	0.3%	2	0.1%	0	0.0%	0	0.0%	0	0.3%	2	0.1%	0	13.9%	85	32.5%	199
>=1,000,000		8		3		1						7		1		1		0		1		0		1		0		0		0		0		0		0		0		10		24
Total Plants	27.7%	1,816	2.6%	170	1.2%	80					6.1%	401	3.1%	203	3.2%	207	2.5%	161	0.6%	40	0.1%	7	0.4%	24	0.1%	4	0.8%	53	0.7%	46	0.3%	18	0.3%	19	0.4%	25	0.2%	16	35.9%	2,350	50.2%	3,290

Note: Detail may not add to totals due to independent rounding

Source: Percent of plants from Appendix A, A.19a for systems serving <100 people, A.19b for systems serving 100 to 999 people, A.19c for systems serving 1,000 to 9,999 people, and Exhibit A.7c for systems serving 10,000 or more people.

Exhibit C.1b
Stage 1 DBPR Treatment Technology Selection for NTNCWS Surface Water Plants (Percent and Number of Plants by Residual Disinfection Type)

System Size (Population Served)	Conventional Plants Adding CLM only		Adding Advanced Treatment Treatment Technologies																																				Total Converting to CLM		Total Adding Treatment Technology	
			Chlorine Dioxide				UV				Ozone				MF/UF				GAC10				GAC10 + Advanced Disinfectants				GAC20				GAC20 + Advanced Disinfectants				Membranes							
			CL2		CLM		CL2		CLM		CL2		CLM		CL2		CLM		CL2		CLM		CL2		CLM		CL2		CLM		CL2		CLM		CL2		CLM					
	A		B				C				D				E				F				G				H				I				J				K		L = SUM(A:J)	
<100	29.7%	67													10.9%	25	7.1%	16									2.0%	4	1.3%	3	0.0%	0	0.0%	0	2.1%	5	1.4%	3	39.6%	89	54.6%	123
100-499	35.4%	111	1.0%	3	0.9%	3					5.1%	16	4.6%	14	5.3%	17	4.8%	15									1.1%	3	1.0%	3	0.5%	2	0.4%	1	0.5%	1	0.4%	1	47.5%	148	60.8%	190
500-999		38		1		1						5		5		6		5										1		1		1		0		0		0		50		64
1,000-3,300	41.3%	38	1.9%	2	2.1%	2					4.0%	4	4.5%	4	2.6%	2	2.9%	3									1.0%	1	1.2%	1	0.5%	0	0.6%	1	0.2%	0	0.2%	0	52.7%	49	63.0%	58
3,301-9,999		10		0		1						1		1		1		1										0		0		0		0		0		0		13		16
10,000-49,999	10.9%	1	4.4%	0	0.7%	0					9.5%	0	1.5%	0	1.6%	0	0.3%	0	1.6%	0	0.3%	0	0.9%	0	0.2%	0	0.3%	0	0.1%	0	0.0%	0	0.0%	0	0.3%	0	0.1%	0	13.9%	1	32.5%	2
50,000-99,999		0		0		0						0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0
100,000-999,999	10.9%	0	4.4%	0	0.7%	0					9.5%	0	1.5%	0	1.6%	0	0.3%	0	1.6%	0	0.3%	0	0.9%	0	0.2%	0	0.3%	0	0.1%	0	0.0%	0	0.0%	0	0.3%	0	0.1%	0	13.9%	0	32.5%	0
>=1,000,000		0		0		0						0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0
Total Plants	34.5%	264	0.8%	7	0.8%	6					3.4%	26	3.2%	24	6.5%	50	5.2%	40	0.0%	0	0.0%	0	0.0%	0	0.0%	0	1.3%	10	1.1%	8	0.3%	3	0.3%	3	0.9%	7	0.7%	5	45.7%	350	59.1%	453

Note: Detail may not add to totals due to independent rounding

Source: Percent of plants from Appendix A, A.19a for systems serving <100 people, A.19b for systems serving 100 to 999 people, A.19c for systems serving 1,000 to 9,999 people, and Exhibit A.7c for systems serving 10,000 or more people.

Exhibit C.2a
Stage 1 DBPR Treatment Technology Selection for CWS Groundwater Plants (Percent and Number of Plants, by Residual

System Size (Population Served)	CLM Only		UV CL2		UV CLM		Ozone CL2		Ozone CLM		GAC20 CL2		GAC20 CLM		Membranes CL2		Membranes CLM		Total Converting to CLM		Total Adding Treatment Technology
	A		B		C		D		E		F		G		H		I		J = A+C+E+G+I		K = SUM(A:I)
<100	2.4%	155	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.9%	56	0.3%	22	0.5%	29	3.7%	240	4.1%
100-499	2.8%	426	0.0%	0	0.0%	0	0.2%	25	0.5%	74	0.0%	0	0.6%	96	0.1%	20	0.5%	79	4.4%	676	4.7%
500-999		170		0		0		10		29		0		39		8		32		270	
1,000-3,300	2.5%	192	0.0%	0	0.0%	0	0.3%	22	0.9%	66	0.0%	0	0.1%	4	0.1%	4	0.5%	36	3.9%	297	4.3%
3,301-9,999		127		0		0		15		44		0		3		3		24		197	
10,000-49,999	1.8%	99					0.1%	4	0.8%	42	0.0%	0	0.0%	2	0.1%	7	0.3%	14	2.9%	157	3.1%
50,000-99,999		13						1		6		0		0		1		2		21	
100,000-999,999	1.7%	15					0.1%	1	0.7%	6	0.0%	0	0.0%	0	0.1%	1	0.2%	2	2.6%	24	2.8%
>=1,000,000		0						0		0		0		0		0		0		1	
Total Plants	2.5%	1,199	0.0%	0	0.0%	0	0.2%	76	0.6%	267	0.0%	0	0.4%	200	0.1%	65	0.5%	217	4.0%	1,883	4.3%

Note: Detail may not add to totals due to independent rounding

Source: Percent of plants from Appendix B, Exhibit B.34a for systems serving <100 people, B.34b for systems serving 100 to 999 people, B.34c for systems serving 1,000 to 9,999 people, Exhibit B.11b for systems serving 10,000 to 99,999 people, and B.11a for systems serving 100,000 or more people.

Exhibit C.2b
Stage 1 DBPR Treatment Technology Selection for NTNCWS Groundwater Plants (Percent and Number of Plants, by Residual

System Size (Population Served)	CLM Only		UV CL2		UV CLM		Ozone CL2		Ozone CLM		GAC20 CL2		GAC20 CLM		Membranes CL2		Membranes CLM		Total Converting to CLM		Total Adding Treatment Technology
	A		B		C		D		E		F		G		H		I		J = A+C+E+G+I		K = SUM(A:I)
<100	2.4%	60	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.9%	22	0.3%	8	0.5%	11	3.7%	93	4.1%
100-499	2.8%	60	0.0%	0	0.0%	0	0.2%	3	0.5%	10	0.0%	0	0.6%	13	0.1%	3	0.5%	11	4.4%	94	4.7%
500-999		16		0		0		1		3		0		4		1		3		26	
1,000-3,300	2.5%	6	0.0%	0	0.0%	0	0.3%	1	0.9%	2	0.0%	0	0.1%	0	0.1%	0	0.5%	1	3.9%	10	4.3%
3,301-9,999		1		0		0		0		0		0		0		0		0		1	
10,000-49,999	1.8%	0					0.1%	0	0.8%	0	0.0%	0	0.0%	0	0.1%	0	0.3%	0	2.9%	0	3.1%
50,000-99,999		0						0		0		0		0		0		0		0	
100,000-999,999	1.7%	0					0.1%	0	0.7%	0	0.0%	0	0.0%	0	0.1%	0	0.2%	0	2.6%	0	2.8%
>=1,000,000		0						0		0		0		0		0		0		0	
Total Plants	2.6%	143	0.0%	0	0.0%	0	0.1%	5	0.3%	15	0.0%	0	0.7%	39	0.2%	12	0.5%	27	4.1%	224	4.4%

Note: Detail may not add to totals due to independent rounding

Source: Percent of plants from Appendix B, Exhibit B.34a for systems serving <100 people, B.34b for systems serving 100 to 999 people, B.34c for systems serving 1,000 to 9,999 people, Exhibit B.11b for systems serving 10,000 to 99,999 people, and B.11a for systems serving 100,000 or more people.

Exhibit C.3a

Stage 2 DBPR Treatment Technology Selection Deltas for CWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)

Alternative 1

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K		
<100	1.5%	0.8%	2.1%							3.3%	1.9%	4.7%	2.5%	1.4%	3.5%							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
100-499	3.6%	2.1%	5.1%	0.1%	0.1%	0.2%	0.4%	0.2%	0.5%	0.9%	0.5%	1.3%	0.9%	0.5%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
500-999	3.6%	2.1%	5.1%	0.1%	0.1%	0.2%	0.4%	0.2%	0.5%	0.9%	0.5%	1.3%	0.9%	0.5%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
1,000-3,300	3.7%	2.2%	5.3%	0.2%	0.1%	0.2%	0.9%	0.5%	1.2%	0.7%	0.4%	0.9%	0.9%	0.5%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
3,301-9,999	3.7%	2.2%	5.3%	0.2%	0.1%	0.2%	0.9%	0.5%	1.2%	0.7%	0.4%	0.9%	0.9%	0.5%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
10,000-49,999	7.4%	4.3%	10.6%	0.1%	0.0%	0.1%	0.6%	0.3%	0.8%	0.5%	0.3%	0.7%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
50,000-99,999	7.4%	4.3%	10.6%	0.1%	0.0%	0.1%	0.6%	0.3%	0.8%	0.5%	0.3%	0.7%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	7.4%	4.3%	10.6%	0.1%	0.0%	0.1%	0.6%	0.3%	0.8%	0.5%	0.3%	0.7%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
>=1,000,000	7.4%	4.3%	10.6%	0.1%	0.0%	0.1%	0.6%	0.3%	0.8%	0.5%	0.3%	0.7%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	5.0%	2.9%	7.2%	0.1%	0.1%	0.2%	0.6%	0.4%	0.9%	0.8%	0.5%	1.1%	0.7%	0.4%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	L			M			N			O			P			Q			R			S			T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	0.8%	2.0%	1.0%	0.6%	1.5%	0.0%	0.0%	0.0%	0.3%	0.2%	0.4%	5.3%	3.0%	7.5%	10.0%	5.7%	14.2%	8.8%	5.1%	12.5%
100-499	Mean						0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.2%	0.4%	0.4%	0.3%	0.6%	0.8%	0.5%	1.2%	1.0%	0.6%	1.4%	6.3%	3.7%	9.0%	8.4%	4.9%	12.0%			
500-999							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.2%	0.4%	0.4%	0.3%	0.6%	0.8%	0.5%	1.2%	1.0%	0.6%	1.4%	6.3%	3.7%	9.0%	8.4%	4.9%	12.0%			
1,000-3,300							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.3%	0.4%	0.3%	0.6%	0.8%	0.5%	1.1%	1.1%	0.6%	1.6%	7.0%	4.1%	10.0%	8.8%	5.1%	12.5%			
3,301-9,999							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.3%	0.4%	0.3%	0.6%	0.8%	0.5%	1.1%	1.1%	0.6%	1.6%	7.0%	4.1%	10.0%	8.8%	5.1%	12.5%			
10,000-49,999	0.4%	0.2%	0.6%	0.2%	0.1%	0.3%	0.5%	0.3%	0.7%	0.2%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	0.9%	2.2%	0.4%	0.2%	0.6%	8.9%	5.2%	12.7%	11.9%	6.9%	16.9%	11.9%	6.9%	16.9%
50,000-99,999	0.4%	0.2%	0.6%	0.2%	0.1%	0.3%	0.5%	0.3%	0.7%	0.2%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	0.9%	2.2%	0.4%	0.2%	0.6%	8.9%	5.2%	12.7%	11.9%	6.9%	16.9%			
100,000-999,999	0.4%	0.2%	0.6%	0.2%	0.1%	0.3%	0.5%	0.3%	0.7%	0.2%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	0.9%	2.2%	0.4%	0.2%	0.6%	8.9%	5.2%	12.7%	11.9%	6.9%	16.9%			
>=1,000,000	0.4%	0.2%	0.6%	0.2%	0.1%	0.3%	0.5%	0.3%	0.7%	0.2%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	0.9%	2.2%	0.4%	0.2%	0.6%	8.9%	5.2%	12.7%	11.9%	6.9%	16.9%			
Total %	0.2%	0.1%	0.2%	0.1%	0.0%	0.1%	0.2%	0.1%	0.3%	0.1%	0.0%	0.1%	0.2%	0.1%	0.3%	0.3%	0.2%	0.4%	1.0%	0.6%	1.5%	0.8%	0.4%	1.1%	7.5%	4.4%	10.7%	10.0%	5.8%	14.2%	10.0%	5.8%	14.2%
Total Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit C.3b

Stage 2 DBPR Treatment Technology Selection Deltas for CWS Surface Water Plants (Number of Plants by Residual Disinfection Type)

Alternative 1

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B						C						D						E						F					
<100	5	3	8							12	7	17	9	5	13							0	0	0	0	0	0						
100-499	28	16	39	1	1	1	3	2	4	7	4	10	7	4	10	0	0	0	0	0	0	0	0	0	0	0	0						
500-999	17	10	25	1	0	1	2	1	2	4	3	6	5	3	6	0	0	0	0	0	0	0	0	0	0	0	0						
1,000-3,300	42	24	60	2	1	3	10	6	14	7	4	10	10	6	14	0	0	0	0	0	0	0	0	0	0	0	0						
3,301-9,999	47	27	67	2	1	3	11	6	16	8	5	12	11	6	15	0	0	0	0	0	0	0	0	0	0	0	0						
10,000-49,999	96	56	137	1	0	1	7	4	11	7	4	9	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000-99,999	43	25	61	0	0	0	3	2	5	3	2	4	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	45	26	65	0	0	1	4	2	5	3	2	4	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>=1,000,000	5	3	8	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	330	191	469	7	4	10	40	23	57	52	30	74	44	26	63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	G						H						I						J						T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							0	0	0	0	0	0	5	3	7	4	2	5	0	0	0	1	1	1	19	11	27	36	21	51	352	204	501
100-499							0	0	0	0	0	0	2	1	3	3	2	5	6	4	9	7	4	11	48	28	69	65	38	92			
500-999							0	0	0	0	0	0	1	1	2	2	1	3	4	2	6	5	3	7	30	18	43	41	24	58			
1,000-3,300							0	0	0	0	0	0	2	1	3	5	3	7	9	5	13	13	7	18	79	46	112	100	58	142			
3,301-9,999							0	0	0	0	0	0	2	1	4	6	3	8	10	6	14	14	8	20	88	51	125	111	65	158			
10,000-49,999	5	3	8	3	2	4	6	4	9	2	1	3	0	0	0	0	0	0	20	11	28	5	3	7	115	67	164	154	89	219	304	177	432
50,000-99,999	2	1	3	1	1	2	3	2	4	1	1	1	0	0	0	0	0	0	9	5	12	2	1	3	52	30	73	69	40	98			
100,000-999,999	3	1	4	1	1	2	3	2	4	1	1	1	0	0	0	0	0	0	9	5	13	2	1	3	54	32	77	73	42	103			
>=1,000,000	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0	7	4	9	9	5	12			
Total Plants	11	6	15	6	3	8	12	7	18	4	2	6	14	8	19	20	11	28	68	40	97	50	29	71	493	286	701	656	381	933	656	381	933

Note: Detail may not add to totals due to independent rounding

Source: Above table with technologies switching from an advanced technology with Cl2 to the same advanced technology with CLM being moved into the CLM only column

Exhibit C.3c
Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)
Alternative 1

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K		
<100	1.5%	0.8%	2.1%							3.3%	1.9%	4.7%	2.5%	1.4%	3.5%							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
100-499	3.6%	2.1%	5.1%	0.1%	0.1%	0.2%	0.4%	0.2%	0.5%	0.9%	0.5%	1.3%	0.9%	0.5%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
500-999	3.6%	2.1%	5.1%	0.1%	0.1%	0.2%	0.4%	0.2%	0.5%	0.9%	0.5%	1.3%	0.9%	0.5%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
1,000-3,300	3.7%	2.2%	5.3%	0.2%	0.1%	0.2%	0.9%	0.5%	1.2%	0.7%	0.4%	0.9%	0.9%	0.5%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
3,301-9,999	3.7%	2.2%	5.3%	0.2%	0.1%	0.2%	0.9%	0.5%	1.2%	0.7%	0.4%	0.9%	0.9%	0.5%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
10,000-49,999	7.4%	4.3%	10.6%	0.1%	0.0%	0.1%	0.6%	0.3%	0.8%	0.5%	0.3%	0.7%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	7.4%	4.3%	10.6%	0.1%	0.0%	0.1%	0.6%	0.3%	0.8%	0.5%	0.3%	0.7%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	3.0%	1.7%	4.3%	0.1%	0.1%	0.1%	0.3%	0.2%	0.5%	1.6%	0.9%	2.2%	1.4%	0.8%	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	L			M			N			O			P			Q			R			S			T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	0.8%	2.0%	1.0%	0.6%	1.5%	0.0%	0.0%	0.0%	0.3%	0.2%	0.4%	5.3%	3.0%	7.5%	10.0%	5.7%	14.2%	9.0%	5.2%	12.7%
100-499	Mean						0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.2%	0.4%	0.4%	0.3%	0.6%	0.8%	0.5%	1.2%	1.0%	0.6%	1.4%	6.3%	3.7%	9.0%	8.4%	4.9%	12.0%			
500-999							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.2%	0.4%	0.4%	0.3%	0.6%	0.8%	0.5%	1.2%	1.0%	0.6%	1.4%	6.3%	3.7%	9.0%	8.4%	4.9%	12.0%			
1,000-3,300							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.3%	0.4%	0.3%	0.6%	0.8%	0.5%	1.1%	1.1%	0.6%	1.6%	7.0%	4.1%	10.0%	8.8%	5.1%	12.5%			
3,301-9,999							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.3%	0.4%	0.3%	0.6%	0.8%	0.5%	1.1%	1.1%	0.6%	1.6%	7.0%	4.1%	10.0%	8.8%	5.1%	12.5%			
10,000-49,999	0.4%	0.2%	0.6%	0.2%	0.1%	0.3%	0.5%	0.3%	0.7%	0.2%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	0.9%	2.2%	0.4%	0.2%	0.6%	8.9%	5.2%	12.7%	11.9%	6.9%	16.9%	11.9%	6.9%	16.9%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
100,000-999,999	0.4%	0.2%	0.6%	0.2%	0.1%	0.3%	0.5%	0.3%	0.7%	0.2%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	0.9%	2.2%	0.4%	0.2%	0.6%	8.9%	5.2%	12.7%	11.9%	6.9%	16.9%			
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
Total %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.4%	0.9%	0.6%	0.4%	0.9%	0.6%	0.3%	0.8%	0.8%	0.5%	1.1%	6.1%	3.5%	8.7%	9.0%	5.2%	12.8%	9.0%	5.2%	12.8%
Total Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit C.3d
Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Surface Water Plants (Number of Plants by Residual Disinfection Type)
Alternative 1

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B						C						D						E						F					
<100	3	2	5							7	4	11	6	3	8							0	0	0	0	0	0						
100-499	11	7	16	0	0	1	1	1	2	3	2	4	3	2	4	0	0	0	0	0	0	0	0	0	0	0	0						
500-999	4	2	5	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0						
1,000-3,300	3	2	5	0	0	0	1	0	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0						
3,301-9,999	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
10,000-49,999	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	23	13	33	1	0	1	3	1	4	12	7	17	10	6	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	G						H						I						J						T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							0	0	0	0	0	0	3	2	5	2	1	3	0	0	0	1	0	1	12	7	17	23	13	32	68	40	97
100-499							0	0	0	0	0	0	1	1	1	1	1	2	3	2	4	3	2	4	20	11	28	26	15	37			
500-999							0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	7	4	10	9	5	13			
1,000-3,300							0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	6	4	9	8	5	12			
3,301-9,999							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	2	2	1	3			
10,000-49,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Total Plants	0	0	0	0	0	0	0	0	0	0	0	0	5	3	7	5	3	7	4	3	6	6	4	9	47	27	67	69	40	98	69	40	98

Note: Detail may not add to totals due to independent rounding

Source: Above table with technologies switching from an advanced technology with Cl2 to the same advanced technology with CLM being moved into the CLM only column

Exhibit C.4a

Stage 2 DBPR Treatment Technology Selection Deltas for CWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)

Alternative 1

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	0.6%	0.0%	1.2%	0.0%	0.0%	0.4%	0.0%	0.0%	0.1%	2.0%	2.4%	2.9%
100-499	0.8%	0.0%	1.9%	0.0%	0.0%	0.2%	0.0%	0.0%	0.2%	2.9%	3.2%	
500-999	0.8%	0.0%	1.9%	0.0%	0.0%	0.2%	0.0%	0.0%	0.2%	2.9%	3.2%	
1,000-3,300	0.0%	0.0%	2.3%	0.0%	0.0%	0.0%	0.3%	0.0%	0.2%	2.7%	2.7%	
3,301-9,999	0.0%	0.0%	2.3%	0.0%	0.0%	0.0%	0.3%	0.0%	0.2%	2.7%	2.7%	
10,000-49,999	0.6%			0.0%	0.0%	0.1%	0.6%	0.1%	0.8%	1.9%	2.1%	2.1%
50,000-99,999	0.6%			0.0%	0.0%	0.1%	0.6%	0.1%	0.8%	1.9%	2.1%	
100,000-999,999	0.6%			0.0%	0.0%	0.0%	0.5%	0.1%	0.7%	1.8%	2.0%	
>=1,000,000	0.6%			0.0%	0.0%	0.0%	0.5%	0.1%	0.7%	1.8%	2.0%	
Total %	0.5%	0.0%	1.6%	0.0%	0.0%	0.2%	0.2%	0.0%	0.3%	2.6%	2.8%	2.8%

Note: Detail may not add to totals due to independent rounding

Exhibit C.4b

Stage 2 DBPR Treatment Technology Selection Deltas for CWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)

Alternative 1

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	3890.3%	0	80	0	0	27	0	1	8	127	155	1,173
100-499	123	0	295	0	0	33	0	3	28	447	483	
500-999	49	0	118	0	0	13	0	1	11	179	193	
1,000-3,300	0	0	171	0	0	0	22	1	11	205	206	
3,301-9,999	0	0	113	0	0	0	15	1	8	136	137	
10,000-49,999	30			0	0	3	30	6	43	103	111	145
50,000-99,999	4			0	0	0	4	1	6	14	15	
100,000-999,999	5			0	0	0	5	1	7	17	18	
>=1,000,000	0			0	0	0	0	0	0	0	1	

Exhibit C.4c
Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Alternative 1

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	0.6%	0.0%	1.2%	0.0%	0.0%	0.4%	0.0%	0.0%	0.1%	2.0%	2.4%	2.8%
100-499	0.8%	0.0%	1.9%	0.0%	0.0%	0.2%	0.0%	0.0%	0.2%	2.9%	3.2%	
500-999	0.8%	0.0%	1.9%	0.0%	0.0%	0.2%	0.0%	0.0%	0.2%	2.9%	3.2%	
1,000-3,300	0.0%	0.0%	2.3%	0.0%	0.0%	0.0%	0.3%	0.0%	0.2%	2.7%	2.7%	
3,301-9,999	0.0%	0.0%	2.3%	0.0%	0.0%	0.0%	0.3%	0.0%	0.2%	2.7%	2.7%	
10,000-49,999	0.6%			0.0%	0.0%	0.1%	0.6%	0.1%	0.8%	1.9%	2.1%	2.1%
50,000-99,999	0.6%			0.0%	0.0%	0.1%	0.6%	0.1%	0.8%	1.9%	2.1%	
100,000-999,999	0.6%			0.0%	0.0%	0.0%	0.5%	0.1%	0.7%	1.8%	2.0%	
>=1,000,000	0.0%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Total %	0.7%	0.0%	1.6%	0.0%	0.0%	0.3%	0.0%	0.0%	0.2%	2.5%	2.8%	2.8%

Note: Detail may not add to totals due to independent rounding

Exhibit C.4d
Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)
Alternative 1

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	1509.9%	0	31	0	0	10	0	0	3	49	60	154
100-499	17	0	41	0	0	5	0	0	4	62	67	
500-999	5	0	11	0	0	1	0	0	1	17	19	
1,000-3,300	0	0	6	0	0	0	1	0	0	7	7	
3,301-9,999	0	0	0	0	0	0	0	0	0	1	1	
10,000-49,999	0			0	0	0	0	0	0	0	0	0
50,000-99,999	0			0	0	0	0	0	0	0	0	
100,000-999,999	0			0	0	0	0	0	0	0	0	
>=1,000,000	0			0	0	0	0	0	0	0	0	

Exhibit C.5a
Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)
Alternative 1

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	31.9%	27.6%	36.1%	31.2%	30.6%	31.9%							3.3%	1.9%	4.7%	2.5%	1.4%	3.5%							14.5%	14.5%	14.5%	7.1%	7.1%	7.1%						
100-499	27.1%	23.6%	30.7%	39.0%	37.5%	40.5%	1.1%	1.0%	1.1%	1.2%	1.1%	1.4%	0.9%	0.5%	1.3%	0.9%	0.5%	1.3%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	8.9%	8.9%	8.9%	4.8%	4.8%	4.8%						
500-999	27.1%	23.6%	30.7%	39.0%	37.5%	40.5%	1.1%	1.0%	1.1%	1.2%	1.1%	1.4%	0.9%	0.5%	1.3%	0.9%	0.5%	1.3%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	8.9%	8.9%	8.9%	4.8%	4.8%	4.8%						
1,000-3,300	24.6%	20.9%	28.3%	45.1%	43.5%	46.6%	2.1%	2.0%	2.1%	3.0%	2.6%	3.4%	0.7%	0.4%	0.9%	0.9%	0.5%	1.2%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.2%	6.2%	6.2%	2.9%	2.9%	2.9%						
3,301-9,999	24.6%	20.9%	28.3%	45.1%	43.5%	46.6%	2.1%	2.0%	2.1%	3.0%	2.6%	3.4%	0.7%	0.4%	0.9%	0.9%	0.5%	1.2%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.2%	6.2%	6.2%	2.9%	2.9%	2.9%						
10,000-49,999	31.2%	31.2%	31.2%	41.0%	41.0%	41.0%	3.0%	3.0%	3.0%	4.0%	4.0%	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.5%	5.5%	5.5%	7.3%	7.3%	7.3%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	1.2%	1.2%	1.2%
50,000-99,999	31.2%	31.2%	31.2%	41.0%	41.0%	41.0%	3.0%	3.0%	3.0%	4.0%	4.0%	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.5%	5.5%	5.5%	7.3%	7.3%	7.3%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	1.2%	1.2%	1.2%
100,000-999,999	31.2%	31.2%	31.2%	41.0%	41.0%	41.0%	3.0%	3.0%	3.0%	4.0%	4.0%	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.5%	5.5%	5.5%	7.3%	7.3%	7.3%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	1.2%	1.2%	1.2%
>=1,000,000	31.2%	31.2%	31.2%	41.0%	41.0%	41.0%	3.0%	3.0%	3.0%	4.0%	4.0%	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.5%	5.5%	5.5%	7.3%	7.3%	7.3%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	1.2%	1.2%	1.2%
Total %	28.1%	25.8%	30.3%	41.6%	40.7%	42.5%	2.1%	2.1%	2.2%	2.9%	2.7%	3.0%	0.6%	0.3%	0.8%	0.6%	0.4%	0.9%	4.6%	4.6%	4.6%	5.3%	5.3%	5.3%	5.1%	5.1%	5.1%	2.8%	2.8%	2.8%	0.4%	0.4%	0.4%	0.5%	0.5%	0.5%

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							2.0%	2.0%	2.0%	1.3%	1.3%	1.3%	1.4%	0.8%	2.0%	1.0%	0.6%	1.5%	2.1%	2.1%	2.1%	1.7%	1.6%	1.8%	55.2%	49.0%	61.4%	44.8%	42.6%	47.1%
100-499							1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	0.8%	0.7%	0.9%	0.9%	0.7%	1.1%	1.3%	0.9%	1.6%	1.4%	1.0%	1.8%	46.2%	41.8%	50.7%	53.8%	51.1%	56.4%
500-999	Mean						1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	0.8%	0.7%	0.9%	0.9%	0.7%	1.1%	1.3%	0.9%	1.6%	1.4%	1.0%	1.8%	46.2%	41.8%	50.7%	53.8%	51.1%	56.4%
1,000-3,300	A						1.0%	1.0%	1.0%	1.2%	1.2%	1.2%	0.7%	0.6%	0.8%	1.0%	0.8%	1.2%	1.0%	0.6%	1.3%	1.3%	0.8%	1.8%	40.2%	35.8%	44.7%	59.8%	56.8%	62.7%
3,301-9,999							1.0%	1.0%	1.0%	1.2%	1.2%	1.2%	0.7%	0.6%	0.8%	1.0%	0.8%	1.2%	1.0%	0.6%	1.3%	1.3%	0.8%	1.8%	40.2%	35.8%	44.7%	59.8%	56.8%	62.7%
10,000-49,999	0.6%	0.6%	0.6%	0.8%	0.8%	0.8%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	43.2%	43.2%	43.2%	56.8%	56.8%	56.8%
50,000-99,999	0.6%	0.6%	0.6%	0.8%	0.8%	0.8%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	43.2%	43.2%	43.2%	56.8%	56.8%	56.8%
100,000-999,999	0.6%	0.6%	0.6%	0.8%	0.8%	0.8%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	43.2%	43.2%	43.2%	56.8%	56.8%	56.8%
>=1,000,000	0.6%	0.6%	0.6%	0.8%	0.8%	0.8%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	43.2%	43.2%	43.2%	56.8%	56.8%	56.8%
Total %	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.5%	0.4%	0.6%	0.6%	0.5%	0.7%	1.0%	0.8%	1.2%	1.2%	1.0%	1.5%	43.4%	40.5%	46.2%	56.6%	54.9%	58.3%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Alternative 1. Surface water systems serving 10,000 or more people: Use ending technology predictions from SWAT (FACA Screen Series3 v3.0 Database) for the Alternative 1.

Exhibit C.5b
Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Surface Water Plants (Number of Plants by Residual Disinfection Type)
Alternative 1

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	114	99	130	112	110	115							12	7	17	9	5	13							52	52	52	26	26	26						
100-499	208	181	235	299	288	311	8	8	9	9	8	11	7	4	10	7	4	10	39	39	39	35	35	35	68	68	68	37	37	37						
500-999	131	114	148	188	181	196	5	5	5	6	5	7	4	3	6	5	3	6	24	24	24	22	22	22	43	43	43	23	23	23						
1,000-3,300	278	236	320	509	491	527	23	23	24	34	30	38	7	4	10	10	6	14	45	45	45	51	51	51	70	70	70	32	32	32						
3,301-9,999	310	263	356	567	548	587	26	25	27	38	33	42	8	5	12	11	6	15	50	50	50	56	56	56	78	78	78	36	36	36						
10,000-49,999	403	403	403	529	529	529	39	39	39	51	51	51	0	0	0	0	0	0	72	72	72	94	94	94	10	10	10	13	13	13	12	12	12	16	16	16
50,000-99,999	181	181	181	237	237	237	17	17	17	23	23	23	0	0	0	0	0	0	32	32	32	42	42	42	5	5	5	6	6	6	6	6	6	7	7	7
100,000-999,999	190	190	190	250	250	250	18	18	18	24	24	24	0	0	0	0	0	0	34	34	34	44	44	44	5	5	5	6	6	6	6	6	6	8	8	8
>=1,000,000	23	23	23	30	30	30	2	2	2	3	3	3	0	0	0	0	0	0	4	4	4	5	5	5	1	1	1	1	1	1	1	1	1	1	1	1
Total Plants	1,838	1,690	1,986	2,723	2,664	2,782	140	137	142	188	177	199	39	22	55	41	24	58	301	301	301	350	350	350	331	331	331	181	181	181	24	24	24	32	32	32

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							7	7	7	5	5	5	5	3	7	4	2	5	8	8	8	6	6	6	198	176	221	161	153	169
100-499							8	8	8	7	7	7	6	5	7	7	5	8	10	7	12	11	7	14	354	320	388	412	392	433
500-999							5	5	5	5	5	5	4	3	4	4	3	5	6	5	8	7	5	9	223	202	245	260	247	273
1,000-3,300							12	12	12	13	13	13	8	7	9	11	9	14	11	7	15	15	9	20	454	404	505	675	642	708
3,301-9,999							13	13	13	15	15	15	9	8	10	13	11	15	12	8	16	16	11	22	506	450	563	752	715	789
10,000-49,999	8	8	8	11	11	11	4	4	4	5	5	5	0	0	0	0	0	0	10	10	10	13	13	13	558	558	558	733	733	733
50,000-99,999	4	4	4	5	5	5	2	2	2	2	2	2	0	0	0	0	0	0	5	5	5	6	6	6	250	250	250	329	329	329
100,000-999,999	4	4	4	5	5	5	2	2	2	3	3	3	0	0	0	0	0	0	5	5	5	6	6	6	264	264	264	347	347	347
>=1,000,000	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	32	32	32	42	42	42
Total Plants	16	16	16	21	21	21	53	53	53	55	55	55	32	26	38	39	31	47	67	55	80	81	64	98	2,841	2,656	3,025	3,710	3,599	3,822

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Alternative 1. Surface water systems serving 10,000 or more people: Use ending technology predictions from SWAT (FACA Screen Series3 v3.0 Database) for the Alternative 1.

Exhibit C.5c
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)
Alternative 1

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	31.9%	27.6%	36.1%	31.2%	30.6%	31.9%							3.3%	1.9%	4.7%	2.5%	1.4%	3.5%							14.5%	14.5%	14.5%	7.1%	7.1%	7.1%						
100-499	27.1%	23.6%	30.7%	39.0%	37.5%	40.5%	1.1%	1.0%	1.1%	1.2%	1.1%	1.4%	0.9%	0.5%	1.3%	0.9%	0.5%	1.3%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	8.9%	8.9%	8.9%	4.8%	4.8%	4.8%						
500-999	27.1%	23.6%	30.7%	39.0%	37.5%	40.5%	1.1%	1.0%	1.1%	1.2%	1.1%	1.4%	0.9%	0.5%	1.3%	0.9%	0.5%	1.3%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	8.9%	8.9%	8.9%	4.8%	4.8%	4.8%						
1,000-3,300	24.6%	20.9%	28.3%	45.1%	43.5%	46.6%	2.1%	2.0%	2.1%	3.0%	2.6%	3.4%	0.7%	0.4%	0.9%	0.9%	0.5%	1.2%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.2%	6.2%	6.2%	2.9%	2.9%	2.9%						
3,301-9,999	24.6%	20.9%	28.3%	45.1%	43.5%	46.6%	2.1%	2.0%	2.1%	3.0%	2.6%	3.4%	0.7%	0.4%	0.9%	0.9%	0.5%	1.2%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.2%	6.2%	6.2%	2.9%	2.9%	2.9%						
10,000-49,999	31.2%	31.2%	31.2%	41.0%	41.0%	41.0%	3.0%	3.0%	3.0%	4.0%	4.0%	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.5%	5.5%	5.5%	7.3%	7.3%	7.3%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	1.2%	1.2%	1.2%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	31.2%	31.2%	31.2%	41.0%	41.0%	41.0%	3.0%	3.0%	3.0%	4.0%	4.0%	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.5%	5.5%	5.5%	7.3%	7.3%	7.3%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	1.2%	1.2%	1.2%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	28.2%	24.4%	31.9%	37.7%	36.4%	38.9%	0.9%	0.9%	1.0%	1.2%	1.0%	1.3%	1.6%	0.9%	2.2%	1.4%	0.8%	1.9%	3.4%	3.4%	3.4%	3.2%	3.2%	3.2%	10.1%	10.1%	10.1%	5.2%	5.2%	5.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							2.0%	2.0%	2.0%	1.3%	1.3%	1.3%	1.4%	0.8%	2.0%	1.0%	0.6%	1.5%	2.1%	2.1%	2.1%	1.7%	1.6%	1.8%	55.2%	49.0%	61.4%	44.8%	42.6%	47.1%
100-499							1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	0.8%	0.7%	0.9%	0.9%	0.7%	1.1%	1.3%	0.9%	1.6%	1.4%	1.0%	1.8%	46.2%	41.8%	50.7%	53.8%	51.1%	56.4%
500-999	Mean						1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	0.8%	0.7%	0.9%	0.9%	0.7%	1.1%	1.3%	0.9%	1.6%	1.4%	1.0%	1.8%	46.2%	41.8%	50.7%	53.8%	51.1%	56.4%
1,000-3,300	A						1.0%	1.0%	1.0%	1.2%	1.2%	1.2%	0.7%	0.6%	0.8%	1.0%	0.8%	1.2%	1.0%	0.6%	1.3%	1.3%	0.8%	1.8%	40.2%	35.8%	44.7%	59.8%	56.8%	62.7%
3,301-9,999							1.0%	1.0%	1.0%	1.2%	1.2%	1.2%	0.7%	0.6%	0.8%	1.0%	0.8%	1.2%	1.0%	0.6%	1.3%	1.3%	0.8%	1.8%	40.2%	35.8%	44.7%	59.8%	56.8%	62.7%
10,000-49,999	0.6%	0.6%	0.6%	0.8%	0.8%	0.8%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	43.2%	43.2%	43.2%	56.8%	56.8%	56.8%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	0.6%	0.6%	0.6%	0.8%	0.8%	0.8%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	43.2%	43.2%	43.2%	56.8%	56.8%	56.8%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	1.3%	1.3%	1.1%	1.1%	1.1%	1.0%	0.7%	1.2%	0.9%	0.7%	1.2%	1.5%	1.2%	1.7%	1.5%	1.1%	1.8%	47.9%	43.0%	52.9%	52.1%	49.5%	54.6%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Alternative 1. Surface water systems serving 10,000 or more people: Use ending technology predictions from SWAT (FACA Screen Series3 v3.0 Database) for the Alternative 1.

Exhibit C.5d
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Surface Water Plants (Number of Plants by Residual Disinfection Type)
Alternative 1

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	72	62	82	71	69	72							7	4	11	6	3	8							33	33	33	16	16	16						
100-499	85	74	96	122	117	127	3	3	3	4	3	4	3	2	4	3	2	4	16	16	16	14	14	14	28	28	28	15	15	15						
500-999	29	25	33	41	40	43	1	1	1	1	1	1	1	1	1	1	1	1	5	5	5	5	5	5	9	9	9	5	5	5						
1,000-3,300	23	19	26	41	40	43	2	2	2	3	2	3	1	0	1	1	0	1	4	4	4	4	4	4	6	6	6	3	3	3						
3,301-9,999	6	5	7	11	11	12	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	2	2	2	1	1	1						
10,000-49,999	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	216	187	245	289	279	299	7	7	7	9	8	10	12	7	17	10	6	15	26	26	26	25	25	25	77	77	77	40	40	40	0	0	0	0	0	0

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							4	4	4	3	3	3	3	2	5	2	1	3	5	5	5	4	4	4	125	111	139	101	96	106
100-499							3	3	3	3	3	3	2	2	3	3	2	3	4	3	5	4	3	6	144	130	158	168	160	176
500-999							1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	49	44	54	57	54	60
1,000-3,300							1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	37	33	41	55	52	58
3,301-9,999							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	9	11	15	14	16
10,000-49,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	3	3	3
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	0	0	0	0	0	0	10	10	10	8	8	8	7	5	9	7	5	9	11	10	13	11	9	14	368	330	405	399	380	419

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Alternative 1. Surface water systems serving 10,000 or more people: Use ending technology predictions from SWAT (FACA Screen Series3 v3.0 Database) for the Alternative 1.

Exhibit C.6a

Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)

Alternative 1

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	93.5%	3.0%	0.0%	1.2%	0.0%	0.0%	0.4%	0.9%	0.4%	0.6%	94.3%	5.7%
100-499	92.1%	3.6%	0.0%	1.9%	0.2%	0.5%	0.2%	0.6%	0.1%	0.7%	92.6%	7.4%
500-999	92.1%	3.6%	0.0%	1.9%	0.2%	0.5%	0.2%	0.6%	0.1%	0.7%	92.6%	7.4%
1,000-3,300	93.0%	2.5%	0.0%	2.3%	0.3%	0.9%	0.0%	0.3%	0.1%	0.6%	93.4%	6.6%
3,301-9,999	93.0%	2.5%	0.0%	2.3%	0.3%	0.9%	0.0%	0.3%	0.1%	0.6%	93.4%	6.6%
10,000-49,999	87.1%	7.8%			0.8%	0.8%	0.1%	0.6%	1.8%	1.1%	89.8%	10.2%
50,000-99,999	87.1%	7.8%			0.8%	0.8%	0.1%	0.6%	1.8%	1.1%	89.8%	10.2%
100,000-999,999	87.5%	7.6%			0.8%	0.7%	0.0%	0.6%	1.8%	1.0%	90.1%	9.9%
>=1,000,000	87.5%	7.6%			0.8%	0.7%	0.0%	0.6%	1.8%	1.0%	90.1%	9.9%
Total %	91.8%	3.9%	0.0%	1.6%	0.3%	0.6%	0.2%	0.6%	0.4%	0.7%	92.6%	7.4%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Alternative 1.

Exhibit C.6b

Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)

Alternative 1	A											
System Size (Population Served)	echnology CL21	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	6,006	194	0	80	0	0	27	56	23	37	6,055	368
100-499	14,040	550	0	295	25	74	33	96	23	107	14,120	1,122
500-999	5,613	220	0	118	10	29	13	39	9	43	5,645	449
1,000-3,300	7,058	192	0	171	22	66	0	26	5	47	7,085	502
3,301-9,999	4,679	127	0	113	15	44	0	18	3	31	4,697	333
10,000-49,999	4,690	419			46	42	3	32	95	57	4,833	549
50,000-99,999	624	56			6	6	0	4	13	8	643	73
Total Plants	43,536	1,829	0	778	130	267	76	277	188	339	43,930	3,489

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Alternative 1.

Exhibit C.6c
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Alternative 1

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	93.5%	3.0%	0.0%	1.2%	0.0%	0.0%	0.4%	0.9%	0.4%	0.6%	94.3%	5.7%
100-499	92.1%	3.6%	0.0%	1.9%	0.2%	0.5%	0.2%	0.6%	0.1%	0.7%	92.6%	7.4%
500-999	92.1%	3.6%	0.0%	1.9%	0.2%	0.5%	0.2%	0.6%	0.1%	0.7%	92.6%	7.4%
1,000-3,300	93.0%	2.5%	0.0%	2.3%	0.3%	0.9%	0.0%	0.3%	0.1%	0.6%	93.4%	6.6%
3,301-9,999	93.0%	2.5%	0.0%	2.3%	0.3%	0.9%	0.0%	0.3%	0.1%	0.6%	93.4%	6.6%
10,000-49,999	87.1%	7.8%			0.8%	0.8%	0.1%	0.6%	1.8%	1.1%	89.8%	10.2%
50,000-99,999	87.1%	7.8%			0.8%	0.8%	0.1%	0.6%	1.8%	1.1%	89.8%	10.2%
100,000-999,999	87.5%	7.6%			0.8%	0.7%	0.0%	0.6%	1.8%	1.0%	90.1%	9.9%
>=1,000,000	0.0%	0.0%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	92.8%	3.3%	0.0%	1.6%	0.1%	0.3%	0.3%	0.7%	0.2%	0.6%	93.4%	6.6%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Alternative 1.

Exhibit C.6d
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)

Alternative 1

A

System Size (Population Served)	echnology CL21	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	2,331	75	0	31	0	0	10	22	9	14	2,350	143
100-499	1,961	77	0	41	3	10	5	13	3	15	1,972	157
500-999	543	21	0	11	1	3	1	4	1	4	546	43
1,000-3,300	230	6	0	6	1	2	0	1	0	2	231	16
3,301-9,999	20	1	0	0	0	0	0	0	0	0	20	1
10,000-49,999	3	0			0	0	0	0	0	0	3	0
50,000-99,999	0	0			0	0	0	0	0	0	0	0
Total Plants	5,088	181	0	90	5	15	16	40	13	35	5,122	361

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Alternative 1.

Exhibit C.7a
Stage 2 DBPR Treatment Technology Selection Deltas for CWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)
Alternative 2

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K		
<100	-2.3%	-2.6%	-1.9%							1.4%	1.2%	1.5%	1.4%	1.2%	1.6%							0.0%	0.0%	0.0%	3.7%	3.2%	4.1%						
100-499	-1.0%	-1.5%	-0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%	0.4%	4.5%	4.0%	5.0%						
500-999	-1.0%	-1.5%	-0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%	0.4%	4.5%	4.0%	5.0%						
1,000-3,300	0.2%	-0.2%	0.7%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.5%	0.6%	4.0%	3.5%	4.4%						
3,301-9,999	0.2%	-0.2%	0.7%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.5%	0.6%	4.0%	3.5%	4.4%						
10,000-49,999	7.7%	6.9%	8.6%	3.6%	3.2%	4.0%	2.7%	2.4%	3.0%	2.4%	2.1%	2.6%	1.0%	0.9%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.5%	5.8%	7.3%	3.1%	2.7%	3.4%
50,000-99,999	7.7%	6.9%	8.6%	3.6%	3.2%	4.0%	2.7%	2.4%	3.0%	2.4%	2.1%	2.6%	1.0%	0.9%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.5%	5.8%	7.3%	3.1%	2.7%	3.4%
100,000-999,999	7.7%	6.9%	8.6%	3.6%	3.2%	4.0%	2.7%	2.4%	3.0%	2.4%	2.1%	2.6%	1.0%	0.9%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.5%	5.8%	7.3%	3.1%	2.7%	3.4%
>=1,000,000	7.7%	6.9%	8.6%	3.6%	3.2%	4.0%	2.7%	2.4%	3.0%	2.4%	2.1%	2.6%	1.0%	0.9%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.5%	5.8%	7.3%	3.1%	2.7%	3.4%
Total %	2.8%	2.2%	3.4%	1.4%	1.2%	1.6%	1.1%	1.0%	1.2%	1.0%	0.9%	1.1%	0.5%	0.4%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	2.5%	2.2%	2.8%	2.5%	2.2%	2.8%	1.2%	1.1%	1.3%

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	ting to CLM			M			N			O			P			Q			R			S			T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100	Only						4.2%	3.7%	4.7%	5.1%	4.5%	5.7%	3.6%	3.2%	4.0%	3.7%	3.2%	4.1%	0.0%	0.0%	0.0%	0.9%	0.8%	1.0%	12.5%	10.4%	14.6%	21.7%	18.6%	24.8%	22.2%	19.1%	25.2%
100-499							3.5%	3.1%	3.9%	6.1%	5.4%	6.8%	2.1%	1.9%	2.4%	3.6%	3.2%	4.1%	0.9%	0.8%	1.0%	1.8%	1.6%	2.0%	15.0%	12.6%	17.4%	21.9%	18.8%	25.1%			
500-999							3.5%	3.1%	3.9%	6.1%	5.4%	6.8%	2.1%	1.9%	2.4%	3.6%	3.2%	4.1%	0.9%	0.8%	1.0%	1.8%	1.6%	2.0%	15.0%	12.6%	17.4%	21.9%	18.8%	25.1%			
1,000-3,300							3.0%	2.7%	3.4%	7.4%	6.5%	8.2%	1.9%	1.6%	2.1%	4.4%	3.9%	4.9%	0.2%	0.2%	0.2%	0.6%	0.6%	0.7%	16.7%	14.3%	19.0%	22.3%	19.3%	25.4%			
3,301-9,999							3.0%	2.7%	3.4%	7.4%	6.5%	8.2%	1.9%	1.6%	2.1%	4.4%	3.9%	4.9%	0.2%	0.2%	0.2%	0.6%	0.6%	0.7%	16.7%	14.3%	19.0%	22.3%	19.3%	25.4%			
10,000-49,999	4.0%	3.5%	4.4%	1.9%	1.7%	2.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.3%	17.1%	15.1%	19.1%	34.8%	30.8%	38.9%	34.8%	30.8%	38.9%
50,000-99,999	4.0%	3.5%	4.4%	1.9%	1.7%	2.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.3%	17.1%	15.1%	19.1%	34.8%	30.8%	38.9%			
100,000-999,999	4.0%	3.5%	4.4%	1.9%	1.7%	2.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.3%	17.1%	15.1%	19.1%	34.8%	30.8%	38.9%			
>=1,000,000	4.0%	3.5%	4.4%	1.9%	1.7%	2.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.3%	17.1%	15.1%	19.1%	34.8%	30.8%	38.9%			
Total %	1.5%	1.4%	1.7%	0.7%	0.6%	0.8%	2.2%	1.9%	2.5%	4.3%	3.8%	4.8%	1.4%	1.2%	1.6%	2.5%	2.3%	2.8%	0.5%	0.4%	0.5%	0.7%	0.6%	0.8%	16.3%	14.1%	18.5%	27.1%	23.7%	30.6%	27.1%	23.7%	30.6%
Total Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit C.7b
Stage 2 DBPR Treatment Technology Selection Deltas for CWS Surface Water Plants (Number of Plants by Residual Disinfection Type)
Alternative 2

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B						C						D						E						F					
<100	-8	-9	-7							5	4	6	5	4	6							0	0	0	13	12	15						
100-499	-8	-11	-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	34	30	38						
500-999	-5	-7	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	22	19	24						
1,000-3,300	2	-3	7	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	6	6	7	45	40	50						
3,301-9,999	3	-3	8	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	7	6	8	50	44	56						
10,000-49,999	100	89	112	46	41	51	35	31	39	31	27	34	12	11	14	0	0	0	0	0	0	0	0	0	0	0	0	84	74	94	40	35	45
50,000-99,999	45	40	50	21	18	23	16	14	17	14	12	15	6	5	6	0	0	0	0	0	0	0	0	0	0	0	0	38	33	42	18	16	20
100,000-999,999	47	42	53	22	19	24	16	15	18	14	13	16	6	5	7	0	0	0	0	0	0	0	0	0	0	0	0	40	35	44	19	17	21
>=1,000,000	6	5	6	3	2	3	2	2	2	2	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	5	4	5	2	2	3
Total Plants	183	141	224	91	81	102	71	63	79	65	58	73	30	26	33	0	0	0	0	0	0	19	16	21	164	145	183	166	147	185	79	70	88

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	G						H						I						J						T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							15	13	17	18	16	20	13	11	14	13	12	15	0	0	0	3	3	4	45	37	52	78	67	89	886	763	1,009
100-499							27	24	30	47	41	52	16	14	18	28	25	31	7	6	8	13	12	15	115	97	133	168	144	193			
500-999							17	15	19	30	26	33	10	9	12	18	16	20	4	4	5	9	8	9	72	61	84	106	91	121			
1,000-3,300							34	30	38	83	74	93	21	19	23	50	44	55	2	2	3	7	6	8	188	162	215	252	218	286			
3,301-9,999							38	34	43	93	82	104	23	21	26	55	49	62	3	2	3	8	7	9	210	180	240	281	243	319			
10,000-49,999	51	45	57	24	21	27	7	6	8	4	3	4	4	3	4	2	1	2	7	6	8	4	3	4	221	195	246	450	398	502	890	788	994
50,000-99,999	23	20	26	11	10	12	3	3	3	2	2	2	2	2	2	1	1	1	3	3	3	2	2	2	99	88	111	202	179	225			
100,000-999,999	24	21	27	11	10	13	3	3	4	2	2	2	2	2	2	1	1	1	3	3	4	2	2	2	104	92	116	213	188	237			
>=1,000,000	3	3	3	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	11	14	26	23	29			
Total Plants	101	89	113	48	42	54	144	128	161	279	247	311	91	81	102	167	148	186	30	27	34	48	42	54	1,067	924	1,212	1,776	1,551	2,003	1,776	1,551	2,003

Note: Detail may not add to totals due to independent rounding

Source: Above table with technologies switching from an advanced technology with Cl2 to the same advanced technology with CLM being moved into the CLM only column

Exhibit C.7c

Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)

Alternative 2

System Size (Population Served)				Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
	Converting to CLM Only			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K		
<100	-2.3%	-2.6%	-1.9%							1.4%	1.2%	1.5%	1.4%	1.2%	1.6%							0.0%	0.0%	0.0%	3.7%	3.2%	4.1%						
100-499	-1.0%	-1.5%	-0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%	0.4%	4.5%	4.0%	5.0%						
500-999	-1.0%	-1.5%	-0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%	0.4%	4.5%	4.0%	5.0%						
1,000-3,300	0.2%	-0.2%	0.7%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.5%	0.6%	4.0%	3.5%	4.4%						
3,301-9,999	0.2%	-0.2%	0.7%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.5%	0.6%	4.0%	3.5%	4.4%						
10,000-49,999	7.7%	6.9%	8.6%	3.6%	3.2%	4.0%	2.7%	2.4%	3.0%	2.4%	2.1%	2.6%	1.0%	0.9%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.5%	5.8%	7.3%	3.1%	2.7%	3.4%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	7.7%	6.9%	8.6%	3.6%	3.2%	4.0%	2.7%	2.4%	3.0%	2.4%	2.1%	2.6%	1.0%	0.9%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.5%	5.8%	7.3%	3.1%	2.7%	3.4%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	-1.1%	-1.6%	-0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%	0.5%	0.4%	0.4%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	4.1%	3.6%	4.6%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	ing to CLM Only			M			N			O			P			Q			R			S			T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							4.2%	3.7%	4.7%	5.1%	4.5%	5.7%	3.6%	3.2%	4.0%	3.7%	3.2%	4.1%	0.0%	0.0%	0.0%	0.9%	0.8%	1.0%	12.5%	10.4%	14.6%	21.7%	18.6%	24.8%	21.9%	18.8%	25.1%
100-499							3.5%	3.1%	3.9%	6.1%	5.4%	6.8%	2.1%	1.9%	2.4%	3.6%	3.2%	4.1%	0.9%	0.8%	1.0%	1.8%	1.6%	2.0%	15.0%	12.6%	17.4%	21.9%	18.8%	25.1%			
500-999							3.5%	3.1%	3.9%	6.1%	5.4%	6.8%	2.1%	1.9%	2.4%	3.6%	3.2%	4.1%	0.9%	0.8%	1.0%	1.8%	1.6%	2.0%	15.0%	12.6%	17.4%	21.9%	18.8%	25.1%			
1,000-3,300							3.0%	2.7%	3.4%	7.4%	6.5%	8.2%	1.9%	1.6%	2.1%	4.4%	3.9%	4.9%	0.2%	0.2%	0.2%	0.6%	0.6%	0.7%	16.7%	14.3%	19.0%	22.3%	19.3%	25.4%			
3,301-9,999							3.0%	2.7%	3.4%	7.4%	6.5%	8.2%	1.9%	1.6%	2.1%	4.4%	3.9%	4.9%	0.2%	0.2%	0.2%	0.6%	0.6%	0.7%	16.7%	14.3%	19.0%	22.3%	19.3%	25.4%			
10,000-49,999	4.0%	3.5%	4.4%	1.9%	1.7%	2.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.3%	17.1%	15.1%	19.1%	34.8%	30.8%	38.9%	34.8%	30.8%	38.9%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
100,000-999,999	4.0%	3.5%	4.4%	1.9%	1.7%	2.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.3%	17.1%	15.1%	19.1%	34.8%	30.8%	38.9%			
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
Total %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.6%	3.2%	4.0%	6.0%	5.3%	6.7%	2.5%	2.2%	2.8%	3.7%	3.3%	4.2%	0.6%	0.5%	0.6%	1.3%	1.2%	1.5%	14.5%	12.3%	16.8%	22.0%	18.9%	25.2%	22.0%	18.9%	25.2%
Total Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit C.7d

Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Surface Water Plants (Number of Plants by Residual Disinfection Type)

Alternative 2

System Size (Population Served)				Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
	Converting to CLM Only			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B						C						D						E						F					
<100	-5	-6	-4							3	3	3	3	3	4							0	0	0	8	7	9						
100-499	-3	-5	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	14	12	16						
500-999	-1	-2	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	4	5						
1,000-3,300	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	4	3	4						
3,301-9,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1						
10,000-49,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	-9	-12	-5	0	0	0	0	0	0	3	3	4	3	3	4	0	0	0	0	0	0	2	2	3	32	28	35	0	0	0	0	0	0

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	G						H						I						J						T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							9	8	11	11	10	13	8	7	9	8	7	9	0	0	0	2	2	2	28	24	33	49	42	56	167	143	191
100-499							11	10	12	19	17	21	7	6	7	11	10	13	3	3	3	5	5	6	47	39	54	68	59	78			
500-999							4	3	4	6	6	7	2	2	3	4	3	4	1	1	1	2	2	2	16	13	18	23	20	27			
1,000-3,300							3	2	3	7	6	8	2	2	2	4	4	5	0	0	0	1	1	1	15	13	18	21	18	23			
3,301-9,999							1	1	1	2	2	2	0	0	1	1	1	1	0	0	0	0	0	0	4	4	5	6	5	6			
10,000-49,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	2	2	2
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Total Plants	0	0	0	0	0	0	28	24	31	46	40	51	19	17	21	29	25	32	4	4	5	10	9	11	112	94	129	169	145	193	169	145	193

Note: Detail may not add to totals due to independent rounding

Source: Above table with technologies switching from an advanced technology with Cl2 to the same advanced technology with CLM being moved into the CLM only column

Exhibit C.8a
Stage 2 DBPR Treatment Technology Selection Deltas for CWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Alternative 2

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	3.8%	0.0%	0.9%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	4.7%	5.1%	5.2%
100-499	3.9%	0.0%	1.3%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	5.2%	5.3%	
500-999	3.9%	0.0%	1.3%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	5.2%	5.3%	
1,000-3,300	3.5%	0.0%	1.4%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	5.0%	5.0%	
3,301-9,999	3.5%	0.0%	1.4%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	5.0%	5.0%	
10,000-49,999	5.9%			0.1%	0.0%	0.0%	0.4%	0.0%	0.5%	6.8%	7.0%	6.9%
50,000-99,999	5.9%			0.1%	0.0%	0.0%	0.4%	0.0%	0.5%	6.8%	7.0%	
100,000-999,999	5.6%			0.1%	0.0%	0.0%	0.4%	0.0%	0.5%	6.5%	6.6%	
>=1,000,000	5.6%			0.1%	0.0%	0.0%	0.4%	0.0%	0.5%	6.5%	6.6%	
Total %	4.1%	0.0%	1.1%	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	5.3%	5.4%	5.4%

Note: Detail may not add to totals due to independent rounding

Exhibit C.8b
Stage 2 DBPR Treatment Technology Selection Deltas for CWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)
Alternative 2

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	24520.6%	0	59	0	0	20	0	0	0	305	324	2,093
100-499	590	0	200	0	0	22	0	0	0	790	812	
500-999	236	0	80	0	0	9	0	0	0	316	325	
1,000-3,300	263	0	108	0	0	0	9	0	0	380	380	
3,301-9,999	175	0	71	0	0	0	6	0	0	252	252	
10,000-49,999	317			7	0	0	22	0	29	368	375	488
50,000-99,999	42			1	0	0	3	0	4	49	50	
100,000-999,999	51			1	0	0	4	0	5	60	61	
>=1,000,000	2			0	0	0	0	0	0	2	2	

Exhibit C.8c

Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)

Alternative 2

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	3.8%	0.0%	0.9%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	4.7%	5.1%	5.2%
100-499	3.9%	0.0%	1.3%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	5.2%	5.3%	
500-999	3.9%	0.0%	1.3%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	5.2%	5.3%	
1,000-3,300	3.5%	0.0%	1.4%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	5.0%	5.0%	
3,301-9,999	3.5%	0.0%	1.4%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	5.0%	5.0%	
10,000-49,999	5.9%			0.1%	0.0%	0.0%	0.4%	0.0%	0.5%	6.8%	7.0%	6.9%
50,000-99,999	5.9%			0.1%	0.0%	0.0%	0.4%	0.0%	0.5%	6.8%	7.0%	
100,000-999,999	5.6%			0.1%	0.0%	0.0%	0.4%	0.0%	0.5%	6.5%	6.6%	
>=1,000,000	0.0%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Total %	3.8%	0.0%	1.1%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	5.0%	5.2%	5.2%

Note: Detail may not add to totals due to independent rounding

Exhibit C.8d

Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)

Alternative 2

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	9516.8%	0	23	0	0	8	0	0	0	118	126	284
100-499	82	0	28	0	0	3	0	0	0	110	113	
500-999	23	0	8	0	0	1	0	0	0	31	31	
1,000-3,300	9	0	4	0	0	0	0	0	0	12	12	
3,301-9,999	1	0	0	0	0	0	0	0	0	1	1	
10,000-49,999	0			0	0	0	0	0	0	0	0	0
50,000-99,999	0			0	0	0	0	0	0	0	0	
100,000-999,999	0			0	0	0	0	0	0	0	0	
>=1,000,000	0			0	0	0	0	0	0	0	0	

Exhibit C.9a
Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)
Alternative 2

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	20.2%	17.0%	23.3%	27.5%	27.1%	27.9%							1.4%	1.2%	1.5%	1.4%	1.2%	1.6%							14.5%	14.5%	14.5%	10.8%	10.4%	11.2%						
100-499	13.7%	10.5%	16.8%	34.4%	33.9%	34.9%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	9.3%	9.3%	9.4%	9.3%	8.8%	9.8%						
500-999	13.7%	10.5%	16.8%	34.4%	33.9%	34.9%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	9.3%	9.3%	9.4%	9.3%	8.8%	9.8%						
1,000-3,300	11.1%	8.1%	14.1%	41.6%	41.1%	42.0%	1.9%	1.9%	1.9%	2.2%	2.2%	2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.7%	6.7%	6.8%	6.8%	6.4%	7.3%						
3,301-9,999	11.1%	8.1%	14.1%	41.6%	41.1%	42.0%	1.9%	1.9%	1.9%	2.2%	2.2%	2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.7%	6.7%	6.8%	6.8%	6.4%	7.3%						
10,000-49,999	16.7%	16.7%	16.7%	34.6%	34.6%	34.6%	3.9%	3.9%	3.9%	8.1%	8.1%	8.1%	0.8%	0.8%	0.8%	1.7%	1.7%	1.7%	4.2%	4.2%	4.2%	8.6%	8.6%	8.6%	0.6%	0.6%	0.6%	1.2%	1.2%	1.2%	3.3%	3.3%	3.3%	6.9%	6.9%	6.9%
50,000-99,999	16.7%	16.7%	16.7%	34.6%	34.6%	34.6%	3.9%	3.9%	3.9%	8.1%	8.1%	8.1%	0.8%	0.8%	0.8%	1.7%	1.7%	1.7%	4.2%	4.2%	4.2%	8.6%	8.6%	8.6%	0.6%	0.6%	0.6%	1.2%	1.2%	1.2%	3.3%	3.3%	3.3%	6.9%	6.9%	6.9%
100,000-999,999	16.7%	16.7%	16.7%	34.6%	34.6%	34.6%	3.9%	3.9%	3.9%	8.1%	8.1%	8.1%	0.8%	0.8%	0.8%	1.7%	1.7%	1.7%	4.2%	4.2%	4.2%	8.6%	8.6%	8.6%	0.6%	0.6%	0.6%	1.2%	1.2%	1.2%	3.3%	3.3%	3.3%	6.9%	6.9%	6.9%
>=1,000,000	16.7%	16.7%	16.7%	34.6%	34.6%	34.6%	3.9%	3.9%	3.9%	8.1%	8.1%	8.1%	0.8%	0.8%	0.8%	1.7%	1.7%	1.7%	4.2%	4.2%	4.2%	8.6%	8.6%	8.6%	0.6%	0.6%	0.6%	1.2%	1.2%	1.2%	3.3%	3.3%	3.3%	6.9%	6.9%	6.9%
Total %	14.3%	12.4%	16.1%	36.7%	36.4%	37.0%	2.4%	2.4%	2.4%	4.2%	4.1%	4.2%	0.4%	0.4%	0.4%	0.8%	0.7%	0.8%	4.1%	4.1%	4.1%	5.9%	5.9%	5.9%	5.3%	5.2%	5.3%	5.3%	5.0%	5.6%	1.3%	1.3%	1.3%	2.7%	2.7%	2.7%

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							6.1%	5.7%	6.6%	6.4%	5.8%	7.0%	3.6%	3.2%	4.0%	3.7%	3.2%	4.1%	2.2%	2.2%	2.2%	2.3%	2.2%	2.4%	47.9%	43.7%	52.1%	52.1%	50.0%	54.1%
100-499							4.5%	4.1%	4.9%	7.1%	6.4%	7.8%	2.6%	2.4%	2.9%	4.1%	3.7%	4.5%	1.4%	1.3%	1.5%	2.2%	2.0%	2.4%	37.5%	33.5%	41.5%	62.5%	60.1%	64.9%
500-999	Mean						4.5%	4.1%	4.9%	7.1%	6.4%	7.8%	2.6%	2.4%	2.9%	4.1%	3.7%	4.5%	1.4%	1.3%	1.5%	2.2%	2.0%	2.4%	37.5%	33.5%	41.5%	62.5%	60.1%	64.9%
1,000-3,300	A						4.1%	3.7%	4.4%	8.6%	7.7%	9.4%	2.4%	2.2%	2.6%	5.0%	4.5%	5.5%	0.4%	0.4%	0.4%	0.8%	0.7%	0.9%	30.6%	26.9%	34.2%	69.4%	67.1%	71.8%
3,301-9,999							4.1%	3.7%	4.4%	8.6%	7.7%	9.4%	2.4%	2.2%	2.6%	5.0%	4.5%	5.5%	0.4%	0.4%	0.4%	0.8%	0.7%	0.9%	30.6%	26.9%	34.2%	69.4%	67.1%	71.8%
10,000-49,999	2.0%	2.0%	2.0%	4.2%	4.2%	4.2%	0.4%	0.4%	0.4%	0.7%	0.7%	0.7%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	32.6%	32.6%	32.6%	67.4%	67.4%	67.4%
50,000-99,999	2.0%	2.0%	2.0%	4.2%	4.2%	4.2%	0.4%	0.4%	0.4%	0.7%	0.7%	0.7%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	32.6%	32.6%	32.6%	67.4%	67.4%	67.4%
100,000-999,999	2.0%	2.0%	2.0%	4.2%	4.2%	4.2%	0.4%	0.4%	0.4%	0.7%	0.7%	0.7%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	32.6%	32.6%	32.6%	67.4%	67.4%	67.4%
>=1,000,000	2.0%	2.0%	2.0%	4.2%	4.2%	4.2%	0.4%	0.4%	0.4%	0.7%	0.7%	0.7%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	32.6%	32.6%	32.6%	67.4%	67.4%	67.4%
Total %	0.8%	0.8%	0.8%	1.6%	1.6%	1.6%	2.8%	2.6%	3.1%	5.1%	4.6%	5.6%	1.6%	1.5%	1.8%	2.9%	2.6%	3.2%	0.7%	0.7%	0.7%	1.2%	1.2%	1.3%	33.6%	31.3%	36.0%	66.4%	64.9%	67.8%

Note: Detail may not add to totals due to independent rounding.

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Alternative 1. Surface water systems serving 10,000 or more people: Use ending technology predictions from SWAT (FACA Screen Series3 v3.0 Database) for the Alternative 1.

Exhibit C.9b
Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Surface Water Plants (Number of Plants by Residual Disinfection Type)
Alternative 2

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	72	61	84	99	97	100							5	4	6	5	4	6							52	52	52	39	37	40						
100-499	105	80	129	264	260	268	7	7	7	7	7	7	0	0	0	0	0	0	39	39	39	35	35	35	71	71	72	71	67	75						
500-999	66	51	81	166	164	169	5	5	5	4	4	4	0	0	0	0	0	0	24	24	24	22	22	22	45	45	45	45	42	47						
1,000-3,300	125	91	159	469	464	474	22	22	22	25	25	25	0	0	0	0	0	0	45	45	45	51	51	51	76	75	77	77	72	82						
3,301-9,999	140	102	177	523	517	529	24	24	24	28	28	28	0	0	0	0	0	0	50	50	50	56	56	56	85	84	86	86	80	92						
10,000-49,999	216	216	216	446	446	446	51	51	51	105	105	105	11	11	11	22	22	22	54	54	54	112	112	112	8	8	8	16	16	16	43	43	43	89	89	89
50,000-99,999	97	97	97	200	200	200	23	23	23	47	47	47	5	5	5	10	10	10	24	24	24	50	50	50	3	3	3	7	7	7	19	19	19	40	40	40
100,000-999,999	102	102	102	211	211	211	24	24	24	50	50	50	5	5	5	11	11	11	26	26	26	53	53	53	4	4	4	8	8	8	20	20	20	42	42	42
>=1,000,000	12	12	12	25	25	25	3	3	3	6	6	6	1	1	1	1	1	1	3	3	3	6	6	6	0	0	0	1	1	1	2	2	2	5	5	5
Total Plants	935	812	1,058	2,404	2,386	2,423	158	158	158	272	272	272	26	26	27	49	49	50	266	266	266	385	385	385	345	342	347	349	330	368	85	85	85	177	177	177

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							22	20	24	23	21	25	13	11	14	13	12	15	8	8	8	8	8	9	172	157	187	187	180	194
100-499							35	32	38	54	49	60	20	18	22	31	28	35	11	10	11	17	15	18	288	257	318	479	461	497
500-999							22	20	24	34	31	38	13	11	14	20	18	22	7	6	7	10	9	11	181	162	200	302	290	313
1,000-3,300							46	42	50	97	87	106	27	24	29	56	50	62	4	4	5	9	8	10	345	304	387	784	757	811
3,301-9,999							51	47	56	108	97	118	30	27	33	63	56	69	5	5	5	10	9	11	385	338	431	874	844	903
10,000-49,999	26	26	26	54	54	54	5	5	5	10	10	10	2	2	2	3	3	3	6	6	6	13	13	13	421	421	421	871	871	871
50,000-99,999	12	12	12	24	24	24	2	2	2	4	4	4	1	1	1	1	1	1	3	3	3	6	6	6	189	189	189	391	391	391
100,000-999,999	12	12	12	26	26	26	2	2	2	5	5	5	1	1	1	2	2	2	3	3	3	6	6	6	199	199	199	411	411	411
>=1,000,000	1	1	1	3	3	3	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	1	1	24	24	24	50	50	50
Total Plants	52	52	52	107	107	107	185	170	200	334	303	366	105	96	115	189	170	208	46	44	48	80	76	85	2,204	2,051	2,356	4,348	4,254	4,441

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Alternative 2. Surface water systems serving 10,000 or more people: Use ending technolo

Exhibit C.9c
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)
Alternative 2

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	20.2%	17.0%	23.3%	27.5%	27.1%	27.9%							1.4%	1.2%	1.5%	1.4%	1.2%	1.6%							14.5%	14.5%	14.5%	10.8%	10.4%	11.2%						
100-499	13.7%	10.5%	16.8%	34.4%	33.9%	34.9%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	9.3%	9.3%	9.4%	9.3%	8.8%	9.8%						
500-999	13.7%	10.5%	16.8%	34.4%	33.9%	34.9%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	9.3%	9.3%	9.4%	9.3%	8.8%	9.8%						
1,000-3,300	11.1%	8.1%	14.1%	41.6%	41.1%	42.0%	1.9%	1.9%	1.9%	2.2%	2.2%	2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.7%	6.7%	6.8%	6.8%	6.4%	7.3%						
3,301-9,999	11.1%	8.1%	14.1%	41.6%	41.1%	42.0%	1.9%	1.9%	1.9%	2.2%	2.2%	2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.7%	6.7%	6.8%	6.8%	6.4%	7.3%						
10,000-49,999	16.7%	16.7%	16.7%	34.6%	34.6%	34.6%	3.9%	3.9%	3.9%	8.1%	8.1%	8.1%	0.8%	0.8%	0.8%	1.7%	1.7%	1.7%	4.2%	4.2%	4.2%	8.6%	8.6%	8.6%	0.6%	0.6%	0.6%	1.2%	1.2%	1.2%	3.3%	3.3%	3.3%	6.9%	6.9%	6.9%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	16.7%	16.7%	16.7%	34.6%	34.6%	34.6%	3.9%	3.9%	3.9%	8.1%	8.1%	8.1%	0.8%	0.8%	0.8%	1.7%	1.7%	1.7%	4.2%	4.2%	4.2%	8.6%	8.6%	8.6%	0.6%	0.6%	0.6%	1.2%	1.2%	1.2%	3.3%	3.3%	3.3%	6.9%	6.9%	6.9%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	15.2%	12.1%	18.3%	33.5%	33.0%	33.9%	0.8%	0.8%	0.8%	0.9%	0.9%	0.9%	0.4%	0.4%	0.5%	0.4%	0.4%	0.5%	3.4%	3.4%	3.4%	3.2%	3.2%	3.2%	10.4%	10.3%	10.4%	9.3%	8.8%	9.8%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							6.1%	5.7%	6.6%	6.4%	5.8%	7.0%	3.6%	3.2%	4.0%	3.7%	3.2%	4.1%	2.2%	2.2%	2.2%	2.3%	2.2%	2.4%	47.9%	43.7%	52.1%	52.1%	50.0%	54.1%
100-499							4.5%	4.1%	4.9%	7.1%	6.4%	7.8%	2.6%	2.4%	2.9%	4.1%	3.7%	4.5%	1.4%	1.3%	1.5%	2.2%	2.0%	2.4%	37.5%	33.5%	41.5%	62.5%	60.1%	64.9%
							4.5%	4.1%	4.9%	7.1%	6.4%	7.8%	2.6%	2.4%	2.9%	4.1%	3.7%	4.5%	1.4%	1.3%	1.5%	2.2%	2.0%	2.4%	37.5%	33.5%	41.5%	62.5%	60.1%	64.9%
							4.1%	3.7%	4.4%	8.6%	7.7%	9.4%	2.4%	2.2%	2.6%	5.0%	4.5%	5.5%	0.4%	0.4%	0.4%	0.8%	0.7%	0.9%	30.6%	26.9%	34.2%	69.4%	67.1%	71.8%
3,301-9,999							4.1%	3.7%	4.4%	8.6%	7.7%	9.4%	2.4%	2.2%	2.6%	5.0%	4.5%	5.5%	0.4%	0.4%	0.4%	0.8%	0.7%	0.9%	30.6%	26.9%	34.2%	69.4%	67.1%	71.8%
10,000-49,999	2.0%	2.0%	2.0%	4.2%	4.2%	4.2%	0.4%	0.4%	0.4%	0.7%	0.7%	0.7%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	32.6%	32.6%	32.6%	67.4%	67.4%	67.4%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	2.0%	2.0%	2.0%	4.2%	4.2%	4.2%	0.4%	0.4%	0.4%	0.7%	0.7%	0.7%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	32.6%	32.6%	32.6%	67.4%	67.4%	67.4%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.9%	4.5%	5.3%	7.0%	6.4%	7.7%	2.8%	2.6%	3.1%	4.1%	3.6%	4.5%	1.5%	1.4%	1.5%	2.0%	1.8%	2.2%	39.5%	35.5%	43.4%	60.5%	58.3%	62.8%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Alternative 2. Surface water systems serving 10,000 or more people: Use ending technolo

Exhibit C.9d
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Surface Water Plants (Number of Plants by Residual Disinfection Type)
Alternative 2

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	46	38	53	62	61	63							3	3	3	3	3	4							33	33	33	24	23	25						
100-499	43	33	52	107	106	109	3	3	3	3	3	3	0	0	0	0	0	0	16	16	16	14	14	14	29	29	29	29	27	31						
500-999	14	11	18	37	36	37	1	1	1	1	1	1	0	0	0	0	0	0	5	5	5	5	5	5	10	10	10	10	9	10						
1,000-3,300	10	7	13	38	38	39	2	2	2	2	2	2	0	0	0	0	0	0	4	4	4	4	4	4	6	6	6	6	6	7						
3,301-9,999	3	2	4	10	10	11	0	0	0	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	2	2	2	2	2	2						
10,000-49,999	1	1	1	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	117	93	140	257	253	260	6	6	6	7	7	7	3	3	4	3	3	4	26	26	26	25	25	25	80	79	80	71	68	75	0	0	0	0	0	0

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							14	13	15	14	13	16	8	7	9	8	7	9	5	5	5	5	5	5	108	99	118	118	113	122
100-499							14	13	15	22	20	24	8	7	9	13	11	14	4	4	5	7	6	7	117	105	129	195	188	202
500-999							5	4	5	7	7	8	3	3	3	4	4	5	1	1	2	2	2	3	40	36	44	66	64	69
1,000-3,300							4	3	4	8	7	9	2	2	2	5	4	5	0	0	0	1	1	1	28	25	32	64	62	66
3,301-9,999							1	1	1	2	2	2	1	1	1	1	1	1	0	0	0	0	0	0	8	7	9	17	17	18
10,000-49,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	3	3	3
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	0	0	0	0	0	0	38	34	41	54	49	59	22	20	24	31	28	35	11	11	12	15	14	17	303	272	333	464	447	481

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Alternative 2. Surface water systems serving 10,000 or more people: Use ending technolo

Exhibit C.10a
Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Alternative 2

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	90.9%	6.2%	0.0%	0.9%	0.0%	0.0%	0.3%	0.9%	0.3%	0.5%	91.5%	8.5%
100-499	89.9%	6.7%	0.0%	1.3%	0.2%	0.5%	0.1%	0.6%	0.1%	0.5%	90.4%	9.6%
500-999	89.9%	6.7%	0.0%	1.3%	0.2%	0.5%	0.1%	0.6%	0.1%	0.5%	90.4%	9.6%
1,000-3,300	90.7%	6.0%	0.0%	1.4%	0.3%	0.9%	0.0%	0.2%	0.1%	0.5%	91.1%	8.9%
3,301-9,999	90.7%	6.0%	0.0%	1.4%	0.3%	0.9%	0.0%	0.2%	0.1%	0.5%	91.1%	8.9%
10,000-49,999	82.2%	13.1%			1.0%	0.8%	0.0%	0.5%	1.7%	0.8%	84.9%	15.1%
50,000-99,999	82.2%	13.1%			1.0%	0.8%	0.0%	0.5%	1.7%	0.8%	84.9%	15.1%
100,000-999,999	82.9%	12.7%			1.0%	0.7%	0.0%	0.4%	1.7%	0.7%	85.5%	14.5%
>=1,000,000	82.9%	12.7%			1.0%	0.7%	0.0%	0.4%	1.7%	0.7%	85.5%	14.5%
Total %	89.1%	7.4%	0.0%	1.1%	0.3%	0.6%	0.1%	0.5%	0.4%	0.5%	89.9%	10.1%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Alternative 2.

Exhibit C.10b

System Size (Population Served)

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	5,836	401	0	59	0	0	20	56	22	29	5,878	545
100-499	13,710	1,017	0	200	25	74	22	96	20	79	13,776	1,466
500-999	5,481	406	0	80	10	29	9	39	8	32	5,507	586
1,000-3,300	6,884	455	0	108	22	66	0	13	4	36	6,910	677
3,301-9,999	4,564	302	0	71	15	44	0	8	3	24	4,581	449
10,000-49,999	4,426	706			53	42	0	24	90	42	4,568	815
50,000-99,999	589	94			7	6	0	3	12	6	608	108
Total Plants	42,273	3,500	0	518	140	267	51	244	173	254	42,637	4,783

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Alternative 2.

Exhibit C.10c
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Alternative 2

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	90.9%	6.2%	0.0%	0.9%	0.0%	0.0%	0.3%	0.9%	0.3%	0.5%	91.5%	8.5%
100-499	89.9%	6.7%	0.0%	1.3%	0.2%	0.5%	0.1%	0.6%	0.1%	0.5%	90.4%	9.6%
500-999	89.9%	6.7%	0.0%	1.3%	0.2%	0.5%	0.1%	0.6%	0.1%	0.5%	90.4%	9.6%
1,000-3,300	90.7%	6.0%	0.0%	1.4%	0.3%	0.9%	0.0%	0.2%	0.1%	0.5%	91.1%	8.9%
3,301-9,999	90.7%	6.0%	0.0%	1.4%	0.3%	0.9%	0.0%	0.2%	0.1%	0.5%	91.1%	8.9%
10,000-49,999	82.2%	13.1%			1.0%	0.8%	0.0%	0.5%	1.7%	0.8%	84.9%	15.1%
50,000-99,999	82.2%	13.1%			1.0%	0.8%	0.0%	0.5%	1.7%	0.8%	84.9%	15.1%
100,000-999,999	82.9%	12.7%			1.0%	0.7%	0.0%	0.4%	1.7%	0.7%	85.5%	14.5%
>=1,000,000	0.0%	0.0%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	90.4%	6.4%	0.0%	1.1%	0.1%	0.3%	0.2%	0.7%	0.2%	0.5%	90.9%	9.1%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Alternative 2.

Exhibit C.10d

System Size (Population Served)

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	2,265	155	0	23	0	0	8	22	8	11	2,281	212
100-499	1,915	142	0	28	3	10	3	13	3	11	1,924	205
500-999	530	39	0	8	1	3	1	4	1	3	533	57
1,000-3,300	224	15	0	4	1	2	0	0	0	1	225	22
3,301-9,999	19	1	0	0	0	0	0	0	0	0	20	2
10,000-49,999	3	0			0	0	0	0	0	0	3	0
50,000-99,999	0	0			0	0	0	0	0	0	0	0
Total Plants	4,957	353	0	62	5	15	12	39	12	27	4,986	497

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Alternative 2.

Exhibit C.11a

Stage 2 DBPR Treatment Technology Selection Deltas for CWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)

Alternative 3

System Size (Population Served)				Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
	Converting to CLM Only			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K		
<100	-8.6%	-9.9%	-7.3%							2.0%	1.7%	2.3%	2.1%	1.8%	2.4%							0.0%	0.0%	0.0%	4.6%	3.9%	5.3%						
100-499	-8.0%	-9.6%	-6.3%	0.0%	0.0%	0.0%	0.6%	0.5%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.6%	0.8%	5.4%	4.6%	6.2%						
500-999	-8.0%	-9.6%	-6.3%	0.0%	0.0%	0.0%	0.6%	0.5%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.6%	0.8%	5.4%	4.6%	6.2%						
1,000-3,300	-8.4%	-10.1%	-6.7%	0.0%	0.0%	0.0%	2.1%	1.8%	2.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.6%	0.9%	4.7%	4.0%	5.4%						
3,301-9,999	-8.4%	-10.1%	-6.7%	0.0%	0.0%	0.0%	2.1%	1.8%	2.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.6%	0.9%	4.7%	4.0%	5.4%						
10,000-49,999	3.9%	3.3%	4.5%	5.7%	4.9%	6.6%	3.8%	3.2%	4.3%	2.7%	2.3%	3.1%	1.2%	1.0%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.5%	0.7%	0.7%	0.6%	0.8%	12.4%	10.6%	14.2%	5.7%	4.9%	6.6%
50,000-99,999	3.9%	3.3%	4.5%	5.7%	4.9%	6.6%	3.8%	3.2%	4.3%	2.7%	2.3%	3.1%	1.2%	1.0%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.5%	0.7%	0.7%	0.6%	0.8%	12.4%	10.6%	14.2%	5.7%	4.9%	6.6%
100,000-999,999	3.9%	3.3%	4.5%	5.7%	4.9%	6.6%	3.8%	3.2%	4.3%	2.7%	2.3%	3.1%	1.2%	1.0%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.5%	0.7%	0.7%	0.6%	0.8%	12.4%	10.6%	14.2%	5.7%	4.9%	6.6%
>=1,000,000	3.9%	3.3%	4.5%	5.7%	4.9%	6.6%	3.8%	3.2%	4.3%	2.7%	2.3%	3.1%	1.2%	1.0%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.5%	0.7%	0.7%	0.6%	0.8%	12.4%	10.6%	14.2%	5.7%	4.9%	6.6%
Total %	-3.5%	-4.8%	-2.3%	2.2%	1.9%	2.6%	2.3%	2.0%	2.7%	1.2%	1.0%	1.3%	0.6%	0.5%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.5%	0.7%	3.3%	2.8%	3.8%	4.8%	4.1%	5.5%	2.2%	1.9%	2.6%

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes														
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			Total Converting to CLM			Total Adding Treatment Technology					
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
System Size (Population Served)	L			M			N			O			P			Q			R			S			T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
							8.0%	6.8%	9.1%	9.2%	7.9%	10.6%	4.5%	3.8%	5.1%	4.7%	4.0%	5.4%	0.6%	0.5%	0.7%	1.6%	1.4%	1.8%	13.6%	9.0%	18.2%	28.6%	21.9%	35.4%	27.4%	20.5%	34.3%
100-499							6.5%	5.5%	7.4%	11.1%	9.5%	12.7%	2.6%	2.2%	3.0%	4.6%	3.9%	5.2%	1.4%	1.2%	1.6%	2.6%	2.2%	3.0%	16.3%	11.1%	21.5%	27.5%	20.7%	34.4%			
500-999							6.5%	5.5%	7.4%	11.1%	9.5%	12.7%	2.6%	2.2%	3.0%	4.6%	3.9%	5.2%	1.4%	1.2%	1.6%	2.6%	2.2%	3.0%	16.3%	11.1%	21.5%	27.5%	20.7%	34.4%			
1,000-3,300							5.8%	4.9%	6.6%	13.6%	11.6%	15.6%	2.3%	1.9%	2.6%	5.5%	4.7%	6.3%	0.2%	0.2%	0.2%	0.7%	0.6%	0.7%	18.1%	12.5%	23.7%	27.1%	20.2%	34.0%			
3,301-9,999							5.8%	4.9%	6.6%	13.6%	11.6%	15.6%	2.3%	1.9%	2.6%	5.5%	4.7%	6.3%	0.2%	0.2%	0.2%	0.7%	0.6%	0.7%	18.1%	12.5%	23.7%	27.1%	20.2%	34.0%			
10,000-49,999	5.0%	4.2%	5.7%	2.4%	2.0%	2.7%	0.8%	0.7%	1.0%	0.5%	0.4%	0.5%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.4%	18.5%	15.8%	21.3%	46.6%	39.8%	53.4%	46.6%	39.8%	53.4%
50,000-99,999	5.0%	4.2%	5.7%	2.4%	2.0%	2.7%	0.8%	0.7%	1.0%	0.5%	0.4%	0.5%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.4%	18.5%	15.8%	21.3%	46.6%	39.8%	53.4%			
100,000-999,999	5.0%	4.2%	5.7%	2.4%	2.0%	2.7%	0.8%	0.7%	1.0%	0.5%	0.4%	0.5%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.4%	18.5%	15.8%	21.3%	46.6%	39.8%	53.4%			
>=1,000,000	5.0%	4.2%	5.7%	2.4%	2.0%	2.7%	0.8%	0.7%	1.0%	0.5%	0.4%	0.5%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.4%	18.5%	15.8%	21.3%	46.6%	39.8%	53.4%			
Total %	1.9%	1.6%	2.2%	0.9%	0.8%	1.1%	4.1%	3.5%	4.7%	7.8%	6.6%	8.9%	1.7%	1.4%	1.9%	3.2%	2.7%	3.6%	0.6%	0.5%	0.7%	0.9%	0.8%	1.1%	17.7%	13.4%	22.0%	34.9%	28.0%	41.7%	34.9%	28.0%	41.7%
Total Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit C.11b

Stage 2 DBPR Treatment Technology Selection Deltas for CWS Surface Water Plants (Number of Plants by Residual Disinfection Type)

Alternative 3

System Size (Population Served)				Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
	Converting to CLM Only			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B						C						D						E						F					
<100	-31	-36	-26							7	6	8	8	6	9							0	0	0	16	14	19						
100-499	-61	-74	-48	0	0	0	5	4	5	0	0	0	0	0	0	0	0	0	0	0	0	6	5	6	42	35	48						
500-999	-38	-46	-31	0	0	0	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	4	3	4	26	22	30						
1,000-3,300	-95	-114	-76	0	0	0	23	20	27	0	0	0	0	0	0	0	0	0	0	0	0	8	7	10	53	45	61						
3,301-9,999	-106	-127	-85	0	0	0	26	22	30	0	0	0	0	0	0	0	0	0	0	0	0	9	8	11	59	50	68						
10,000-49,999	50	43	58	74	63	85	49	42	56	35	30	40	15	13	17	0	0	0	0	0	0	7	6	8	9	8	11	160	137	184	74	63	85
50,000-99,999	23	19	26	33	28	38	22	19	25	16	14	18	7	6	8	0	0	0	0	0	0	3	3	4	4	4	5	72	61	82	33	28	38
100,000-999,999	24	20	27	35	30	40	23	20	26	17	14	19	7	6	8	0	0	0	0	0	0	3	3	4	4	4	5	76	65	87	35	30	40
>=1,000,000	3	2	3	4	4	5	3	2	3	2	2	2	1	1	1	0	0	0	0	0	0	0	0	0	1	0	1	9	8	10	4	4	5
Total Plants	-232	-312	-151	146	125	168	153	131	176	77	66	88	37	32	42	0	0	0	0	0	0	42	36	48	215	183	246	317	271	363	146	125	167

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes														
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			Total Converting to CLM			Total Adding Treatment Technology					
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	G						H						I						J						T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							29	24	33	33	28	38	16	14	18	17	14	19	2	2	2	6	5	7	49	32	65	103	79	127	1,094	820	1,369
100-499							50	42	57	85	73	98	20	17	23	35	30	40	11	9	12	20	17	23	125	85	165	211	159	263			
500-999							31	27	36	54	46	61	13	11	15	22	19	25	7	6	8	12	11	14	79	54	104	133	100	166			
1,000-3,300							65	56	75	154	131	176	26	22	29	62	53	71	2	2	3	7	6	8	204	142	268	306	229	384			
3,301-9,999							73	62	83	171	146	197	29	24	33	69	59	79	3	2	3	8	7	9	228	158	298	341	255	428			
10,000-49,999	64	55	73	31	26	35	11	9	12	6	5	7	4	3	4	2	1	2	7	6	8	4	4	5	239	205	275	602	514	690	1,190	1,017	1,365
50,000-99,999	29	25	33	14	12	16	5	4	6	3	2	3	2	2	2	1	1	1	3	3	4	2	2	2	107	92	123	270	231	310			
100,000-999,999	30	26	35	15	12	17	5	4	6	3	2	3	2	2	2	1	1	1	3	3	4	2	2	2	113	97	130	284	243	326			
>=1,000,000	4	3	4	2	1	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	12	16	34	29	39			
Total Plants	127	108	145	61	52	70	269	230	309	508	434	583	111	95	127	208	178	238	38	33	44	62	53	71	1,159	875	1,443	2,285	1,837	2,735	2,285	1,837	2,735

Note: Detail may not add to totals due to independent rounding

Source: Above table with technologies switching from an advanced technology with Cl2 to the same advanced technology with CLM being moved into the CLM only column

Exhibit C.11c

Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)

Alternative 3

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K		
<100	-8.6%	-9.9%	-7.3%							2.0%	1.7%	2.3%	2.1%	1.8%	2.4%							0.0%	0.0%	0.0%	4.6%	3.9%	5.3%						
100-499	-8.0%	-9.6%	-6.3%	0.0%	0.0%	0.0%	0.6%	0.5%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.6%	0.8%	5.4%	4.6%	6.2%						
500-999	-8.0%	-9.6%	-6.3%	0.0%	0.0%	0.0%	0.6%	0.5%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.6%	0.8%	5.4%	4.6%	6.2%						
1,000-3,300	-8.4%	-10.1%	-6.7%	0.0%	0.0%	0.0%	2.1%	1.8%	2.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.6%	0.9%	4.7%	4.0%	5.4%						
3,301-9,999	-8.4%	-10.1%	-6.7%	0.0%	0.0%	0.0%	2.1%	1.8%	2.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.6%	0.9%	4.7%	4.0%	5.4%						
10,000-49,999	3.9%	3.3%	4.5%	5.7%	4.9%	6.6%	3.8%	3.2%	4.3%	2.7%	2.3%	3.1%	1.2%	1.0%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.5%	0.7%	0.7%	0.6%	0.8%	12.4%	10.6%	14.2%	5.7%	4.9%	6.6%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	3.9%	3.3%	4.5%	5.7%	4.9%	6.6%	3.8%	3.2%	4.3%	2.7%	2.3%	3.1%	1.2%	1.0%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.5%	0.7%	0.7%	0.6%	0.8%	12.4%	10.6%	14.2%	5.7%	4.9%	6.6%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	-8.1%	-9.7%	-6.6%	0.0%	0.0%	0.1%	0.7%	0.6%	0.8%	0.6%	0.5%	0.7%	0.6%	0.5%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.4%	0.6%	5.0%	4.3%	5.8%	0.1%	0.1%	0.1%	0.0%	0.0%	0.1%

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
System Size (Population Served)	L			M			N			O			P			Q			R			S			T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
							8.0%	6.8%	9.1%	9.2%	7.9%	10.6%	4.5%	3.8%	5.1%	4.7%	4.0%	5.4%	0.6%	0.5%	0.7%	1.6%	1.4%	1.8%	13.6%	9.0%	18.2%	28.6%	21.9%	35.4%	27.8%	21.0%	34.6%
100-499							6.5%	5.5%	7.4%	11.1%	9.5%	12.7%	2.6%	2.2%	3.0%	4.6%	3.9%	5.2%	1.4%	1.2%	1.6%	2.6%	2.2%	3.0%	16.3%	11.1%	21.5%	27.5%	20.7%	34.4%			
500-999							6.5%	5.5%	7.4%	11.1%	9.5%	12.7%	2.6%	2.2%	3.0%	4.6%	3.9%	5.2%	1.4%	1.2%	1.6%	2.6%	2.2%	3.0%	16.3%	11.1%	21.5%	27.5%	20.7%	34.4%			
1,000-3,300							5.8%	4.9%	6.6%	13.6%	11.6%	15.6%	2.3%	1.9%	2.6%	5.5%	4.7%	6.3%	0.2%	0.2%	0.2%	0.7%	0.6%	0.7%	18.1%	12.5%	23.7%	27.1%	20.2%	34.0%			
3,301-9,999							5.8%	4.9%	6.6%	13.6%	11.6%	15.6%	2.3%	1.9%	2.6%	5.5%	4.7%	6.3%	0.2%	0.2%	0.2%	0.7%	0.6%	0.7%	18.1%	12.5%	23.7%	27.1%	20.2%	34.0%			
10,000-49,999	5.0%	4.2%	5.7%	2.4%	2.0%	2.7%	0.8%	0.7%	1.0%	0.5%	0.4%	0.5%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.4%	18.5%	15.8%	21.3%	46.6%	39.8%	53.4%	46.6%	39.8%	53.4%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
100,000-999,999	5.0%	4.2%	5.7%	2.4%	2.0%	2.7%	0.8%	0.7%	1.0%	0.5%	0.4%	0.5%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%	0.5%	0.5%	0.6%	0.3%	0.3%	0.4%	18.5%	15.8%	21.3%	46.6%	39.8%	53.4%			
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
Total %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.8%	5.8%	7.8%	10.8%	9.3%	12.4%	3.1%	2.6%	3.6%	4.7%	4.0%	5.4%	1.0%	0.8%	1.1%	2.0%	1.7%	2.3%	15.8%	10.7%	20.8%	27.9%	21.1%	34.8%	27.9%	21.1%	34.8%
Total Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit C.11d

Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Surface Water Plants (Number of Plants by Residual Disinfection Type)

Alternative 3

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B						C						D						E						F					
<100	-19	-22	-16							5	4	5	5	4	5							0	0	0	10	9	12						
100-499	-25	-30	-20	0	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3	17	14	19						
500-999	-8	-10	-7	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	6	5	7						
1,000-3,300	-8	-9	-6	0	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	4	4	5						
3,301-9,999	-2	-3	-2	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1						
10,000-49,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	-62	-74	-50	0	0	0	5	4	6	5	4	5	5	4	6	0	0	0	0	0	0	4	3	5	39	33	44	1	1	1	0	0	0

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	G						H						I						J						T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							18	15	21	21	18	24	10	9	12	11	9	12	1	1	2	4	3	4	31	20	41	65	49	80	211	160	263
100-499							20	17	23	35	30	40	8	7	9	14	12	16	4	4	5	8	7	9	51	35	67	86	65	107			
500-999							7	6	8	12	10	13	3	2	3	5	4	6	1	1	2	3	2	3	17	12	23	29	22	36			
1,000-3,300							5	5	6	13	11	14	2	2	2	5	4	6	0	0	0	1	1	1	17	12	22	25	19	31			
3,301-9,999							1	1	2	3	3	4	1	0	1	1	1	2	0	0	0	0	0	0	5	3	6	7	5	9			
10,000-49,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	3	3	2	3
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1			
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Total Plants	0	0	0	0	0	0	52	44	59	83	71	95	24	20	27	36	31	41	7	6	9	15	13	17	121	82	160	214	162	267	214	162	267

Note: Detail may not add to totals due to independent rounding

Source: Above table with technologies switching from an advanced technology with Cl2 to the same advanced technology with CLM being moved into the CLM only column

Exhibit C.12a
Stage 2 DBPR Treatment Technology Selection Deltas for CWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Alternative 3

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	1.8%	0.0%	1.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	2.8%	3.2%	3.5%
100-499	2.1%	0.0%	1.5%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.6%	3.8%	
500-999	2.1%	0.0%	1.5%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.6%	3.8%	
1,000-3,300	1.5%	0.0%	1.6%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	3.3%	3.3%	
3,301-9,999	1.5%	0.0%	1.6%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	3.3%	3.3%	
10,000-49,999	3.4%			0.1%	0.0%	0.0%	0.6%	0.0%	0.6%	4.7%	4.8%	4.7%
50,000-99,999	3.4%			0.1%	0.0%	0.0%	0.6%	0.0%	0.6%	4.7%	4.8%	
100,000-999,999	3.2%			0.1%	0.0%	0.0%	0.6%	0.0%	0.5%	4.3%	4.4%	
>=1,000,000	3.2%			0.1%	0.0%	0.0%	0.6%	0.0%	0.5%	4.3%	4.4%	
Total %	2.1%	0.0%	1.2%	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	3.6%	3.7%	3.7%

Note: Detail may not add to totals due to independent rounding

Exhibit C.12b
Stage 2 DBPR Treatment Technology Selection Deltas for CWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)
Alternative 3

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	117	0	64	0	0	21	0	0	0	181	202	1,423
100-499	321	0	230	0	0	26	0	0	0	550	576	
500-999	128	0	92	0	0	10	0	0	0	220	230	
1,000-3,300	112	0	122	0	0	0	15	0	0	249	249	
3,301-9,999	74	0	81	0	0	0	10	0	0	165	165	
10,000-49,999	185			7	0	0	34	0	31	251	258	334
50,000-99,999	25			1	0	0	5	0	4	33	34	
100,000-999,999	29			1	0	0	5	0	5	40	41	
>=1,000,000	1			0	0	0	0	0	0	1	1	

Exhibit C.12c
Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Alternative 3

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	1.8%	0.0%	1.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	2.8%	3.2%	3.5%
100-499	2.1%	0.0%	1.5%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.6%	3.8%	
500-999	2.1%	0.0%	1.5%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.6%	3.8%	
1,000-3,300	1.5%	0.0%	1.6%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	3.3%	3.3%	
3,301-9,999	1.5%	0.0%	1.6%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	3.3%	3.3%	
10,000-49,999	3.4%			0.1%	0.0%	0.0%	0.6%	0.0%	0.6%	4.7%	4.8%	4.8%
50,000-99,999	3.4%			0.1%	0.0%	0.0%	0.6%	0.0%	0.6%	4.7%	4.8%	
100,000-999,999	3.2%			0.1%	0.0%	0.0%	0.6%	0.0%	0.5%	4.3%	4.4%	
>=1,000,000	0.0%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Total %	1.9%	0.0%	1.3%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.2%	3.5%	3.5%

Note: Detail may not add to totals due to independent rounding

Exhibit C.12d
Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)
Alternative 3

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	4552.9%	0	25	0	0	8	0	0	0	70	79	190
100-499	45	0	32	0	0	4	0	0	0	77	80	
500-999	12	0	9	0	0	1	0	0	0	21	22	
1,000-3,300	4	0	4	0	0	0	1	0	0	8	8	
3,301-9,999	0	0	0	0	0	0	0	0	0	1	1	
10,000-49,999	0			0	0	0	0	0	0	0	0	0
50,000-99,999	0			0	0	0	0	0	0	0	0	
100,000-999,999	0			0	0	0	0	0	0	0	0	
>=1,000,000	0			0	0	0	0	0	0	0	0	

Exhibit C.13a
Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)
Alternative 3

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	13.2%	6.4%	20.0%	21.1%	19.8%	22.5%							2.0%	1.7%	2.3%	2.1%	1.8%	2.4%							14.5%	14.5%	14.5%	11.7%	11.1%	12.4%						
100-499	8.1%	1.2%	14.9%	27.5%	25.8%	29.1%	1.0%	1.0%	1.0%	1.5%	1.4%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	9.6%	9.5%	9.7%	10.2%	9.4%	11.0%						
500-999	8.1%	1.2%	14.9%	27.5%	25.8%	29.1%	1.0%	1.0%	1.0%	1.5%	1.4%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	9.6%	9.5%	9.7%	10.2%	9.4%	11.0%						
1,000-3,300	6.3%	-0.6%	13.2%	32.9%	31.2%	34.6%	1.9%	1.9%	1.9%	4.2%	3.9%	4.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.9%	6.8%	7.0%	7.6%	6.9%	8.2%						
3,301-9,999	6.3%	-0.6%	13.2%	32.9%	31.2%	34.6%	1.9%	1.9%	1.9%	4.2%	3.9%	4.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.9%	6.8%	7.0%	7.6%	6.9%	8.2%						
10,000-49,999	12.6%	12.6%	12.6%	27.0%	27.0%	27.0%	4.6%	4.6%	4.6%	9.7%	9.7%	9.7%	0.8%	0.8%	0.8%	1.7%	1.7%	1.7%	4.1%	4.1%	4.1%	8.7%	8.7%	8.7%	0.9%	0.9%	0.9%	2.0%	2.0%	2.0%	5.5%	5.5%	5.5%	11.7%	11.7%	11.7%
50,000-99,999	12.6%	12.6%	12.6%	27.0%	27.0%	27.0%	4.6%	4.6%	4.6%	9.7%	9.7%	9.7%	0.8%	0.8%	0.8%	1.7%	1.7%	1.7%	4.1%	4.1%	4.1%	8.7%	8.7%	8.7%	0.9%	0.9%	0.9%	2.0%	2.0%	2.0%	5.5%	5.5%	5.5%	11.7%	11.7%	11.7%
100,000-999,999	12.6%	12.6%	12.6%	27.0%	27.0%	27.0%	4.6%	4.6%	4.6%	9.7%	9.7%	9.7%	0.8%	0.8%	0.8%	1.7%	1.7%	1.7%	4.1%	4.1%	4.1%	8.7%	8.7%	8.7%	0.9%	0.9%	0.9%	2.0%	2.0%	2.0%	5.5%	5.5%	5.5%	11.7%	11.7%	11.7%
>=1,000,000	12.6%	12.6%	12.6%	27.0%	27.0%	27.0%	4.6%	4.6%	4.6%	9.7%	9.7%	9.7%	0.8%	0.8%	0.8%	1.7%	1.7%	1.7%	4.1%	4.1%	4.1%	8.7%	8.7%	8.7%	0.9%	0.9%	0.9%	2.0%	2.0%	2.0%	5.5%	5.5%	5.5%	11.7%	11.7%	11.7%
Total %	9.5%	5.3%	13.7%	28.9%	27.9%	29.9%	2.7%	2.7%	2.7%	5.6%	5.5%	5.7%	0.4%	0.4%	0.4%	0.8%	0.8%	0.8%	4.0%	4.0%	4.0%	5.9%	5.9%	5.9%	5.5%	5.5%	5.6%	6.1%	5.7%	6.6%	2.1%	2.1%	2.1%	4.6%	4.6%	4.6%

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							9.9%	8.8%	11.1%	10.5%	9.2%	11.9%	4.5%	3.8%	5.1%	4.7%	4.0%	5.4%	2.7%	2.6%	2.8%	3.0%	2.8%	3.2%	46.9%	37.9%	55.8%	53.1%	48.6%	57.7%
100-499							7.5%	6.6%	8.5%	12.1%	10.4%	13.7%	3.1%	2.7%	3.5%	5.0%	4.3%	5.7%	1.8%	1.6%	2.1%	3.0%	2.6%	3.4%	36.2%	27.7%	44.7%	63.8%	58.6%	69.0%
500-999	Mean						7.5%	6.6%	8.5%	12.1%	10.4%	13.7%	3.1%	2.7%	3.5%	5.0%	4.3%	5.7%	1.8%	1.6%	2.1%	3.0%	2.6%	3.4%	36.2%	27.7%	44.7%	63.8%	58.6%	69.0%
1,000-3,300	A						6.8%	6.0%	7.7%	14.8%	12.8%	16.8%	2.8%	2.5%	3.1%	6.1%	5.3%	6.9%	0.4%	0.4%	0.4%	0.8%	0.8%	0.9%	29.1%	20.9%	37.4%	70.9%	65.3%	76.4%
3,301-9,999							6.8%	6.0%	7.7%	14.8%	12.8%	16.8%	2.8%	2.5%	3.1%	6.1%	5.3%	6.9%	0.4%	0.4%	0.4%	0.8%	0.8%	0.9%	29.1%	20.9%	37.4%	70.9%	65.3%	76.4%
10,000-49,999	2.3%	2.3%	2.3%	5.0%	5.0%	5.0%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	31.9%	31.9%	31.9%	68.1%	68.1%	68.1%
50,000-99,999	2.3%	2.3%	2.3%	5.0%	5.0%	5.0%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	31.9%	31.9%	31.9%	68.1%	68.1%	68.1%
100,000-999,999	2.3%	2.3%	2.3%	5.0%	5.0%	5.0%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	31.9%	31.9%	31.9%	68.1%	68.1%	68.1%
>=1,000,000	2.3%	2.3%	2.3%	5.0%	5.0%	5.0%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	31.9%	31.9%	31.9%	68.1%	68.1%	68.1%
Total %	0.9%	0.9%	0.9%	1.9%	1.9%	1.9%	4.6%	4.1%	5.2%	8.6%	7.5%	9.8%	1.9%	1.7%	2.1%	3.5%	3.1%	4.0%	0.8%	0.8%	0.9%	1.4%	1.3%	1.6%	32.5%	27.4%	37.6%	67.5%	64.2%	70.8%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Alternative 3. Surface water systems serving 10,000 or more people: Use ending technolo

Exhibit C.13b
Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Surface Water Plants (Number of Plants by Residual Disinfection Type)
Alternative 3

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	47	23	72	76	71	81							7	6	8	8	6	9							52	52	52	42	40	45						
100-499	62	9	114	211	198	223	7	7	7	11	11	12	0	0	0	0	0	0	39	39	39	35	35	35	74	73	75	78	72	84						
500-999	39	6	72	133	125	141	5	5	5	7	7	8	0	0	0	0	0	0	24	24	24	22	22	22	47	46	47	49	46	53						
1,000-3,300	71	-7	149	372	353	391	22	22	22	47	44	51	0	0	0	0	0	0	45	45	45	51	51	51	78	77	79	85	78	93						
3,301-9,999	79	-8	166	414	393	436	24	24	24	53	49	57	0	0	0	0	0	0	50	50	50	56	56	56	87	86	88	95	87	104						
10,000-49,999	163	163	163	348	348	348	59	59	59	126	126	126	11	11	11	23	23	23	53	53	53	113	113	113	12	12	12	26	26	26	71	71	71	152	152	152
50,000-99,999	73	73	73	156	156	156	26	26	26	56	56	56	5	5	5	10	10	10	24	24	24	51	51	51	5	5	5	12	12	12	32	32	32	68	68	68
100,000-999,999	77	77	77	165	165	165	28	28	28	59	59	59	5	5	5	11	11	11	25	25	25	53	53	53	6	6	6	12	12	12	33	33	33	72	72	72
>=1,000,000	9	9	9	20	20	20	3	3	3	7	7	7	1	1	1	1	1	1	3	3	3	6	6	6	1	1	1	1	1	1	4	4	4	9	9	9
Total Plants	621	346	895	1,894	1,828	1,960	174	174	174	367	359	376	28	27	29	52	51	53	263	263	263	387	387	387	362	358	366	401	373	430	140	140	140	300	300	300

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							36	32	40	38	33	43	16	14	18	17	14	19	10	9	10	11	10	12	168	136	201	191	174	207
100-499							58	50	65	92	80	105	24	21	27	38	33	43	14	13	16	23	20	26	278	213	343	489	449	529
500-999							36	32	41	58	50	66	15	13	17	24	21	27	9	8	10	14	13	16	175	134	216	308	283	333
1,000-3,300							77	68	87	167	144	189	32	28	35	69	59	78	4	4	5	10	8	11	329	236	422	800	737	863
3,301-9,999							86	75	97	186	161	211	35	31	39	76	66	86	5	4	5	11	9	12	367	263	470	892	821	962
10,000-49,999	30	30	30	64	64	64	6	6	6	13	13	13	2	2	2	3	3	3	6	6	6	13	13	13	412	412	412	880	880	880
50,000-99,999	14	14	14	29	29	29	3	3	3	6	6	6	1	1	1	1	1	1	3	3	3	6	6	6	185	185	185	395	395	395
100,000-999,999	14	14	14	30	30	30	3	3	3	6	6	6	1	1	1	2	2	2	3	3	3	6	6	6	195	195	195	416	416	416
>=1,000,000	2	2	2	4	4	4	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	1	1	23	23	23	50	50	50
Total Plants	60	60	60	128	128	128	305	268	341	567	494	640	125	110	140	230	201	260	54	50	57	94	86	102	2,131	1,796	2,465	4,420	4,206	4,635

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Alternative 3. Surface water systems serving 10,000 or more people: Use ending technolo

Exhibit C.13c

Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)

Alternative 3

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	13.2%	6.4%	20.0%	21.1%	19.8%	22.5%							2.0%	1.7%	2.3%	2.1%	1.8%	2.4%							14.5%	14.5%	14.5%	11.7%	11.1%	12.4%						
100-499	8.1%	1.2%	14.9%	27.5%	25.8%	29.1%	1.0%	1.0%	1.0%	1.5%	1.4%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	9.6%	9.5%	9.7%	10.2%	9.4%	11.0%						
500-999	8.1%	1.2%	14.9%	27.5%	25.8%	29.1%	1.0%	1.0%	1.0%	1.5%	1.4%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	9.6%	9.5%	9.7%	10.2%	9.4%	11.0%						
1,000-3,300	6.3%	-0.6%	13.2%	32.9%	31.2%	34.6%	1.9%	1.9%	1.9%	4.2%	3.9%	4.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.9%	6.8%	7.0%	7.6%	6.9%	8.2%						
3,301-9,999	6.3%	-0.6%	13.2%	32.9%	31.2%	34.6%	1.9%	1.9%	1.9%	4.2%	3.9%	4.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.9%	6.8%	7.0%	7.6%	6.9%	8.2%						
10,000-49,999	12.6%	12.6%	12.6%	27.0%	27.0%	27.0%	4.6%	4.6%	4.6%	9.7%	9.7%	9.7%	0.8%	0.8%	0.8%	1.7%	1.7%	1.7%	4.1%	4.1%	4.1%	8.7%	8.7%	8.7%	0.9%	0.9%	0.9%	2.0%	2.0%	2.0%	5.5%	5.5%	5.5%	11.7%	11.7%	11.7%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	12.6%	12.6%	12.6%	27.0%	27.0%	27.0%	4.6%	4.6%	4.6%	9.7%	9.7%	9.7%	0.8%	0.8%	0.8%	1.7%	1.7%	1.7%	4.1%	4.1%	4.1%	8.7%	8.7%	8.7%	0.9%	0.9%	0.9%	2.0%	2.0%	2.0%	5.5%	5.5%	5.5%	11.7%	11.7%	11.7%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	9.4%	2.6%	16.1%	26.4%	24.9%	28.0%	0.8%	0.8%	0.8%	1.5%	1.4%	1.6%	0.6%	0.5%	0.7%	0.6%	0.5%	0.7%	3.4%	3.4%	3.4%	3.2%	3.2%	3.2%	10.6%	10.5%	10.7%	10.2%	9.5%	10.9%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							9.9%	8.8%	11.1%	10.5%	9.2%	11.9%	4.5%	3.8%	5.1%	4.7%	4.0%	5.4%	2.7%	2.6%	2.8%	3.0%	2.8%	3.2%	46.9%	37.9%	55.8%	53.1%	48.6%	57.7%
System Size							7.5%	6.6%	8.5%	12.1%	10.4%	13.7%	3.1%	2.7%	3.5%	5.0%	4.3%	5.7%	1.8%	1.6%	2.1%	3.0%	2.6%	3.4%	36.2%	27.7%	44.7%	63.8%	58.6%	69.0%
(Population Served)							7.5%	6.6%	8.5%	12.1%	10.4%	13.7%	3.1%	2.7%	3.5%	5.0%	4.3%	5.7%	1.8%	1.6%	2.1%	3.0%	2.6%	3.4%	36.2%	27.7%	44.7%	63.8%	58.6%	69.0%
1,000-3,300							6.8%	6.0%	7.7%	14.8%	12.8%	16.8%	2.8%	2.5%	3.1%	6.1%	5.3%	6.9%	0.4%	0.4%	0.4%	0.8%	0.8%	0.9%	29.1%	20.9%	37.4%	70.9%	65.3%	76.4%
3,301-9,999							6.8%	6.0%	7.7%	14.8%	12.8%	16.8%	2.8%	2.5%	3.1%	6.1%	5.3%	6.9%	0.4%	0.4%	0.4%	0.8%	0.8%	0.9%	29.1%	20.9%	37.4%	70.9%	65.3%	76.4%
10,000-49,999	2.3%	2.3%	2.3%	5.0%	5.0%	5.0%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	31.9%	31.9%	31.9%	68.1%	68.1%	68.1%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	2.3%	2.3%	2.3%	5.0%	5.0%	5.0%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.5%	0.5%	0.5%	1.0%	1.0%	1.0%	31.9%	31.9%	31.9%	68.1%	68.1%	68.1%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.1%	7.1%	9.1%	11.9%	10.3%	13.5%	3.4%	3.0%	3.9%	5.0%	4.3%	5.7%	1.9%	1.7%	2.0%	2.6%	2.4%	2.9%	38.2%	29.7%	46.8%	61.8%	56.7%	66.8%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plar

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Alternative 3. Surface water systems serving 10,000 or more people: Use ending technolo

Exhibit C.13d

Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Surface Water Plants (Number of Plants by Residual Disinfection Type)

Alternative 3

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	30	15	45	48	45	51							5	4	5	5	4	5							33	33	33	26	25	28						
100-499	25	4	46	86	81	91	3	3	3	5	4	5	0	0	0	0	0	0	16	16	16	14	14	14	30	30	30	32	29	34						
500-999	9	1	16	29	27	31	1	1	1	2	1	2	0	0	0	0	0	0	5	5	5	5	5	5	10	10	10	11	10	12						
1,000-3,300	6	-1	12	30	29	32	2	2	2	4	4	4	0	0	0	0	0	0	4	4	4	4	4	4	6	6	6	7	6	8						
3,301-9,999	2	0	3	8	8	9	0	0	0	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	2	2	2	2	2	2						
10,000-49,999	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	72	20	124	203	191	215	7	7	7	12	11	12	5	4	5	5	4	6	26	26	26	25	25	25	81	81	82	78	73	84	0	0	0	1	1	1

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							22	20	25	24	21	27	10	9	12	11	9	12	6	6	6	7	6	7	106	86	126	120	110	130
100-499							23	21	26	38	33	43	10	9	11	16	13	18	6	5	6	9	8	10	113	87	139	199	183	215
500-999							8	7	9	13	11	15	3	3	4	5	5	6	2	2	2	3	3	4	38	29	47	68	62	73
1,000-3,300							6	6	7	14	12	15	3	2	3	6	5	6	0	0	0	1	1	1	27	19	34	65	60	70
3,301-9,999							2	1	2	4	3	4	1	1	1	2	1	2	0	0	0	0	0	0	7	5	9	18	16	19
10,000-49,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	3	3	3
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	0	0	0	0	0	0	62	54	70	91	79	104	26	23	30	39	33	44	14	13	15	20	18	22	293	228	359	474	435	512

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plar

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Alternative 3. Surface water systems serving 10,000 or more people: Use ending technolo

Exhibit C.14a
Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Alternative 3

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	92.8%	4.2%	0.0%	1.0%	0.0%	0.0%	0.3%	0.9%	0.3%	0.5%	93.4%	6.6%
100-499	91.5%	4.9%	0.0%	1.5%	0.2%	0.5%	0.2%	0.6%	0.1%	0.5%	92.0%	8.0%
500-999	91.5%	4.9%	0.0%	1.5%	0.2%	0.5%	0.2%	0.6%	0.1%	0.5%	92.0%	8.0%
1,000-3,300	92.5%	4.0%	0.0%	1.6%	0.3%	0.9%	0.0%	0.3%	0.1%	0.5%	92.8%	7.2%
3,301-9,999	92.5%	4.0%	0.0%	1.6%	0.3%	0.9%	0.0%	0.3%	0.1%	0.5%	92.8%	7.2%
10,000-49,999	84.4%	10.7%			1.0%	0.8%	0.0%	0.7%	1.7%	0.8%	87.0%	13.0%
50,000-99,999	84.4%	10.7%			1.0%	0.8%	0.0%	0.7%	1.7%	0.8%	87.0%	13.0%
100,000-999,999	85.0%	10.3%			1.0%	0.7%	0.0%	0.6%	1.7%	0.8%	87.6%	12.4%
>=1,000,000	85.0%	10.3%			1.0%	0.7%	0.0%	0.6%	1.7%	0.8%	87.6%	12.4%
Total %	90.9%	5.4%	0.0%	1.2%	0.3%	0.6%	0.1%	0.6%	0.4%	0.5%	91.7%	8.3%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Alternative 3.

Exhibit C.14b
Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)

Alternative 3	A											
System Size (Population Served)	echnology CL21	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	5,958	273	0	64	0	0	21	56	22	29	6,001	421
100-499	13,947	747	0	230	25	74	26	96	20	79	14,016	1,226
500-999	5,575	299	0	92	10	29	10	39	8	32	5,603	490
1,000-3,300	7,015	304	0	122	22	66	0	19	4	36	7,041	547
3,301-9,999	4,650	201	0	81	15	44	0	13	3	24	4,668	362
10,000-49,999	4,543	574			53	42	0	36	90	45	4,685	697
50,000-99,999	604	76			7	6	0	5	12	6	623	93
Total Plants	43,097	2,572	0	587	140	267	57	270	173	258	43,466	3,953

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Alternative 3.

Exhibit C.14c
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Alternative 3

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	92.8%	4.2%	0.0%	1.0%	0.0%	0.0%	0.3%	0.9%	0.3%	0.5%	93.4%	6.6%
100-499	91.5%	4.9%	0.0%	1.5%	0.2%	0.5%	0.2%	0.6%	0.1%	0.5%	92.0%	8.0%
500-999	91.5%	4.9%	0.0%	1.5%	0.2%	0.5%	0.2%	0.6%	0.1%	0.5%	92.0%	8.0%
1,000-3,300	92.5%	4.0%	0.0%	1.6%	0.3%	0.9%	0.0%	0.3%	0.1%	0.5%	92.8%	7.2%
3,301-9,999	92.5%	4.0%	0.0%	1.6%	0.3%	0.9%	0.0%	0.3%	0.1%	0.5%	92.8%	7.2%
10,000-49,999	84.4%	10.7%			1.0%	0.8%	0.0%	0.7%	1.7%	0.8%	87.0%	13.0%
50,000-99,999	84.4%	10.7%			1.0%	0.8%	0.0%	0.7%	1.7%	0.8%	87.0%	13.0%
100,000-999,999	85.0%	10.3%			1.0%	0.7%	0.0%	0.6%	1.7%	0.8%	87.6%	12.4%
>=1,000,000	0.0%	0.0%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	92.1%	4.6%	0.0%	1.3%	0.1%	0.3%	0.2%	0.7%	0.2%	0.5%	92.7%	7.3%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Alternative 3.

Exhibit C.14d
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)

Alternative 3	A											
System Size (Population Served)	echnology CL21	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	2,313	106	0	25	0	0	8	22	8	11	2,329	164
100-499	1,948	104	0	32	3	10	4	13	3	11	1,958	171
500-999	539	29	0	9	1	3	1	4	1	3	542	47
1,000-3,300	228	10	0	4	1	2	0	1	0	1	229	18
3,301-9,999	20	1	0	0	0	0	0	0	0	0	20	2
10,000-49,999	3	0			0	0	0	0	0	0	3	0
50,000-99,999	0	0			0	0	0	0	0	0	0	0
Total Plants	5,051	250	0	70	5	15	13	40	12	27	5,081	402

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Alternative 3.

Exhibit C.15a
Stage 2 DBPR Treatment Technology Selection Deltas for CWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)
Stage 2 Preferred Alternative, 20% Safety Margin

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K		
<100	1.9%	1.1%	2.7%							4.1%	2.3%	5.9%	3.0%	1.7%	4.3%							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
100-499	4.1%	2.3%	5.9%	0.1%	0.1%	0.2%	0.4%	0.2%	0.5%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
500-999	4.1%	2.3%	5.9%	0.1%	0.1%	0.2%	0.4%	0.2%	0.5%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
1,000-3,300	4.2%	2.4%	6.1%	0.2%	0.1%	0.2%	0.9%	0.5%	1.3%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
3,301-9,999	4.2%	2.4%	6.1%	0.2%	0.1%	0.2%	0.9%	0.5%	1.3%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
10,000-49,999	7.8%	4.4%	11.2%	0.1%	0.0%	0.1%	0.6%	0.3%	0.9%	1.1%	0.6%	1.5%	0.2%	0.1%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
50,000-99,999	7.8%	4.4%	11.2%	0.1%	0.0%	0.1%	0.6%	0.3%	0.9%	1.1%	0.6%	1.5%	0.2%	0.1%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	7.8%	4.4%	11.2%	0.1%	0.0%	0.1%	0.6%	0.3%	0.9%	1.1%	0.6%	1.5%	0.2%	0.1%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
>=1,000,000	7.8%	4.4%	11.2%	0.1%	0.0%	0.1%	0.6%	0.3%	0.9%	1.1%	0.6%	1.5%	0.2%	0.1%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	5.5%	3.1%	7.9%	0.1%	0.1%	0.2%	0.6%	0.4%	0.9%	1.2%	0.7%	1.7%	1.0%	0.5%	1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	L			M			N			O			P			Q			R			S			T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.4%	1.0%	0.5%	0.3%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.4%	3.0%	7.8%	10.1%	5.7%	14.6%	8.8%	4.9%	12.6%
100-499	Mean						0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.3%	0.8%	0.7%	0.4%	1.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	6.5%	3.6%	9.3%	8.4%	4.7%	12.0%			
500-999							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.3%	0.8%	0.7%	0.4%	1.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	6.5%	3.6%	9.3%	8.4%	4.7%	12.0%			
1,000-3,300							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.3%	0.7%	0.8%	0.5%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.2%	4.0%	10.3%	8.8%	4.9%	12.7%			
3,301-9,999							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.3%	0.7%	0.8%	0.5%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.2%	4.0%	10.3%	8.8%	4.9%	12.7%			
10,000-49,999	1.0%	0.5%	1.4%	0.3%	0.2%	0.5%	0.5%	0.3%	0.7%	0.2%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.1%	5.1%	13.2%	11.7%	6.6%	16.9%	11.7%	6.6%	16.9%
50,000-99,999	1.0%	0.5%	1.4%	0.3%	0.2%	0.5%	0.5%	0.3%	0.7%	0.2%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.1%	5.1%	13.2%	11.7%	6.6%	16.9%			
100,000-999,999	1.0%	0.5%	1.4%	0.3%	0.2%	0.5%	0.5%	0.3%	0.7%	0.2%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.1%	5.1%	13.2%	11.7%	6.6%	16.9%			
>=1,000,000	1.0%	0.5%	1.4%	0.3%	0.2%	0.5%	0.5%	0.3%	0.7%	0.2%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.1%	5.1%	13.2%	11.7%	6.6%	16.9%			
Total %	0.4%	0.2%	0.5%	0.1%	0.1%	0.2%	0.2%	0.1%	0.3%	0.1%	0.0%	0.1%	0.3%	0.2%	0.5%	0.5%	0.3%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.7%	4.3%	11.1%	9.9%	5.6%	14.3%	9.9%	5.6%	14.3%
Total Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit C.15b
Stage 2 DBPR Treatment Technology Selection Deltas for CWS Surface Water Plants (Number of Plants by Residual Disinfection Type)
Stage 2 Preferred Alternative, 20% Safety Margin

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B						C						D						E						F					
<100	7	4	10							15	8	21	11	6	16							0	0	0	0	0	0						
100-499	31	18	45	1	1	1	3	2	4	9	5	13	10	5	14	0	0	0	0	0	0	0	0	0	0	0	0						
500-999	20	11	28	1	0	1	2	1	3	6	3	8	6	3	9	0	0	0	0	0	0	0	0	0	0	0	0						
1,000-3,300	48	27	69	2	1	3	10	6	15	11	6	15	14	8	20	0	0	0	0	0	0	0	0	0	0	0	0						
3,301-9,999	53	30	76	2	1	3	11	6	16	12	7	17	16	9	23	0	0	0	0	0	0	0	0	0	0	0	0						
10,000-49,999	101	57	145	1	0	1	8	4	11	14	8	20	3	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000-99,999	45	25	65	0	0	0	3	2	5	6	3	9	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	48	27	69	0	0	1	4	2	5	6	4	9	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>=1,000,000	6	3	8	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	358	201	515	7	4	10	41	23	59	80	45	115	63	35	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	G						H						I						J						T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							0	0	0	0	0	0	2	1	3	2	1	3	0	0	0	0	0	0	19	11	28	36	20	52	351	197	505
100-499							0	0	0	0	0	0	4	2	6	5	3	8	0	0	0	0	0	1	50	28	71	64	36	92			
500-999							0	0	0	0	0	0	3	1	4	3	2	5	0	0	0	0	0	0	31	18	45	40	23	58			
1,000-3,300							0	0	0	0	0	0	5	3	8	9	5	13	0	0	0	0	0	0	81	46	117	99	56	143			
3,301-9,999							0	0	0	0	0	0	6	3	9	10	6	15	0	0	0	0	0	0	90	51	130	111	62	159			
10,000-49,999	12	7	18	5	3	6	6	4	9	2	1	3	0	0	0	0	0	0	0	0	0	0	0	0	118	66	170	151	85	218	299	169	431
50,000-99,999	6	3	8	2	1	3	3	2	4	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	53	30	76	68	38	98			
100,000-999,999	6	3	8	2	1	3	3	2	4	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	56	31	80	72	40	103			
>=1,000,000	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	4	10	9	5	12			
Total Plants	24	14	35	9	5	13	13	7	18	4	2	6	21	12	30	30	17	43	0	0	0	1	0	1	505	285	728	650	366	936	650	366	936

Note: Detail may not add to totals due to independent rounding

Source: Above table with technologies switching from an advanced technology with Cl2 to the same advanced technology with CLM being moved into the CLM only column

Exhibit C.15c

Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)

Stage 2 Preferred Alternative, 20% Safety Margin

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K		
<100	1.9%	1.1%	2.7%							4.1%	2.3%	5.9%	3.0%	1.7%	4.3%							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
100-499	4.1%	2.3%	5.9%	0.1%	0.1%	0.2%	0.4%	0.2%	0.5%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
500-999	4.1%	2.3%	5.9%	0.1%	0.1%	0.2%	0.4%	0.2%	0.5%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
1,000-3,300	4.2%	2.4%	6.1%	0.2%	0.1%	0.2%	0.9%	0.5%	1.3%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
3,301-9,999	4.2%	2.4%	6.1%	0.2%	0.1%	0.2%	0.9%	0.5%	1.3%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
10,000-49,999	7.8%	4.4%	11.2%	0.1%	0.0%	0.1%	0.6%	0.3%	0.9%	1.1%	0.6%	1.5%	0.2%	0.1%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	7.8%	4.4%	11.2%	0.1%	0.0%	0.1%	0.6%	0.3%	0.9%	1.1%	0.6%	1.5%	0.2%	0.1%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	3.5%	2.0%	5.0%	0.1%	0.1%	0.1%	0.3%	0.2%	0.5%	2.0%	1.1%	2.9%	1.8%	1.0%	2.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	L			M			N			O			P			Q			R			S			T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.4%	1.0%	0.5%	0.3%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.4%	3.0%	7.8%	10.1%	5.7%	14.6%	8.9%	5.0%	12.9%
100-499	Mean						0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.3%	0.8%	0.7%	0.4%	1.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	6.5%	3.6%	9.3%	8.4%	4.7%	12.0%			
500-999							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.3%	0.8%	0.7%	0.4%	1.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	6.5%	3.6%	9.3%	8.4%	4.7%	12.0%			
1,000-3,300							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.3%	0.7%	0.8%	0.5%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.2%	4.0%	10.3%	8.8%	4.9%	12.7%			
3,301-9,999							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.3%	0.7%	0.8%	0.5%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.2%	4.0%	10.3%	8.8%	4.9%	12.7%			
10,000-49,999	1.0%	0.5%	1.4%	0.3%	0.2%	0.5%	0.5%	0.3%	0.7%	0.2%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.1%	5.1%	13.2%	11.7%	6.6%	16.9%	11.7%	6.6%	16.9%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
100,000-999,999	1.0%	0.5%	1.4%	0.3%	0.2%	0.5%	0.5%	0.3%	0.7%	0.2%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.1%	5.1%	13.2%	11.7%	6.6%	16.9%			
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
Total %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.3%	0.8%	0.7%	0.4%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.3%	3.5%	9.0%	9.0%	5.0%	12.9%	9.0%	5.0%	12.9%
Total Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit C.15d

Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Surface Water Plants (Number of Plants by Residual Disinfection Type)

Stage 2 Preferred Alternative, 20% Safety Margin

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B						C						D						E						F					
<100	4	2	6							9	5	13	7	4	10							0	0	0	0	0	0						
100-499	13	7	18	0	0	1	1	1	2	4	2	5	4	2	6	0	0	0	0	0	0	0	0	0	0	0	0						
500-999	4	2	6	0	0	0	0	0	1	1	1	2	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0						
1,000-3,300	4	2	6	0	0	0	1	0	1	1	0	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0						
3,301-9,999	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
10,000-49,999	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	27	15	38	1	0	1	3	1	4	15	9	22	14	8	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	G						H						I						J						T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							0	0	0	0	0	0	2	1	2	1	1	2	0	0	0	0	0	0	12	7	18	23	13	33	68	38	98
100-499							0	0	0	0	0	0	2	1	2	2	1	3	0	0	0	0	0	0	20	11	29	26	15	38			
500-999							0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	7	4	10	9	5	13			
1,000-3,300							0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	7	4	10	8	5	12			
3,301-9,999							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3	2	1	3			
10,000-49,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Total Plants	0	0	0	0	0	0	0	0	0	0	0	0	4	2	6	5	3	7	0	0	0	0	0	0	48	27	69	69	39	99	69	39	99

Note: Detail may not add to totals due to independent rounding

Source: Above table with technologies switching from an advanced technology with Cl2 to the same advanced technology with CLM being moved into the CLM only column

Exhibit C.16a
Stage 2 DBPR Treatment Technology Selection Deltas for CWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Stage 2 Preferred Alternative, 20% Safety Margin

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	1.0%	0.0%	1.1%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	2.1%	2.4%	2.9%
100-499	1.4%	0.0%	1.6%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.0%	3.2%	
500-999	1.4%	0.0%	1.6%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.0%	3.2%	
1,000-3,300	1.1%	0.0%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	2.7%	
3,301-9,999	1.1%	0.0%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	2.7%	
10,000-49,999	1.4%			0.1%	0.2%	0.0%	0.2%	0.0%	0.2%	2.0%	2.1%	2.1%
50,000-99,999	1.4%			0.1%	0.2%	0.0%	0.2%	0.0%	0.2%	2.0%	2.1%	
100,000-999,999	1.3%			0.1%	0.2%	0.0%	0.1%	0.0%	0.2%	1.9%	2.0%	
>=1,000,000	1.4%			0.1%	0.2%	0.0%	0.1%	0.0%	0.2%	2.0%	2.1%	
Total %	1.3%	0.0%	1.3%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	2.6%	2.8%	2.8%

Note: Detail may not add to totals due to independent rounding

Exhibit C.16b
Stage 2 DBPR Treatment Technology Selection Deltas for CWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)
Stage 2 Preferred Alternative, 20% Safety Margin

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	6159.5%	0	70	0	0	23	0	0	0	132	155	1,170
100-499	213	0	242	0	0	27	0	0	0	456	483	
500-999	85	0	97	0	0	11	0	0	0	182	193	
1,000-3,300	82	0	118	0	0	0	4	0	0	204	204	
3,301-9,999	54	0	78	0	0	0	2	0	0	135	135	
10,000-49,999	75			3	12	0	8	2	11	107	111	145
50,000-99,999	10			0	2	0	1	0	2	14	15	
100,000-999,999	12			0	2	0	1	0	2	17	18	
>=1,000,000	0			0	0	0	0	0	0	1	1	

Exhibit C.16c
Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Stage 2 Preferred Alternative, 20% Safety Margin

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	1.0%	0.0%	1.1%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	2.1%	2.4%	2.8%
100-499	1.4%	0.0%	1.6%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.0%	3.2%	
500-999	1.4%	0.0%	1.6%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.0%	3.2%	
1,000-3,300	1.1%	0.0%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	2.7%	
3,301-9,999	1.1%	0.0%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	2.7%	
10,000-49,999	1.4%			0.1%	0.2%	0.0%	0.2%	0.0%	0.2%	2.0%	2.1%	2.1%
50,000-99,999	1.4%			0.1%	0.2%	0.0%	0.2%	0.0%	0.2%	2.0%	2.1%	
100,000-999,999	1.3%			0.1%	0.2%	0.0%	0.1%	0.0%	0.2%	1.9%	2.0%	
>=1,000,000	0.0%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Total %	1.2%	0.0%	1.4%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	2.5%	2.8%	2.8%

Note: Detail may not add to totals due to independent rounding

Exhibit C.16d
Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)
Stage 2 Preferred Alternative, 20% Safety Margin

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	2389.6%	0	27	0	0	9	0	0	0	51	60	153
100-499	30	0	34	0	0	4	0	0	0	64	67	
500-999	8	0	9	0	0	1	0	0	0	18	19	
1,000-3,300	3	0	4	0	0	0	0	0	0	7	7	
3,301-9,999	0	0	0	0	0	0	0	0	0	1	1	
10,000-49,999	0			0	0	0	0	0	0	0	0	0
50,000-99,999	0			0	0	0	0	0	0	0	0	
100,000-999,999	0			0	0	0	0	0	0	0	0	
>=1,000,000	0			0	0	0	0	0	0	0	0	

Exhibit C.17a

Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)

Stage 2 Preferred Alternative, 20% Safety Margin

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	31.7%	27.3%	36.1%	31.6%	30.8%	32.4%							4.1%	2.3%	5.9%	3.0%	1.7%	4.3%							14.5%	14.5%	14.5%	7.1%	7.1%	7.1%						
100-499	27.2%	23.6%	30.9%	39.5%	37.7%	41.3%	1.1%	1.0%	1.1%	1.2%	1.1%	1.4%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	8.9%	8.9%	8.9%	4.8%	4.8%	4.8%						
500-999	27.2%	23.6%	30.9%	39.5%	37.7%	41.3%	1.1%	1.0%	1.1%	1.2%	1.1%	1.4%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	8.9%	8.9%	8.9%	4.8%	4.8%	4.8%						
1,000-3,300	24.6%	20.8%	28.5%	45.6%	43.7%	47.4%	2.1%	2.0%	2.2%	3.0%	2.6%	3.4%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.2%	6.2%	6.2%	2.9%	2.9%	2.9%						
3,301-9,999	24.6%	20.8%	28.5%	45.6%	43.7%	47.4%	2.1%	2.0%	2.2%	3.0%	2.6%	3.4%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.2%	6.2%	6.2%	2.9%	2.9%	2.9%						
10,000-49,999	31.2%	31.2%	31.2%	41.0%	41.0%	41.0%	3.0%	3.0%	3.0%	4.0%	4.0%	4.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	5.5%	5.5%	5.5%	7.3%	7.3%	7.3%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	1.2%	1.2%	1.2%
50,000-99,999	31.2%	31.2%	31.2%	41.0%	41.0%	41.0%	3.0%	3.0%	3.0%	4.0%	4.0%	4.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	5.5%	5.5%	5.5%	7.3%	7.3%	7.3%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	1.2%	1.2%	1.2%
100,000-999,999	31.2%	31.2%	31.2%	41.0%	41.0%	41.0%	3.0%	3.0%	3.0%	4.0%	4.0%	4.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	5.5%	5.5%	5.5%	7.3%	7.3%	7.3%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	1.2%	1.2%	1.2%
>=1,000,000	31.2%	31.2%	31.2%	41.0%	41.0%	41.0%	3.0%	3.0%	3.0%	4.0%	4.0%	4.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	5.5%	5.5%	5.5%	7.3%	7.3%	7.3%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	1.2%	1.2%	1.2%
Total %	28.1%	25.7%	30.4%	41.9%	40.8%	42.9%	2.1%	2.1%	2.2%	2.9%	2.7%	3.1%	0.9%	0.6%	1.3%	1.0%	0.6%	1.4%	4.6%	4.6%	4.6%	5.3%	5.3%	5.3%	5.1%	5.1%	5.1%	2.8%	2.8%	2.8%	0.4%	0.4%	0.4%	0.5%	0.5%	0.5%

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							2.0%	2.0%	2.0%	1.3%	1.3%	1.3%	0.7%	0.4%	1.0%	0.5%	0.3%	0.7%	2.1%	2.1%	2.1%	1.4%	1.4%	1.4%	55.1%	48.5%	61.6%	44.9%	42.6%	47.3%
100-499							1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	0.8%	1.3%	1.1%	0.8%	1.4%	0.5%	0.5%	0.5%	0.5%	0.4%	0.5%	46.1%	41.6%	50.5%	53.9%	51.1%	56.8%
500-999	Mean						1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	0.8%	1.3%	1.1%	0.8%	1.4%	0.5%	0.5%	0.5%	0.5%	0.4%	0.5%	46.1%	41.6%	50.5%	53.9%	51.1%	56.8%
1,000-3,300	A						1.0%	1.0%	1.0%	1.2%	1.2%	1.2%	1.0%	0.8%	1.2%	1.4%	1.0%	1.8%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	40.1%	35.5%	44.6%	59.9%	56.8%	63.1%
3,301-9,999							1.0%	1.0%	1.0%	1.2%	1.2%	1.2%	1.0%	0.8%	1.2%	1.4%	1.0%	1.8%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	40.1%	35.5%	44.6%	59.9%	56.8%	63.1%
10,000-49,999	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	43.2%	43.2%	43.2%	56.8%	56.8%	56.8%
50,000-99,999	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	43.2%	43.2%	43.2%	56.8%	56.8%	56.8%
100,000-999,999	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	43.2%	43.2%	43.2%	56.8%	56.8%	56.8%
>=1,000,000	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	43.2%	43.2%	43.2%	56.8%	56.8%	56.8%
Total %	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.6%	0.5%	0.7%	0.8%	0.6%	1.0%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	43.3%	40.4%	46.1%	56.7%	54.9%	58.6%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Unadjusted Stage 2 Preferred Alternative. Surface water systems serving 10,000 or more p

Exhibit C.17b

Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Surface Water Plants (Number of Plants by Residual Disinfection Type)

Stage 2 Preferred Alternative, 20% Safety Margin

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	114	98	130	114	111	117							15	8	21	11	6	16							52	52	52	26	26	26						
100-499	209	181	237	303	289	317	8	8	9	9	8	11	9	5	13	10	5	14	39	39	39	35	35	35	68	68	68	37	37	37						
500-999	132	114	149	191	182	199	5	5	5	6	5	7	6	3	8	6	3	9	24	24	24	22	22	22	43	43	43	23	23	23						
1,000-3,300	278	235	322	515	494	536	23	23	24	34	30	39	11	6	15	14	8	20	45	45	45	51	51	51	70	70	70	32	32	32						
3,301-9,999	310	262	359	573	550	597	26	25	27	38	33	43	12	7	17	16	9	23	50	50	50	56	56	56	78	78	78	36	36	36						
10,000-49,999	403	403	403	529	529	529	39	39	39	51	51	51	4	4	4	5	5	5	72	72	72	94	94	94	10	10	10	13	13	13	12	12	12	16	16	16
50,000-99,999	181	181	181	237	237	237	17	17	17	23	23	23	2	2	2	2	2	2	32	32	32	42	42	42	5	5	5	6	6	6	6	6	6	7	7	7
100,000-999,999	190	190	190	250	250	250	18	18	18	24	24	24	2	2	2	3	3	3	34	34	34	44	44	44	5	5	5	6	6	6	6	6	6	8	8	8
>=1,000,000	23	23	23	30	30	30	2	2	2	3	3	3	0	0	0	0	0	0	4	4	4	5	5	5	1	1	1	1	1	1	1	1	1	1	1	1
Total Plants	1,840	1,686	1,993	2,742	2,673	2,812	140	137	142	189	177	200	61	38	84	67	42	92	301	301	301	350	350	350	331	331	331	181	181	181	24	24	24	32	32	32

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							7	7	7	5	5	5	2	1	3	2	1	3	8	8	8	5	5	5	198	174	221	161	153	170
100-499							8	8	8	7	7	7	8	6	10	9	6	11	3	3	3	4	3	4	353	319	387	414	392	435
500-999							5	5	5	5	5	5	5	4	6	5	4	7	2	2	2	2	2	2	222	201	244	260	247	274
1,000-3,300							12	12	12	13	13	13	11	9	14	16	12	20	2	2	2	2	2	2	452	401	504	677	641	712
3,301-9,999							13	13	13	15	15	15	13	10	15	18	13	22	2	2	2	2	2	2	504	447	561	754	715	794
10,000-49,999	10	10	10	13	13	13	4	4	4	5	5	5	0	0	0	0	0	0	4	4	4	5	5	5	558	558	558	733	733	733
50,000-99,999	5	5	5	6	6	6	2	2	2	2	2	2	0	0	0	0	0	0	2	2	2	2	2	2	250	250	250	329	329	329
100,000-999,999	5	5	5	6	6	6	2	2	2	3	3	3	0	0	0	0	0	0	2	2	2	3	3	3	264	264	264	347	347	347
>=1,000,000	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	32	32	42	42	42
Total Plants	20	20	20	27	27	27	53	53	53	55	55	55	39	30	49	49	36	63	26	26	26	26	26	26	2,834	2,646	3,022	3,717	3,598	3,837

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Unadjusted Stage 2 Preferred Alternative. Surface water systems serving 10,000 or more p

Exhibit C.17c
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)
Stage 2 Preferred Alternative, 20% Safety Margin

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	31.7%	27.3%	36.1%	31.6%	30.8%	32.4%							4.1%	2.3%	5.9%	3.0%	1.7%	4.3%							14.5%	14.5%	14.5%	7.1%	7.1%	7.1%						
100-499	27.2%	23.6%	30.9%	39.5%	37.7%	41.3%	1.1%	1.0%	1.1%	1.2%	1.1%	1.4%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	8.9%	8.9%	8.9%	4.8%	4.8%	4.8%						
500-999	27.2%	23.6%	30.9%	39.5%	37.7%	41.3%	1.1%	1.0%	1.1%	1.2%	1.1%	1.4%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	8.9%	8.9%	8.9%	4.8%	4.8%	4.8%						
1,000-3,300	24.6%	20.8%	28.5%	45.6%	43.7%	47.4%	2.1%	2.0%	2.2%	3.0%	2.6%	3.4%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.2%	6.2%	6.2%	2.9%	2.9%	2.9%						
3,301-9,999	24.6%	20.8%	28.5%	45.6%	43.7%	47.4%	2.1%	2.0%	2.2%	3.0%	2.6%	3.4%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.2%	6.2%	6.2%	2.9%	2.9%	2.9%						
10,000-49,999	31.2%	31.2%	31.2%	41.0%	41.0%	41.0%	3.0%	3.0%	3.0%	4.0%	4.0%	4.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	5.5%	5.5%	5.5%	7.3%	7.3%	7.3%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	1.2%	1.2%	1.2%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	31.2%	31.2%	31.2%	41.0%	41.0%	41.0%	3.0%	3.0%	3.0%	4.0%	4.0%	4.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	5.5%	5.5%	5.5%	7.3%	7.3%	7.3%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	1.2%	1.2%	1.2%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	28.2%	24.3%	32.1%	38.1%	36.6%	39.6%	0.9%	0.9%	1.0%	1.2%	1.0%	1.3%	2.0%	1.1%	2.9%	1.8%	1.0%	2.6%	3.4%	3.4%	3.4%	3.2%	3.2%	3.2%	10.1%	10.1%	10.1%	5.2%	5.2%	5.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							2.0%	2.0%	2.0%	1.3%	1.3%	1.3%	0.7%	0.4%	1.0%	0.5%	0.3%	0.7%	2.1%	2.1%	2.1%	1.4%	1.4%	1.4%	55.1%	48.5%	61.6%	44.9%	42.6%	47.3%
100-499							1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	0.8%	1.3%	1.1%	0.8%	1.4%	0.5%	0.5%	0.5%	0.5%	0.4%	0.5%	46.1%	41.6%	50.5%	53.9%	51.1%	56.8%
500-999	Mean						1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	0.8%	1.3%	1.1%	0.8%	1.4%	0.5%	0.5%	0.5%	0.5%	0.4%	0.5%	46.1%	41.6%	50.5%	53.9%	51.1%	56.8%
1,000-3,300	A						1.0%	1.0%	1.0%	1.2%	1.2%	1.2%	1.0%	0.8%	1.2%	1.4%	1.0%	1.8%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	40.1%	35.5%	44.6%	59.9%	56.8%	63.1%
3,301-9,999							1.0%	1.0%	1.0%	1.2%	1.2%	1.2%	1.0%	0.8%	1.2%	1.4%	1.0%	1.8%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	40.1%	35.5%	44.6%	59.9%	56.8%	63.1%
10,000-49,999	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	43.2%	43.2%	43.2%	56.8%	56.8%	56.8%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	43.2%	43.2%	43.2%	56.8%	56.8%	56.8%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	1.3%	1.3%	1.1%	1.1%	1.1%	0.9%	0.7%	1.2%	1.0%	0.7%	1.3%	0.9%	0.9%	0.9%	0.7%	0.7%	0.7%	47.8%	42.7%	52.8%	52.2%	49.5%	55.0%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Unadjusted Stage 2 Preferred Alternative. Surface water systems serving 10,000 or more p

Exhibit C.17d
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Surface Water Plants (Number of Plants by Residual Disinfection Type)
Stage 2 Preferred Alternative, 20% Safety Margin

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	72	62	82	71	70	73							9	5	13	7	4	10							33	33	33	16	16	16						
100-499	85	74	96	123	118	129	3	3	4	4	3	4	4	2	5	4	2	6	16	16	16	14	14	14	28	28	28	15	15	15						
500-999	29	25	33	42	40	44	1	1	1	1	1	1	1	1	2	1	1	2	5	5	5	5	5	5	9	9	9	5	5	5						
1,000-3,300	23	19	26	42	40	44	2	2	2	3	2	3	1	0	1	1	1	2	4	4	4	4	4	4	6	6	6	3	3	3						
3,301-9,999	6	5	7	11	11	12	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	2	2	2	1	1	1						
10,000-49,999	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	216	186	246	292	281	304	7	7	7	9	8	10	15	9	22	14	8	20	26	26	26	25	25	25	77	77	77	40	40	40	0	0	0	0	0	0

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							4	4	4	3	3	3	2	1	2	1	1	2	5	5	5	3	3	3	124	110	139	102	96	107
100-499							3	3	3	3	3	3	3	2	4	4	3	4	1	1	1	1	1	2	144	130	158	168	159	177
500-999							1	1	1	1	1	1	1	1	1	1	1	2	0	0	0	0	0	1	49	44	54	57	54	60
1,000-3,300							1	1	1	1	1	1	1	1	1	1	1	2	0	0	0	0	0	0	37	33	41	55	52	58
3,301-9,999							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	9	11	15	14	16
10,000-49,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	3	3	3
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	0	0	0	0	0	0	10	10	10	8	8	8	7	5	9	8	5	10	7	7	7	5	5	5	366	328	405	401	380	422

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the Unadjusted Stage 2 Preferred Alternative. Surface water systems serving 10,000 or more p

Exhibit C.18a

Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)

Stage 2 Preferred Alternative, 20% Safety Margin

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	93.5%	3.4%	0.0%	1.1%	0.0%	0.0%	0.4%	0.9%	0.3%	0.5%	94.2%	5.8%
100-499	92.1%	4.2%	0.0%	1.6%	0.2%	0.5%	0.2%	0.6%	0.1%	0.5%	92.6%	7.4%
500-999	92.1%	4.2%	0.0%	1.6%	0.2%	0.5%	0.2%	0.6%	0.1%	0.5%	92.6%	7.4%
1,000-3,300	93.1%	3.6%	0.0%	1.6%	0.3%	0.9%	0.0%	0.1%	0.1%	0.5%	93.4%	6.6%
3,301-9,999	93.1%	3.6%	0.0%	1.6%	0.3%	0.9%	0.0%	0.1%	0.1%	0.5%	93.4%	6.6%
10,000-49,999	87.1%	8.6%			0.9%	1.0%	0.0%	0.2%	1.7%	0.5%	89.7%	10.3%
50,000-99,999	87.1%	8.6%			0.9%	1.0%	0.0%	0.2%	1.7%	0.5%	89.7%	10.3%
100,000-999,999	87.5%	8.4%			0.9%	0.9%	0.0%	0.2%	1.7%	0.4%	90.1%	9.9%
>=1,000,000	87.4%	8.5%			0.9%	0.9%	0.0%	0.2%	1.7%	0.4%	90.0%	10.0%
Total %	91.8%	4.6%	0.0%	1.3%	0.3%	0.6%	0.1%	0.5%	0.4%	0.5%	92.6%	7.4%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Unadjusted Stage 2 Preferred Alternative.

Exhibit C.18b

Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)

rred Alternative, 20% A

System Size (Population Served)	echnology CL21	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	6,006	217	0	70	0	0	23	56	22	29	6,051	372
100-499	14,040	640	0	242	25	74	27	96	20	79	14,111	1,131
500-999	5,613	256	0	97	10	29	11	39	8	32	5,641	452
1,000-3,300	7,060	274	0	118	22	66	0	8	4	36	7,086	501
3,301-9,999	4,681	181	0	78	15	44	0	5	3	24	4,698	332
10,000-49,999	4,690	464			48	53	0	10	91	25	4,829	553
50,000-99,999	624	62			6	7	0	1	12	3	642	74
Total Plants	43,539	2,173	0	606	134	282	61	217	175	232	43,910	3,510

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Unadjusted Stage 2 Preferred Alternative.

Exhibit C.18c
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Stage 2 Preferred Alternative, 20% Safety Margin

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	93.5%	3.4%	0.0%	1.1%	0.0%	0.0%	0.4%	0.9%	0.3%	0.5%	94.2%	5.8%
100-499	92.1%	4.2%	0.0%	1.6%	0.2%	0.5%	0.2%	0.6%	0.1%	0.5%	92.6%	7.4%
500-999	92.1%	4.2%	0.0%	1.6%	0.2%	0.5%	0.2%	0.6%	0.1%	0.5%	92.6%	7.4%
1,000-3,300	93.1%	3.6%	0.0%	1.6%	0.3%	0.9%	0.0%	0.1%	0.1%	0.5%	93.4%	6.6%
3,301-9,999	93.1%	3.6%	0.0%	1.6%	0.3%	0.9%	0.0%	0.1%	0.1%	0.5%	93.4%	6.6%
10,000-49,999	87.1%	8.6%			0.9%	1.0%	0.0%	0.2%	1.7%	0.5%	89.7%	10.3%
50,000-99,999	87.1%	8.6%			0.9%	1.0%	0.0%	0.2%	1.7%	0.5%	89.7%	10.3%
100,000-999,999	87.5%	8.4%			0.9%	0.9%	0.0%	0.2%	1.7%	0.4%	90.1%	9.9%
>=1,000,000	0.0%	0.0%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	92.8%	3.8%	0.0%	1.4%	0.1%	0.3%	0.3%	0.7%	0.2%	0.5%	93.4%	6.6%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Unadjusted Stage 2 Preferred Alternative.

Exhibit C.18d
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)

rred Alternative, 20%

A

System Size (Population Served)	echnology CL21	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	2,331	84	0	27	0	0	9	22	8	11	2,348	144
100-499	1,961	89	0	34	3	10	4	13	3	11	1,971	158
500-999	543	25	0	9	1	3	1	4	1	3	546	44
1,000-3,300	230	9	0	4	1	2	0	0	0	1	231	16
3,301-9,999	20	1	0	0	0	0	0	0	0	0	20	1
10,000-49,999	3	0			0	0	0	0	0	0	3	0
50,000-99,999	0	0			0	0	0	0	0	0	0	0
Total Plants	5,088	208	0	75	5	15	14	39	12	27	5,119	364

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the Unadjusted Stage 2 Preferred Alternative.

Exhibit C.19a
Stage 2 DBPR Treatment Technology Selection Deltas for CWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)
Stage 2 Preferred Alternative, 25% Safety Margin

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K		
<100	1.9%	1.1%	2.7%							4.1%	2.3%	5.9%	3.0%	1.7%	4.3%							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
100-499	4.1%	2.3%	5.9%	0.1%	0.1%	0.2%	0.4%	0.2%	0.5%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
500-999	4.1%	2.3%	5.9%	0.1%	0.1%	0.2%	0.4%	0.2%	0.5%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
1,000-3,300	4.2%	2.4%	6.1%	0.2%	0.1%	0.2%	0.9%	0.5%	1.3%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
3,301-9,999	4.2%	2.4%	6.1%	0.2%	0.1%	0.2%	0.9%	0.5%	1.3%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
10,000-49,999	9.6%	7.1%	12.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.6%	3.4%	5.8%	1.3%	1.0%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
50,000-99,999	9.6%	7.1%	12.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.6%	3.4%	5.8%	1.3%	1.0%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	9.6%	7.1%	12.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.6%	3.4%	5.8%	1.3%	1.0%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
>=1,000,000	9.6%	7.1%	12.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.6%	3.4%	5.8%	1.3%	1.0%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	6.1%	4.1%	8.2%	0.1%	0.0%	0.1%	0.4%	0.2%	0.6%	2.6%	1.8%	3.4%	1.4%	0.9%	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	L			M			N			O			P			Q			R			S			T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.4%	1.0%	0.5%	0.3%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.4%	3.0%	7.8%	10.1%	5.7%	14.6%	8.8%	4.9%	12.6%
100-499	Mean						0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.3%	0.8%	0.7%	0.4%	1.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	6.5%	3.6%	9.3%	8.4%	4.7%	12.0%			
500-999							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.3%	0.8%	0.7%	0.4%	1.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	6.5%	3.6%	9.3%	8.4%	4.7%	12.0%			
1,000-3,300							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.3%	0.7%	0.8%	0.5%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.2%	4.0%	10.3%	8.8%	4.9%	12.7%			
3,301-9,999							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.3%	0.7%	0.8%	0.5%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.2%	4.0%	10.3%	8.8%	4.9%	12.7%			
10,000-49,999	1.4%	1.1%	1.8%	0.6%	0.4%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.5%	8.5%	14.4%	17.5%	13.0%	22.0%	17.5%	13.0%	22.0%
50,000-99,999	1.4%	1.1%	1.8%	0.6%	0.4%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.5%	8.5%	14.4%	17.5%	13.0%	22.0%			
100,000-999,999	1.4%	1.1%	1.8%	0.6%	0.4%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.5%	8.5%	14.4%	17.5%	13.0%	22.0%			
>=1,000,000	1.4%	1.1%	1.8%	0.6%	0.4%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.5%	8.5%	14.4%	17.5%	13.0%	22.0%			
Total %	0.6%	0.4%	0.7%	0.2%	0.2%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.2%	0.5%	0.5%	0.3%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.6%	5.6%	11.6%	12.2%	8.1%	16.3%	12.2%	8.1%	16.3%
Total Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit C.19b
Stage 2 DBPR Treatment Technology Selection Deltas for CWS Surface Water Plants (Number of Plants by Residual Disinfection Type)
Stage 2 Preferred Alternative, 25% Safety Margin

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B						C						D						E						F					
<100	7	4	10							15	8	21	11	6	16							0	0	0	0	0	0						
100-499	31	18	45	1	1	1	3	2	4	9	5	13	10	5	14	0	0	0	0	0	0	0	0	0	0	0	0						
500-999	20	11	28	1	0	1	2	1	3	6	3	8	6	3	9	0	0	0	0	0	0	0	0	0	0	0	0						
1,000-3,300	48	27	69	2	1	3	10	6	15	11	6	15	14	8	20	0	0	0	0	0	0	0	0	0	0	0	0						
3,301-9,999	53	30	76	2	1	3	11	6	16	12	7	17	16	9	23	0	0	0	0	0	0	0	0	0	0	0	0						
10,000-49,999	123	91	155	0	0	0	0	0	0	60	44	75	17	13	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000-99,999	55	41	70	0	0	0	0	0	0	27	20	34	8	6	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	58	43	73	0	0	0	0	0	0	28	21	36	8	6	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>=1,000,000	7	5	9	0	0	0	0	0	0	3	3	4	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	403	270	535	6	3	8	26	15	37	171	117	225	91	57	124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	G						H						I						J						T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							0	0	0	0	0	0	2	1	3	2	1	3	0	0	0	0	0	0	19	11	28	36	20	52	351	197	505
100-499							0	0	0	0	0	0	4	2	6	5	3	8	0	0	0	0	0	1	50	28	71	64	36	92			
500-999							0	0	0	0	0	0	3	1	4	3	2	5	0	0	0	0	0	0	31	18	45	40	23	58			
1,000-3,300							0	0	0	0	0	0	5	3	8	9	5	13	0	0	0	0	0	0	81	46	117	99	56	143			
3,301-9,999							0	0	0	0	0	0	6	3	9	10	6	15	0	0	0	0	0	0	90	51	130	111	62	159			
10,000-49,999	18	14	23	7	5	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	148	110	186	226	168	285	448	332	563
50,000-99,999	8	6	10	3	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	66	49	83	102	75	128			
100,000-999,999	9	6	11	3	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	52	88	107	79	134			
>=1,000,000	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	6	11	13	10	16			
Total Plants	36	27	46	15	11	18	0	0	0	0	0	0	21	12	30	30	17	43	0	0	0	1	0	1	565	370	759	799	529	1,068	799	529	1,068

Note: Detail may not add to totals due to independent rounding

Source: Above table with technologies switching from an advanced technology with Cl2 to the same advanced technology with CLM being moved into the CLM only column

Exhibit C.19c

Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)

Stage 2 Preferred Alternative, 25% Safety Margin

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K		
<100	1.9%	1.1%	2.7%							4.1%	2.3%	5.9%	3.0%	1.7%	4.3%							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
100-499	4.1%	2.3%	5.9%	0.1%	0.1%	0.2%	0.4%	0.2%	0.5%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
500-999	4.1%	2.3%	5.9%	0.1%	0.1%	0.2%	0.4%	0.2%	0.5%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
1,000-3,300	4.2%	2.4%	6.1%	0.2%	0.1%	0.2%	0.9%	0.5%	1.3%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
3,301-9,999	4.2%	2.4%	6.1%	0.2%	0.1%	0.2%	0.9%	0.5%	1.3%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%						
10,000-49,999	9.6%	7.1%	12.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.6%	3.4%	5.8%	1.3%	1.0%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	9.6%	7.1%	12.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.6%	3.4%	5.8%	1.3%	1.0%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	3.5%	2.0%	5.0%	0.1%	0.1%	0.1%	0.3%	0.2%	0.5%	2.0%	1.2%	2.9%	1.8%	1.0%	2.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	L			M			N			O			P			Q			R			S			T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.4%	1.0%	0.5%	0.3%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.4%	3.0%	7.8%	10.1%	5.7%	14.6%	8.9%	5.0%	12.9%
100-499	Mean						0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.3%	0.8%	0.7%	0.4%	1.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	6.5%	3.6%	9.3%	8.4%	4.7%	12.0%			
500-999							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.3%	0.8%	0.7%	0.4%	1.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	6.5%	3.6%	9.3%	8.4%	4.7%	12.0%			
1,000-3,300							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.3%	0.7%	0.8%	0.5%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.2%	4.0%	10.3%	8.8%	4.9%	12.7%			
3,301-9,999							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.3%	0.7%	0.8%	0.5%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.2%	4.0%	10.3%	8.8%	4.9%	12.7%			
10,000-49,999	1.4%	1.1%	1.8%	0.6%	0.4%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.5%	8.5%	14.4%	17.5%	13.0%	22.0%	17.5%	13.0%	22.0%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
100,000-999,999	1.4%	1.1%	1.8%	0.6%	0.4%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.5%	8.5%	14.4%	17.5%	13.0%	22.0%			
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
Total %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.3%	0.8%	0.7%	0.4%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.3%	3.6%	9.1%	9.0%	5.1%	13.0%	9.0%	5.1%	13.0%
Total Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit C.19d

Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Surface Water Plants (Number of Plants by Residual Disinfection Type)

Stage 2 Preferred Alternative, 25% Safety Margin

System Size (Population Served)	Converting to CLM Only			Chlorine Dioxide						UV						Ozone						MF/UF						GAC10					
				CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B						C						D						E						F					
<100	4	2	6							9	5	13	7	4	10							0	0	0	0	0	0						
100-499	13	7	18	0	0	1	1	1	2	4	2	5	4	2	6	0	0	0	0	0	0	0	0	0	0	0	0						
500-999	4	2	6	0	0	0	0	0	1	1	1	2	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0						
1,000-3,300	4	2	6	0	0	0	1	0	1	1	0	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0						
3,301-9,999	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
10,000-49,999	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	27	15	38	1	0	1	3	1	4	16	9	23	14	8	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

System Size (Population Served)	GAC10 + Advanced Disinfectants						GAC20						GAC20 + Advanced Disinfectants						Membranes						Total Converting to CLM			Total Adding Treatment Technology					
	CL2			CLM			CL2			CLM			CL2			CLM			CL2			CLM											
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	G						H						I						J						T=A+C+E+G+I+K+M+O+Q+S			L = SUM(A:S)					
<100							0	0	0	0	0	0	2	1	2	1	1	2	0	0	0	0	0	0	12	7	18	23	13	33	68	38	98
100-499							0	0	0	0	0	0	2	1	2	2	1	3	0	0	0	0	0	0	20	11	29	26	15	38			
500-999							0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	7	4	10	9	5	13			
1,000-3,300							0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	7	4	10	8	5	12			
3,301-9,999							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3	2	1	3			
10,000-49,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Total Plants	0	0	0	0	0	0	0	0	0	0	0	0	4	2	6	5	3	7	0	0	0	0	0	0	48	27	69	69	39	99	69	39	99

Note: Detail may not add to totals due to independent rounding

Source: Above table with technologies switching from an advanced technology with Cl2 to the same advanced technology with CLM being moved into the CLM only column

Exhibit C.20a
Stage 2 DBPR Treatment Technology Selection Deltas for CWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Stage 2 Preferred Alternative, 25% Safety Margin

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	1.0%	0.0%	1.1%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	2.1%	2.4%	2.9%
100-499	1.4%	0.0%	1.6%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.0%	3.2%	
500-999	1.4%	0.0%	1.6%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.0%	3.2%	
1,000-3,300	1.1%	0.0%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	2.7%	
3,301-9,999	1.1%	0.0%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	2.7%	
10,000-49,999	1.4%			0.1%	0.2%	0.0%	0.2%	0.0%	0.2%	2.0%	2.1%	2.1%
50,000-99,999	1.4%			0.1%	0.2%	0.0%	0.2%	0.0%	0.2%	2.0%	2.1%	
100,000-999,999	1.3%			0.1%	0.2%	0.0%	0.1%	0.0%	0.2%	1.9%	2.0%	
>=1,000,000	1.4%			0.1%	0.2%	0.0%	0.1%	0.0%	0.2%	2.0%	2.1%	
Total %	1.3%	0.0%	1.3%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	2.6%	2.8%	2.8%

Note: Detail may not add to totals due to independent rounding

Exhibit C.20b
Stage 2 DBPR Treatment Technology Selection Deltas for CWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)
Stage 2 Preferred Alternative, 25% Safety Margin

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	6160.1%	0	70	0	0	23	0	0	0	132	155	1,170
100-499	213	0	242	0	0	27	0	0	0	456	483	
500-999	85	0	97	0	0	11	0	0	0	182	193	
1,000-3,300	82	0	118	0	0	0	4	0	0	204	204	
3,301-9,999	54	0	78	0	0	0	2	0	0	135	135	
10,000-49,999	75			3	12	0	8	2	11	107	111	145
50,000-99,999	10			0	2	0	1	0	2	14	15	
100,000-999,999	12			0	2	0	1	0	2	17	18	
>=1,000,000	0			0	0	0	0	0	0	1	1	

Exhibit C.20c
Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Stage 2 Preferred Alternative, 25% Safety Margin

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	1.0%	0.0%	1.1%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	2.1%	2.4%	2.8%
100-499	1.4%	0.0%	1.6%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.0%	3.2%	
500-999	1.4%	0.0%	1.6%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.0%	3.2%	
1,000-3,300	1.1%	0.0%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	2.7%	
3,301-9,999	1.1%	0.0%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	2.7%	
10,000-49,999	1.4%			0.1%	0.2%	0.0%	0.2%	0.0%	0.2%	2.0%	2.1%	2.1%
50,000-99,999	1.4%			0.1%	0.2%	0.0%	0.2%	0.0%	0.2%	2.0%	2.1%	
100,000-999,999	1.3%			0.1%	0.2%	0.0%	0.1%	0.0%	0.2%	1.9%	2.0%	
>=1,000,000	0.0%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Total %	1.2%	0.0%	1.4%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	2.5%	2.8%	2.8%

Note: Detail may not add to totals due to independent rounding

Exhibit C.20d
Stage 2 DBPR Treatment Technology Selection Deltas for NTNCWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)
Stage 2 Preferred Alternative, 25% Safety Margin

System Size (Population Served)	CLM Only	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Converting to CLM	Total Adding Treatment Technology	
	A	B	C	D	E	F	G	H	I	J = A+C+E+G+I	K = SUM(A:I)	
<100	2389.6%	0	27	0	0	9	0	0	0	51	60	153
100-499	30	0	34	0	0	4	0	0	0	64	67	
500-999	8	0	9	0	0	1	0	0	0	18	19	
1,000-3,300	3	0	4	0	0	0	0	0	0	7	7	
3,301-9,999	0	0	0	0	0	0	0	0	0	1	1	
10,000-49,999	0			0	0	0	0	0	0	0	0	0
50,000-99,999	0			0	0	0	0	0	0	0	0	
100,000-999,999	0			0	0	0	0	0	0	0	0	
>=1,000,000	0			0	0	0	0	0	0	0	0	

Exhibit C.21a

Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)

Stage 2 Preferred Alternative, 25% Safety Margin

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
		A			B			C			D			E			F			G			H			I			J			K			L	
<100	31.7%	27.3%	36.1%	31.6%	30.8%	32.4%							4.1%	2.3%	5.9%	3.0%	1.7%	4.3%							14.5%	14.5%	14.5%	7.1%	7.1%	7.1%						
100-499	27.2%	23.6%	30.9%	39.5%	37.7%	41.3%	1.1%	1.0%	1.1%	1.2%	1.1%	1.4%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	8.9%	8.9%	8.9%	4.8%	4.8%	4.8%						
500-999	27.2%	23.6%	30.9%	39.5%	37.7%	41.3%	1.1%	1.0%	1.1%	1.2%	1.1%	1.4%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	8.9%	8.9%	8.9%	4.8%	4.8%	4.8%						
1,000-3,300	24.6%	20.8%	28.5%	45.6%	43.7%	47.4%	2.1%	2.0%	2.2%	3.0%	2.6%	3.4%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.2%	6.2%	6.2%	2.9%	2.9%	2.9%						
3,301-9,999	24.6%	20.8%	28.5%	45.6%	43.7%	47.4%	2.1%	2.0%	2.2%	3.0%	2.6%	3.4%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.2%	6.2%	6.2%	2.9%	2.9%	2.9%						
10,000-49,999	27.5%	27.5%	27.5%	41.4%	41.4%	41.4%	2.3%	2.3%	2.3%	3.5%	3.5%	3.5%	1.9%	1.9%	1.9%	2.9%	2.9%	2.9%	5.1%	5.1%	5.1%	7.7%	7.7%	7.7%	0.7%	0.7%	0.7%	1.1%	1.1%	1.1%	0.9%	0.9%	0.9%	1.3%	1.3%	1.3%
50,000-99,999	27.5%	27.5%	27.5%	41.4%	41.4%	41.4%	2.3%	2.3%	2.3%	3.5%	3.5%	3.5%	1.9%	1.9%	1.9%	2.9%	2.9%	2.9%	5.1%	5.1%	5.1%	7.7%	7.7%	7.7%	0.7%	0.7%	0.7%	1.1%	1.1%	1.1%	0.9%	0.9%	0.9%	1.3%	1.3%	1.3%
100,000-999,999	27.5%	27.5%	27.5%	41.4%	41.4%	41.4%	2.3%	2.3%	2.3%	3.5%	3.5%	3.5%	1.9%	1.9%	1.9%	2.9%	2.9%	2.9%	5.1%	5.1%	5.1%	7.7%	7.7%	7.7%	0.7%	0.7%	0.7%	1.1%	1.1%	1.1%	0.9%	0.9%	0.9%	1.3%	1.3%	1.3%
>=1,000,000	27.5%	27.5%	27.5%	41.4%	41.4%	41.4%	2.3%	2.3%	2.3%	3.5%	3.5%	3.5%	1.9%	1.9%	1.9%	2.9%	2.9%	2.9%	5.1%	5.1%	5.1%	7.7%	7.7%	7.7%	0.7%	0.7%	0.7%	1.1%	1.1%	1.1%	0.9%	0.9%	0.9%	1.3%	1.3%	1.3%
Total %	26.6%	24.3%	29.0%	42.0%	41.0%	43.1%	1.9%	1.8%	1.9%	2.7%	2.5%	2.9%	1.5%	1.2%	1.9%	2.0%	1.6%	2.4%	4.4%	4.4%	4.4%	5.5%	5.5%	5.5%	5.0%	5.0%	5.0%	2.8%	2.8%	2.8%	0.3%	0.3%	0.3%	0.5%	0.5%	0.5%

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
		M			N			O			P			Q			R			S			T		U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							2.0%	2.0%	2.0%	1.3%	1.3%	1.3%	0.7%	0.4%	1.0%	0.5%	0.3%	0.7%	2.1%	2.1%	2.1%	1.4%	1.4%	1.4%	55.1%	48.5%	61.6%	44.9%	42.6%	47.3%
100-499							1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	0.8%	1.3%	1.1%	0.8%	1.4%	0.5%	0.5%	0.5%	0.5%	0.4%	0.5%	46.1%	41.6%	50.5%	53.9%	51.1%	56.8%
500-999	Mean						1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	0.8%	1.3%	1.1%	0.8%	1.4%	0.5%	0.5%	0.5%	0.5%	0.4%	0.5%	46.1%	41.6%	50.5%	53.9%	51.1%	56.8%
1,000-3,300	A						1.0%	1.0%	1.0%	1.2%	1.2%	1.2%	1.0%	0.8%	1.2%	1.4%	1.0%	1.8%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	40.1%	35.5%	44.6%	59.9%	56.8%	63.1%
3,301-9,999							1.0%	1.0%	1.0%	1.2%	1.2%	1.2%	1.0%	0.8%	1.2%	1.4%	1.0%	1.8%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	40.1%	35.5%	44.6%	59.9%	56.8%	63.1%
10,000-49,999	1.0%	1.0%	1.0%	1.5%	1.5%	1.5%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	39.9%	39.9%	39.9%	60.1%	60.1%	60.1%
50,000-99,999	1.0%	1.0%	1.0%	1.5%	1.5%	1.5%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	39.9%	39.9%	39.9%	60.1%	60.1%	60.1%
100,000-999,999	1.0%	1.0%	1.0%	1.5%	1.5%	1.5%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	39.9%	39.9%	39.9%	60.1%	60.1%	60.1%
>=1,000,000	1.0%	1.0%	1.0%	1.5%	1.5%	1.5%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	39.9%	39.9%	39.9%	60.1%	60.1%	60.1%
Total %	0.4%	0.4%	0.4%	0.6%	0.6%	0.6%	0.7%	0.7%	0.7%	0.8%	0.8%	0.8%	0.6%	0.5%	0.7%	0.8%	0.6%	1.0%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	42.0%	39.1%	44.8%	58.0%	56.2%	59.8%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the IDSE Alternative Stage 2 Preferred Alternative. Surface water systems serving 10,000 or

Exhibit C.21b

Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Surface Water Plants (Number of Plants by Residual Disinfection Type)

Stage 2 Preferred Alternative, 25% Safety Margin

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
		A			B			C			D			E			F			G			H			I			J			K			L	
<100	114	98	130	114	111	117							15	8	21	11	6	16							52	52	52	26	26	26						
100-499	209	181	237	303	289	317	8	8	9	9	8	11	9	5	13	10	5	14	39	39	39	35	35	35	68	68	68	37	37	37						
500-999	132	114	149	191	182	199	5	5	5	6	5	7	6	3	8	6	3	9	24	24	24	22	22	22	43	43	43	23	23	23						
1,000-3,300	278	235	322	515	494	536	23	23	24	34	30	39	11	6	15	14	8	20	45	45	45	51	51	51	70	70	70	32	32	32						
3,301-9,999	310	262	359	573	550	597	26	25	27	38	33	43	12	7	17	16	9	23	50	50	50	56	56	56	78	78	78	36	36	36						
10,000-49,999	355	355	355	534	534	534	30	30	30	45	45	45	25	25	25	37	37	37	66	66	66	99	99	99	9	9	9	14	14	14	11	11	11	17	17	17
50,000-99,999	159	159	159	240	240	240	14	14	14	20	20	20	11	11	11	17	17	17	30	30	30	45	45	45	4	4	4	6	6	6	5	5	5	8	8	8
100,000-999,999	168	168	168	253	253	253	14	14	14	21	21	21	12	12	12	17	17	17	31	31	31	47	47	47	4	4	4	7	7	7	5	5	5	8	8	8
>=1,000,000	20	20	20	30	30	30	2	2	2	3	3	3	1	1	1	2	2	2	4	4	4	6	6	6	1	1	1	1	1	1	1	1	1	1	1	1
Total Plants	1,745	1,591	1,899	2,752	2,683	2,822	123	120	125	178	166	189	101	78	124	130	105	154	290	290	290	361	361	361	329	329	329	182	182	182	22	22	22	34	34	34

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
		M			N			O			P			Q			R			S			T		U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							7	7	7	5	5	5	2	1	3	2	1	3	8	8	8	5	5	5	198	174	221	161	153	170
100-499							8	8	8	7	7	7	8	6	10	9	6	11	3	3	3	4	3	4	353	319	387	414	392	435
500-999							5	5	5	5	5	5	5	4	6	5	4	7	2	2	2	2	2	2	222	201	244	260	247	274
1,000-3,300							12	12	12	13	13	13	11	9	14	16	12	20	2	2	2	2	2	2	452	401	504	677	641	712
3,301-9,999							13	13	13	15	15	15	13	10	15	18	13	22	2	2	2	2	2	2	504	447	561	754	715	794
10,000-49,999	13	13	13	20	20	20	2	2	2	3	3	3	0	0	0	0	0	0	4	4	4	6	6	6	516	516	516	776	776	776
50,000-99,999	6	6	6	9	9	9	1	1	1	1	1	1	0	0	0	0	0	0	2	2	2	3	3	3	231	231	231	348	348	348
100,000-999,999	6	6	6	9	9	9	1	1	1	1	1	1	0	0	0	0	0	0	2	2	2	3	3	3	244	244	244	367	367	367
>=1,000,000	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	29	29	44	44	44
Total Plants	26	26	26	39	39	39	49	49	49	50	50	50	39	30	49	49	36	63	25	25	25	27	26	27	2,750	2,561	2,938	3,801	3,683	3,921

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the IDSE Alternative Stage 2 Preferred Alternative. Surface water systems serving 10,000 or

Exhibit C.21c

Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Surface Water Plants (Percent of Plants by Residual Disinfection Type)

Stage 2 Preferred Alternative, 25% Safety Margin

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	31.7%	27.3%	36.1%	31.6%	30.8%	32.4%							4.1%	2.3%	5.9%	3.0%	1.7%	4.3%							14.5%	14.5%	14.5%	7.1%	7.1%	7.1%						
100-499	27.2%	23.6%	30.9%	39.5%	37.7%	41.3%	1.1%	1.0%	1.1%	1.2%	1.1%	1.4%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	8.9%	8.9%	8.9%	4.8%	4.8%	4.8%						
500-999	27.2%	23.6%	30.9%	39.5%	37.7%	41.3%	1.1%	1.0%	1.1%	1.2%	1.1%	1.4%	1.2%	0.7%	1.8%	1.3%	0.7%	1.8%	5.1%	5.1%	5.1%	4.6%	4.6%	4.6%	8.9%	8.9%	8.9%	4.8%	4.8%	4.8%						
1,000-3,300	24.6%	20.8%	28.5%	45.6%	43.7%	47.4%	2.1%	2.0%	2.2%	3.0%	2.6%	3.4%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.2%	6.2%	6.2%	2.9%	2.9%	2.9%						
3,301-9,999	24.6%	20.8%	28.5%	45.6%	43.7%	47.4%	2.1%	2.0%	2.2%	3.0%	2.6%	3.4%	0.9%	0.5%	1.4%	1.2%	0.7%	1.8%	4.0%	4.0%	4.0%	4.5%	4.5%	4.5%	6.2%	6.2%	6.2%	2.9%	2.9%	2.9%						
10,000-49,999	27.5%	27.5%	27.5%	41.4%	41.4%	41.4%	2.3%	2.3%	2.3%	3.5%	3.5%	3.5%	1.9%	1.9%	1.9%	2.9%	2.9%	2.9%	5.1%	5.1%	5.1%	7.7%	7.7%	7.7%	0.7%	0.7%	0.7%	1.1%	1.1%	1.1%	0.9%	0.9%	0.9%	1.3%	1.3%	1.3%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	27.5%	27.5%	27.5%	41.4%	41.4%	41.4%	2.3%	2.3%	2.3%	3.5%	3.5%	3.5%	1.9%	1.9%	1.9%	2.9%	2.9%	2.9%	5.1%	5.1%	5.1%	7.7%	7.7%	7.7%	0.7%	0.7%	0.7%	1.1%	1.1%	1.1%	0.9%	0.9%	0.9%	1.3%	1.3%	1.3%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	28.2%	24.3%	32.0%	38.1%	36.6%	39.6%	0.9%	0.9%	1.0%	1.2%	1.0%	1.3%	2.0%	1.1%	2.9%	1.8%	1.0%	2.6%	3.4%	3.4%	3.4%	3.2%	3.2%	3.2%	10.1%	10.1%	10.1%	5.2%	5.2%	5.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							2.0%	2.0%	2.0%	1.3%	1.3%	1.3%	0.7%	0.4%	1.0%	0.5%	0.3%	0.7%	2.1%	2.1%	2.1%	1.4%	1.4%	1.4%	55.1%	48.5%	61.6%	44.9%	42.6%	47.3%
100-499							1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	0.8%	1.3%	1.1%	0.8%	1.4%	0.5%	0.5%	0.5%	0.5%	0.4%	0.5%	46.1%	41.6%	50.5%	53.9%	51.1%	56.8%
500-999	Mean						1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	0.8%	1.3%	1.1%	0.8%	1.4%	0.5%	0.5%	0.5%	0.5%	0.4%	0.5%	46.1%	41.6%	50.5%	53.9%	51.1%	56.8%
1,000-3,300	A						1.0%	1.0%	1.0%	1.2%	1.2%	1.2%	1.0%	0.8%	1.2%	1.4%	1.0%	1.8%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	40.1%	35.5%	44.6%	59.9%	56.8%	63.1%
3,301-9,999							1.0%	1.0%	1.0%	1.2%	1.2%	1.2%	1.0%	0.8%	1.2%	1.4%	1.0%	1.8%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	40.1%	35.5%	44.6%	59.9%	56.8%	63.1%
10,000-49,999	1.0%	1.0%	1.0%	1.5%	1.5%	1.5%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	39.9%	39.9%	39.9%	60.1%	60.1%	60.1%
50,000-99,999	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100,000-999,999	1.0%	1.0%	1.0%	1.5%	1.5%	1.5%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	39.9%	39.9%	39.9%	60.1%	60.1%	60.1%
>=1,000,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	1.3%	1.3%	1.1%	1.1%	1.1%	0.9%	0.7%	1.2%	1.0%	0.7%	1.3%	0.9%	0.9%	0.9%	0.7%	0.7%	0.7%	47.7%	42.7%	52.8%	52.3%	49.5%	55.0%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the IDSE Alternative Stage 2 Preferred Alternative. Surface water systems serving 10,000 or

Exhibit C.21d

Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Surface Water Plants (Number of Plants by Residual Disinfection Type)

Stage 2 Preferred Alternative, 25% Safety Margin

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]			No Advanced Treatment Technologies CLM[1]			Chlorine Dioxide CL2			Chlorine Dioxide CLM			UV CL2			UV CLM			Ozone CL2			Ozone CLM			MF/UF CL2			MF/UF CLM			GAC 10 CL2			GAC 10 CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	A			B			C			D			E			F			G			H			I			J			K			L		
<100	72	62	82	71	70	73							9	5	13	7	4	10							33	33	33	16	16	16						
100-499	85	74	96	123	118	129	3	3	4	4	3	4	4	2	5	4	2	6	16	16	16	14	14	14	28	28	28	15	15	15						
500-999	29	25	33	42	40	44	1	1	1	1	1	1	1	1	2	1	1	2	5	5	5	5	5	5	9	9	9	5	5	5						
1,000-3,300	23	19	26	42	40	44	2	2	2	3	2	3	1	0	1	1	1	2	4	4	4	4	4	4	6	6	6	3	3	3						
3,301-9,999	6	5	7	11	11	12	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	2	2	2	1	1	1						
10,000-49,999	1	1	1	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	216	186	246	292	281	304	7	7	7	9	8	10	16	9	22	14	8	20	26	26	26	25	25	25	77	77	77	40	40	40	0	0	0	0	0	0

System Size (Population Served)	GAC10 + AD CL2			GAC10 + AD CLM			GAC20 CL2			GAC20 CLM			GAC20 + AD CL2			GAC20 + AD CLM			Membranes CL2			Membranes CLM			TOTAL CL2			TOTAL CLM		
	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th	Mean	5th	95th
	M			N			O			P			Q			R			S			T			U = A+C+E+G+I+K+M+O+Q+S			V = B+D+F+H+J+L+N+P+R+T		
<100							4	4	4	3	3	3	2	1	2	1	1	2	5	5	5	3	3	3	124	110	139	102	96	107
100-499							3	3	3	3	3	3	3	2	4	4	3	4	1	1	1	1	1	2	144	130	158	168	159	177
500-999							1	1	1	1	1	1	1	1	1	1	1	2	0	0	0	0	0	1	49	44	54	57	54	60
1,000-3,300							1	1	1	1	1	1	1	1	1	1	1	2	0	0	0	0	0	0	37	33	41	55	52	58
3,301-9,999							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	9	11	15	14	16
10,000-49,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	3	3	3
50,000-99,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100,000-999,999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
>=1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plants	0	0	0	0	0	0	10	10	10	8	8	8	7	5	9	8	5	10	7	7	7	5	5	5	366	327	405	401	380	422

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Surface water systems serving <10,000 people: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.16) to the Technology Selection Delta for the IDSE Alternative Stage 2 Preferred Alternative. Surface water systems serving 10,000 or

Exhibit C.22a

Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)

Stage 2 Preferred Alternative, 25% Safety Margin

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	93.5%	3.4%	0.0%	1.1%	0.0%	0.0%	0.4%	0.9%	0.3%	0.5%	94.2%	5.8%
100-499	92.1%	4.2%	0.0%	1.6%	0.2%	0.5%	0.2%	0.6%	0.1%	0.5%	92.6%	7.4%
500-999	92.1%	4.2%	0.0%	1.6%	0.2%	0.5%	0.2%	0.6%	0.1%	0.5%	92.6%	7.4%
1,000-3,300	93.1%	3.6%	0.0%	1.6%	0.3%	0.9%	0.0%	0.1%	0.1%	0.5%	93.4%	6.6%
3,301-9,999	93.1%	3.6%	0.0%	1.6%	0.3%	0.9%	0.0%	0.1%	0.1%	0.5%	93.4%	6.6%
10,000-49,999	87.1%	8.6%			0.9%	1.0%	0.0%	0.2%	1.7%	0.5%	89.7%	10.3%
50,000-99,999	87.1%	8.6%			0.9%	1.0%	0.0%	0.2%	1.7%	0.5%	89.7%	10.3%
100,000-999,999	87.5%	8.4%			0.9%	0.9%	0.0%	0.2%	1.7%	0.4%	90.1%	9.9%
>=1,000,000	87.4%	8.5%			0.9%	0.9%	0.0%	0.2%	1.7%	0.4%	90.0%	10.0%
Total %	91.8%	4.6%	0.0%	1.3%	0.3%	0.6%	0.1%	0.5%	0.4%	0.5%	92.6%	7.4%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the IDSE Alternative Stage 2 Preferred Alternative.

Exhibit C.22b

Post-Stage 2 DBPR Treatment Technologies-in-Place for CWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)

rred Alternative, 25%

A

System Size (Population Served)	echnology CL21	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	6,006	217	0	70	0	0	23	56	22	29	6,051	372
100-499	14,040	640	0	242	25	74	27	96	20	79	14,111	1,131
500-999	5,613	256	0	97	10	29	11	39	8	32	5,641	452
1,000-3,300	7,060	274	0	118	22	66	0	8	4	36	7,086	501
3,301-9,999	4,681	181	0	78	15	44	0	5	3	24	4,698	332
10,000-49,999	4,690	464			48	53	0	10	91	25	4,829	553
50,000-99,999	624	62			6	7	0	1	12	3	642	74
Total Plants	43,539	2,173	0	606	134	282	61	217	175	232	43,910	3,510

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the IDSE Alternative Stage 2 Preferred Alternative.

Exhibit C.22c
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Ground Water Plants (Percent of Plants, by Residual Disinfectant Type)
Stage 2 Preferred Alternative, 25% Safety Margin

System Size (Population Served)	No Advanced Treatment Technologies CL2[1]	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	93.5%	3.4%	0.0%	1.1%	0.0%	0.0%	0.4%	0.9%	0.3%	0.5%	94.2%	5.8%
100-499	92.1%	4.2%	0.0%	1.6%	0.2%	0.5%	0.2%	0.6%	0.1%	0.5%	92.6%	7.4%
500-999	92.1%	4.2%	0.0%	1.6%	0.2%	0.5%	0.2%	0.6%	0.1%	0.5%	92.6%	7.4%
1,000-3,300	93.1%	3.6%	0.0%	1.6%	0.3%	0.9%	0.0%	0.1%	0.1%	0.5%	93.4%	6.6%
3,301-9,999	93.1%	3.6%	0.0%	1.6%	0.3%	0.9%	0.0%	0.1%	0.1%	0.5%	93.4%	6.6%
10,000-49,999	87.1%	8.6%			0.9%	1.0%	0.0%	0.2%	1.7%	0.5%	89.7%	10.3%
50,000-99,999	87.1%	8.6%			0.9%	1.0%	0.0%	0.2%	1.7%	0.5%	89.7%	10.3%
100,000-999,999	87.5%	8.4%			0.9%	0.9%	0.0%	0.2%	1.7%	0.4%	90.1%	9.9%
>=1,000,000	0.0%	0.0%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total %	92.8%	3.8%	0.0%	1.4%	0.1%	0.3%	0.3%	0.7%	0.2%	0.5%	93.4%	6.6%

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the IDSE Alternative Stage 2 Preferred Alternative.

Exhibit C.22d
Post-Stage 2 DBPR Treatment Technologies-in-Place for NTNCWS Ground Water Plants (Number of Plants, by Residual Disinfectant Type)

rred Alternative, 25%

A

System Size (Population Served)	echnology CL21	No Advanced Treatment Technologies CLM[1]	UV CL2	UV CLM	Ozone CL2	Ozone CLM	GAC20 CL2	GAC20 CLM	Membranes CL2	Membranes CLM	Total Using CL2	Total Using CLM
	A	B	C	D	E	F	G	H	I	J	K = A+C+E+G+I	L = B+D+F+H+J
<100	2,331	84	0	27	0	0	9	22	8	11	2,348	144
100-499	1,961	89	0	34	3	10	4	13	3	11	1,971	158
500-999	543	25	0	9	1	3	1	4	1	3	546	44
1,000-3,300	230	9	0	4	1	2	0	0	0	1	231	16
3,301-9,999	20	1	0	0	0	0	0	0	0	0	20	1
10,000-49,999	3	0			0	0	0	0	0	0	3	0
50,000-99,999	0	0			0	0	0	0	0	0	0	0
Total Plants	5,088	208	0	75	5	15	14	39	12	27	5,119	364

Note: Detail may not add to totals due to independent rounding

[1] No advanced Treatment Technologies includes conventional, non-conventional, and softening plants.

Source: Add Technologies-in-Place for the Pre-Stage 2 Baseline (Exhibit 3.17) to the Technology Selection Delta for the IDSE Alternative Stage 2 Preferred Alternative.

Appendix D
Rule Activity Schedule

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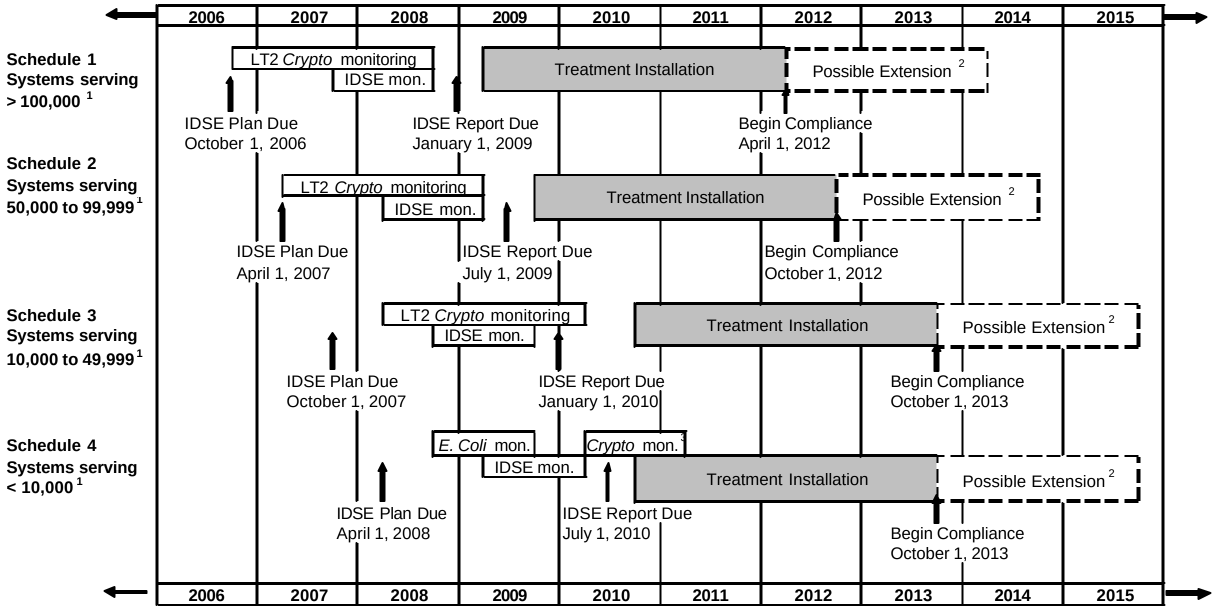
Rule Activity Schedule

This appendix presents the year-by-year schedules for systems for the following rule activities: capital and operations and maintenance (O&M) treatment technology costs (Exhibits D.3 and D.4), implementation (Exhibit D.5), Initial Distribution System Evaluation (IDSE) activities (Exhibit D.6), preparation of monitoring plans (Exhibit D.7), annual routine monitoring (Exhibit D.8), and operational evaluations (Exhibit D.9). Schedules for State/Primacy Agency activities are presented in Exhibit D.10. These schedules are based on the Stage 2 implementation timeline, as presented in Exhibit D.1. When systems and States had several years within which to complete a rule activity, the Environmental Protection Agency (EPA) assumed that the same proportion of systems would perform the activity in each year. EPA recognizes that more systems may start in early or later years, but believes that a uniform schedule is still a reasonable approximation nationally.

Exhibit D.1 Schedule of Rule Activities



[1] Includes all systems that are part of a combined distribution system that has a largest system with this population.
[2] A State may grant up to a two year extension for systems to comply if the State determines that additional time is necessary for capital improvements needed for compliance.
[3] Subpart H systems serving fewer than 10,000 that must conduct Crypto monitoring have an additional 12 months to comply with Stage 2 DBPR MCLs.

D.1 Estimate of Small and Medium Systems on Early Implementation Schedules

Systems are required to perform IDSE and routine monitoring on the same schedule as the largest system in their combined distribution system. For the Stage 2 DBPR, a combined distribution system encompasses all systems that are connected by common buyers and sellers. Exhibit D.2 presents an estimate of surface water CWSs that will be on early implementation schedules based on the linking analysis.

There are uncertainties in using the results of the linking exercise to estimate the number of small systems on accelerated schedules. The analysis was performed by obtaining data from EPA regions and States on which systems would be considered in a combined distribution system. The data was collected in 2005 and was used as it more accurately portrays how Primacy Agencies will handle consecutive systems. Although SDWIS contains information on consecutive systems it does not differentiate between regular connections and emergency connections. It also cannot give information on the multiple levels of buyers and sellers that often exist.

Exhibit D.2 Numbers of Surface Water CWSs on Accelerated Schedules

Type of System	Size Category (People Served)	Total Systems	Number of Smaller Systems Buying from or Selling to Medium 1 Category	Number of Smaller Systems Buying from or Selling to Medium 2 Category	Number of Smaller Systems Buying from or Selling to Large Category	Percent Systems on Medium 1 Schedule	Percent Systems on Medium 2 Schedule	Percent Systems on Large Schedule
		A	**B**	**C**	**D**	**E = B/A**[1]	**F = C/A**[1]	**G = D/A**
SW CWS	Small	9,136	1,666	585	1,989	18.24%	6.40%	21.77%
	Medium 1	1,758	875	130	753	49.77%	7.39%	42.83%
	Medium 2	339	0	196	143		57.82%	42.18%
	Large	298	0	0	298			100.00%
SW NTNCWS	Small	713	64	22	75	8.98%	3.09%	10.52%
	Medium 1	0	0	0	0	0.00%	0.00%	0.00%
	Medium 2	0	0	0	0		0.00%	0.00%
	Large	0	0	0	0			0.00%
GW CWS	Small	39,519	886	234	515	2.24%	0.59%	1.30%
	Medium 1	1,313	1149	35	129	87.51%	2.67%	9.82%
	Medium 2	147	0	127	20		86.39%	13.61%
	Large	75	0	0	75			100.00%
GW NTNCWS	Small	18,528	35	28	31	0.19%	0.15%	0.17%
	Medium 1	0	0	0	0	0.00%	0.00%	0.00%
	Medium 2	0	0	0	0		0.00%	0.00%
	Large	0	0	0	0			0.00%

Notes:

Small serves < 10,000 retail population

Medium 1 serves from 10,000 to 49,999 retail population

Medium 2 serves from 50,000 to 99,999 retail population

Large serves 100,000 or more retail population

[1] For medium 1 E = 1 - F - G, for medium 2 F = 1 - G

Sources:

(A) - (D) SDWIS 4th quarter 2003 frozen database - IDSE4 analysis 10/14/2004

D.2 Capital and Operation and Maintenance Schedule

The schedule for making treatment technology changes is based on the rule schedule. EPA assumed that systems will start making capital improvements soon after their IDSE monitoring and report are complete. EPA assumes that large systems would start making capital improvements one year after the IDSE is complete. As a simplifying assumption, EPA spreads capital costs equally through the end of the possible 2-year extension period. Capital costs are spread over 5 years for systems serving between

50,000 and 99,999 people, 6 years for systems serving between 10,000 and 49,999 people, and 7 years for small systems. This reflects that these systems have longer to comply with the rule. It also reflects the fact that some of these systems will be required to monitor on the same schedule with the large systems and may begin installing treatment at the same time as the large systems. For simplicity, the installation of treatment for the smaller systems is distributed evenly over the period from when the large systems begin installing treatment until the compliance deadline. For small systems the schedule also reflects the fact that some of them will have additional time for compliance because of *Cryptosporidium* monitoring.[1] O&M costs for all system sizes lag behind capital costs by 1 year and are incurred annually.

Exhibits D.3a and D.3b display the capital cost schedule for surface and ground water systems, respectively. Exhibits D.4a and D.4b display the O&M costs for surface and ground water systems, respectively.

D.3 Implementation and IDSE Schedule

EPA assumed that systems will incur half of their implementation costs the year before they begin IDSE monitoring and the other half the year after completing their IDSE monitoring. The implementation and IDSE schedules for small surface water CWSs are adjusted to account for small systems that are in a combined distribution system with medium and large systems and are thus on an earlier schedule. See section D.1 for a discussion on how EPA estimated the number of systems on an accelerated schedule. Implementation costs are distributed according to the estimated percentages of systems on accelerated schedules. For example, for the 50,000 to 99,999 category incurring IDSE costs, 42 percent are expected to be on the greater than 100,000 schedule, and the remaining 58 percent are expected to stay on the 50,000 to 99,999 schedule, which is delayed by 6 months.

The IDSE schedule applies to costs related to the standard monitoring, System Specific Studies (SSSs), and 40/30 certification. Although the 40/30 certification will occur before the IDSE and SSSs, the portion of the costs represented by the 40/30 certification is so small (< 0.1%) that discounting it on a separate schedule would make no noticeable difference in total costs. Therefore, to simplify the calculations, EPA discounted the 40/30 costs using the same schedule.

Exhibits D.5a and D.5b present the schedule for implementation costs for surface and ground water systems, respectively. Exhibits D.6a and D.6b display the schedule for IDSE costs for surface and ground water systems, respectively.

D.4 Monitoring Plans

The routine monitoring plans indicate the planned locations and schedule on which routine monitoring will be conducted, based on information collected during the IDSE and provided in the IDSE report. EPA assumed that the costs for preparing routine monitoring plans will be incurred as soon as the IDSE ends. This may be a conservative estimate, as systems could potentially delay monitoring plans until just before the Stage 2 DBPR requirements take effect. Exhibits D.7a and D.7b display the schedule for monitoring plan preparation for surface and ground water systems, respectively.

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[1] Time periods for capital costs for small and medium systems include a possible 2-year extension for systems making capital improvements.

D.5 Additional Routine Monitoring

The costs for additional routine monitoring are assumed to begin when Stage 2 DBPR requirements take effect. The ground water schedule also is assumed to reflect the schedule for systems that add disinfection for the Ground Water Rule prior to compliance monitoring. Exhibits D.8a and D.8b display the routine monitoring schedule for surface and ground water systems, respectively.

D.6 Operational Evaluations

An operational evaluation is only triggered when a system exceeds an operational evaluation level. Since a system needs at least three quarters of data to calculate an operational evaluation level, EPA assumes that operational evaluations will not begin until 1 year after Stage 2 DBPR requirements take effect. Exhibits D.9a and D.9b display the operational evaluation level schedule for costs for surface and ground water systems, respectively.

D.7 Primacy Agency Schedule

EPA assumed that primacy agencies will incur implementation costs during the first 2 years after promulgation of the Stage 2 DBPR. Since primacy agencies will incur IDSE costs as systems conduct their IDSEs, cost were weighted according to the number of systems performing the IDSE each year. EPA assumed that monitoring costs will be incurred annually. Exhibit D.10 displays the schedule for primacy agency costs.

Exhibit D.3a Schedule for Surface Water Capital Costs

All Alternatives

Year	Community Water Systems				Nontransient Noncommunity Water Systems			
	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	15%	18%	22%	25%	15%	18%	22%	25%
6	15%	18%	22%	25%	15%	18%	22%	25%
7	15%	18%	22%	25%	15%	18%	22%	25%
8	15%	18%	22%	25%	15%	18%	22%	25%
9	15%	18%	11%	-	15%	18%	11%	-
10	15%	9%	-	-	15%	9%	-	-
11	8%	-	-	-	8%	-	-	-
12-25	No Capital Costs							

Source: Derived from rule implementation schedule.

Exhibit D.3b Schedule for Ground Water Capital Costs

All Alternatives

Year	Community Water Systems				Nontransient Noncommunity Water Systems			
	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	15%	18%	22%	25%	15%	18%	22%	25%
6	15%	18%	22%	25%	15%	18%	22%	25%
7	15%	18%	22%	25%	15%	18%	22%	25%
8	15%	18%	22%	25%	15%	18%	22%	25%
9	15%	18%	11%	-	15%	18%	11%	-
10	15%	9%	-	-	15%	9%	-	-
11	8%	-	-	-	8%	-	-	-
11 - 25	No Capital Costs							

Source: Derived from rule implementation schedule.

Exhibit D.4a Schedule for Surface Water O&M Costs

All Alternatives

Year	Community Water Systems				Nontransient Noncommunity Water Systems			
	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	15%	18%	22%	25%	15%	18%	22%	25%
7	31%	36%	44%	50%	31%	36%	44%	50%
8	46%	55%	67%	75%	46%	55%	67%	75%
9	62%	73%	89%	100%	62%	73%	89%	100%
10	77%	91%	100%	100%	77%	91%	100%	100%
11	92%	100%	100%	100%	92%	100%	100%	100%
12	100%	100%	100%	100%	100%	100%	100%	100%
13	100%	100%	100%	100%	100%	100%	100%	100%
14	100%	100%	100%	100%	100%	100%	100%	100%
15	100%	100%	100%	100%	100%	100%	100%	100%
16	100%	100%	100%	100%	100%	100%	100%	100%
17	100%	100%	100%	100%	100%	100%	100%	100%
18	100%	100%	100%	100%	100%	100%	100%	100%
19	100%	100%	100%	100%	100%	100%	100%	100%
20	100%	100%	100%	100%	100%	100%	100%	100%
21	100%	100%	100%	100%	100%	100%	100%	100%
22	100%	100%	100%	100%	100%	100%	100%	100%
23	100%	100%	100%	100%	100%	100%	100%	100%
24	100%	100%	100%	100%	100%	100%	100%	100%
25	100%	100%	100%	100%	100%	100%	100%	100%

Source: Derived from rule implementation schedule.

Exhibit D.4b Schedule for Ground Water O&M Costs

All Alternatives

Year	Community Water Systems				Nontransient Noncommunity Water Systems			
	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	15%	18%	22%	25%	15%	18%	22%	25%
7	31%	36%	44%	50%	31%	36%	44%	50%
8	46%	55%	67%	75%	46%	55%	67%	75%
9	62%	73%	89%	100%	62%	73%	89%	100%
10	77%	91%	100%	100%	77%	91%	100%	100%
11	92%	100%	100%	100%	92%	100%	100%	100%
12	100%	100%	100%	100%	100%	100%	100%	100%
13	100%	100%	100%	100%	100%	100%	100%	100%
14	100%	100%	100%	100%	100%	100%	100%	100%
15	100%	100%	100%	100%	100%	100%	100%	100%
16	100%	100%	100%	100%	100%	100%	100%	100%
17	100%	100%	100%	100%	100%	100%	100%	100%
18	100%	100%	100%	100%	100%	100%	100%	100%
19	100%	100%	100%	100%	100%	100%	100%	100%
20	100%	100%	100%	100%	100%	100%	100%	100%
21	100%	100%	100%	100%	100%	100%	100%	100%
22	100%	100%	100%	100%	100%	100%	100%	100%
23	100%	100%	100%	100%	100%	100%	100%	100%
24	100%	100%	100%	100%	100%	100%	100%	100%
25	100%	100%	100%	100%	100%	100%	100%	100%

Source: Derived from rule implementation schedule.

Exhibit D.5a Schedule for SW PWS Implementation Costs

All Alternatives

	Community Water Systems				Nontransient Noncommunity Water Systems			
Year	**< 10,000**	**10,000 - 49,999**	**50,000 - 99,999**	**100,000+**	**< 10,000**	**10,000 - 49,999**	**50,000 - 99,999**	**100,000+**
1	14%	25%	50%	50%	7%	-	50%	50%
2	36%	25%	-	-	43%	50%	-	-
3	-	-	-	-	-	-	-	-
4	12%	23%	36%	50%	6%	-	25%	50%
5	20%	14%	14%	-	22%	25%	25%	-
6	18%	12%	-	-	22%	25%	-	-
7-25	No Implementation Costs							

Source: Derived from rule implementation schedule.
The schedule for all systems assumes that they will incur half of implementation costs as they prepare for the IDSE and the other half as they prepare for compliance with the Stage 2 requirements.
The schedule for small surface water systems has been adjusted to account for consecutive systems that are on a faster schedule because they buy from or sell to larger systems

Exhibit D.5b Schedule for GW PWS Implementation Costs

All Alternatives

Year	Community Water Systems				Nontransient Noncommunity Water Systems			
	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+
1	1%	6%	50%	50%	0.2%	-	50%	50%
2	49%	44%	-	-	49.8%	50%	-	-
3	-	-	-	-	-	-	-	-
4	1%	6%	28%	50%	0.1%	-	25%	50%
5	25%	23%	22%	-	25.0%	25%	25%	-
6	25%	22%	-	-	24.9%	25%	-	-
7 - 25	No Implementation Costs							

Source: Derived from rule implementation schedule.

The schedule for all systems assumes that they will incur half of implementation costs as they prepare for the IDSE and the other half as they prepare for compliance with the Stage 2 requirements.

The schedule for small surface water systems has been adjusted to account for consecutive systems that are on a faster schedule because they buy from or sell to larger systems

Exhibit D.6a Schedule for SW PWS IDSE Costs

All Alternatives

Year	Community Water Systems				Nontransient Noncommunity Water Systems			
	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+
1	-	-	-	-	-	-	-	
2	11%	21%	21%	50%	-	-	-	50%
3	26%	54%	79%	50%	-	50%	100%	50%
4	63%	25%	-	-	100%	50%	-	-
5 - 25	No IDSE Costs							

Source: Derived from rule implementation schedule.
Although 40/30 Certification costs will be incurred earlier, the percent of total costs is so small as to be negligible.

Exhibit D.6b Schedule for GW PWS IDSE Costs

All Alternatives

Year	Community Water Systems				Nontransient Noncommunity Water Systems			
	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+
1	-	-	-	-	-	-	-	-
2	-	-	-	50%	-	-	-	50%
3	-	50%	100%	50%	-	50%	100%	50%
4	100%	50%	-	-	100%	50%	-	-
5 - 25	No IDSE Costs							

Source: Derived from rule implementation schedule.
The schedule for small surface water systems has been adjusted to account for consecutive systems that are on a faster schedule because they buy from or sell to larger systems

Exhibit D.7a Schedule for SW PWS Monitoring Plan Costs

All Alternatives

	Community Water Systems				Nontransient Noncommunity Water Systems			
Year	**< 10,000**	**10,000 - 49,999**	**50,000 - 99,999**	**100,000+**	**< 10,000**	**10,000 - 49,999**	**50,000 - 99,999**	**100,000+**
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	11%	21%	21%	50%	-	-	-	50%
4	26%	54%	79%	50%	-	50%	100%	50%
5	63%	25%	-	-	100%	50%	-	-
6 - 25	No Monitoring Plan Costs							

Source: Derived from rule implementation schedule.
The schedule for small surface water systems has been adjusted to account for consecutive systems that are

Exhibit D.7b Schedule for GW PWS Monitoring Plan Costs

All Alternatives

Year	Community Water Systems				NonTransient Noncommunity Water Systems			
	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	50%	-	-	-	50%
4	-	50%	100%	50%	-	50%	100%	50%
5	100%	50%	-	-	100%	50%	-	-
6 - 25	No Monitoring Plan Costs							

Source: Derived from rule implementation schedule.
The schedule for small surface water systems has been adjusted to account for consecutive systems that are on a faster

Exhibit D.8a Schedule for Annual Surface Water Stage 2 Routine Compliance Monitoring Costs

All Alternatives

Year	Community Water Systems				Nontransient Noncommunity Water Systems			
	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	50%	100%	-	-	50%	100%
8	50%	50%	100%	100%	50%	50%	100%	100%
9	100%	100%	100%	100%	100%	100%	100%	100%
10	100%	100%	100%	100%	100%	100%	100%	100%
11	100%	100%	100%	100%	100%	100%	100%	100%
12	100%	100%	100%	100%	100%	100%	100%	100%
13	100%	100%	100%	100%	100%	100%	100%	100%
14	100%	100%	100%	100%	100%	100%	100%	100%
15	100%	100%	100%	100%	100%	100%	100%	100%
16	100%	100%	100%	100%	100%	100%	100%	100%
17	100%	100%	100%	100%	100%	100%	100%	100%
18	100%	100%	100%	100%	100%	100%	100%	100%
19	100%	100%	100%	100%	100%	100%	100%	100%
20	100%	100%	100%	100%	100%	100%	100%	100%
21	100%	100%	100%	100%	100%	100%	100%	100%
22	100%	100%	100%	100%	100%	100%	100%	100%
23	100%	100%	100%	100%	100%	100%	100%	100%
24	100%	100%	100%	100%	100%	100%	100%	100%
25	100%	100%	100%	100%	100%	100%	100%	100%

Source: Derived from rule implementation schedule.

Exhibit D.8b Schedule for Annual Ground Water Routine Stage 2 Compliance Monitoring Costs

All Alternatives

Year	Community Water Systems				Nontransient Noncommunity Water Systems			
	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	50%	100%	-	-	50%	100%
8	50%	50%	100%	100%	50%	50%	100%	100%
9	100%	100%	100%	100%	100%	100%	100%	100%
10	100%	100%	100%	100%	100%	100%	100%	100%
11	100%	100%	100%	100%	100%	100%	100%	100%
12	100%	100%	100%	100%	100%	100%	100%	100%
13	100%	100%	100%	100%	100%	100%	100%	100%
14	100%	100%	100%	100%	100%	100%	100%	100%
15	100%	100%	100%	100%	100%	100%	100%	100%
16	100%	100%	100%	100%	100%	100%	100%	100%
17	100%	100%	100%	100%	100%	100%	100%	100%
18	100%	100%	100%	100%	100%	100%	100%	100%
19	100%	100%	100%	100%	100%	100%	100%	100%
20	100%	100%	100%	100%	100%	100%	100%	100%
21	100%	100%	100%	100%	100%	100%	100%	100%
22	100%	100%	100%	100%	100%	100%	100%	100%
23	100%	100%	100%	100%	100%	100%	100%	100%
24	100%	100%	100%	100%	100%	100%	100%	100%
25	100%	100%	100%	100%	100%	100%	100%	100%

Source: Derived from rule implementation schedule.

Exhibit D.9a Schedule for Annual Surface Water Operational Evaluation Costs

All Alternatives

	Community Water Systems				Nontransient Noncommunity Water Systems			
Year	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+	< 10,000	10,000 - 49,999	50,000 - 99,999	100,000+
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	50%	100%	-	-	50%	100%
9	50%	50%	100%	100%	50%	50%	100%	100%
10	100%	100%	100%	100%	100%	100%	100%	100%
11	100%	100%	100%	100%	100%	100%	100%	100%
12	100%	100%	100%	100%	100%	100%	100%	100%
13	100%	100%	100%	100%	100%	100%	100%	100%
14	100%	100%	100%	100%	100%	100%	100%	100%
15	100%	100%	100%	100%	100%	100%	100%	100%
16	100%	100%	100%	100%	100%	100%	100%	100%
17	100%	100%	100%	100%	100%	100%	100%	100%
18	100%	100%	100%	100%	100%	100%	100%	100%
19	100%	100%	100%	100%	100%	100%	100%	100%
20	100%	100%	100%	100%	100%	100%	100%	100%
21	100%	100%	100%	100%	100%	100%	100%	100%
22	100%	100%	100%	100%	100%	100%	100%	100%
23	100%	100%	100%	100%	100%	100%	100%	100%
24	100%	100%	100%	100%	100%	100%	100%	100%
25	100%	100%	100%	100%	100%	100%	100%	100%

Source: Derived from rule implementation schedule.

Exhibit D.9b Schedule for Annual Ground Water Operational Evaluation Costs

All Alternatives

	Community Water Systems				Nontransient Noncommunity Water Systems			
Year	**< 10,000**	**10,000 - 49,999**	**50,000 - 99,999**	**100,000+**	**< 10,000**	**10,000 - 49,999**	**50,000 - 99,999**	**100,000+**
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	50%	100%	-	-	50%	100%
9	50%	50%	100%	100%	50%	50%	100%	100%
10	100%	100%	100%	100%	100%	100%	100%	100%
11	100%	100%	100%	100%	100%	100%	100%	100%
12	100%	100%	100%	100%	100%	100%	100%	100%
13	100%	100%	100%	100%	100%	100%	100%	100%
14	100%	100%	100%	100%	100%	100%	100%	100%
15	100%	100%	100%	100%	100%	100%	100%	100%
16	100%	100%	100%	100%	100%	100%	100%	100%
17	100%	100%	100%	100%	100%	100%	100%	100%
18	100%	100%	100%	100%	100%	100%	100%	100%
19	100%	100%	100%	100%	100%	100%	100%	100%
20	100%	100%	100%	100%	100%	100%	100%	100%
21	100%	100%	100%	100%	100%	100%	100%	100%
22	100%	100%	100%	100%	100%	100%	100%	100%
23	100%	100%	100%	100%	100%	100%	100%	100%
24	100%	100%	100%	100%	100%	100%	100%	100%
25	100%	100%	100%	100%	100%	100%	100%	100%

Source: Derived from rule implementation schedule.

Exhibit D.10 Schedule for State/Primacy Agency Costs

All Alternatives

Year	Implementation Costs	IDSE Costs	Monitoring Plan Costs	Compliance Monitoring Costs	Significant Excursion Report Cost
1	50%	-	-	-	-
2	50%	2%	-	-	-
3	-	7%	2%	-	-
4	-	91%	7%	-	-
5	-	-	91%	-	-
6	-	-	-	-	-
7	-	-	-	100%	100%
8	-	-	-	100%	100%
9	-	-	-	100%	100%
10	-	-	-	100%	100%
11	-	-	-	100%	100%
12	-	-	-	100%	100%
13	-	-	-	100%	100%
14	-	-	-	100%	100%
15	-	-	-	100%	100%
16	-	-	-	100%	100%
17	-	-	-	100%	100%
18	-	-	-	100%	100%
19	-	-	-	100%	100%
20	-	-	-	100%	100%
21	-	-	-	100%	100%
22	-	-	-	100%	100%
23	-	-	-	100%	100%
24	-	-	-	100%	100%
25	-	-	-	100%	100%

Source: Derived from rule implementation schedule.
State implementation will occur in years 1 and 2 as states prepare their primacy packages.

State IDSE activities will lag 6 months behind large system IDSE progress and be concurrent with IDSE work by small systems.

Appendix E

Annual Bladder Cancer Cases Avoided as a Result of the Stage 2 DBPR

Appendix E
Annual Bladder Cancer Cases Avoided as a Result of the Stage 2 DBPR

E.1 Introduction

This appendix presents the assumptions and calculations used to estimate reductions in the number of bladder cancer cases as a result of the Stage 2 Disinfectants and Disinfection Byproducts Rule (DBPR), and supports the discussion related to average exposure reduction in Chapter 5. This Appendix is organized as follows:

- Section E.2 describes the number of baseline bladder cancers in the U.S. by age group and in total.
- Section E.3 explains the derivation of Population Attributable Risk (PAR), Relative Risk (RR) and Odds Ratios (OR); it explains the derivation of the PAR of bladder cancer associated with chlorination disinfection byproducts (DBPs); and it presents estimates of the pre-Stage 1 occurrence of bladder cancer cases attributable to DBPs using three different approaches.
- Section E.4 defines "Annual bladder cancer cases ultimately avoidable" in relation to predicted reductions in total trihalomethane (TTHM) and haloacetic acid (HAA5) concentrations from pre-Stage 1 to pre-Stage 2 and from pre-Stage 2 to post-Stage 2 conditions for all regulatory alternatives.
- Section E.5 defines "cessation lag" and discusses how it affects the prediction of avoidable cases in the population born prior to rule implementation.
- Section E.6 presents the computational procedures for predicting cases of bladder cancer avoided for each regulatory alternative, along with consideration of model uncertainties. It also presents the implementation schedule and describes how it affects the computation of costs and benefits over the 25-year horizon considered in the benefit analysis.
- Section E.7 presents the results in detail.

All data in this appendix are derived from the Stage 2 DBPR Benefits Model (USEPA 2005).

E.2 Baseline Bladder Cancer Cases in the U.S., in Total and by Age Group

The American Cancer Society (ACS) predicted in 2004 that 60,240 new cases of bladder cancer would occur in the U.S. population that year, of which approximately 75 percent were expected to occur in men and 25 percent in women (ACS 2004). To model the incidence of bladder cancer cases attributable to DBPs and cases avoidable from the Stage 2 DBPR regulations so that information on cessation lag can be incorporated, it is necessary to use bladder cancer incidence data that represent the age at which bladder cancer cases occur. (See Sections E.5 and E.6 for how cessation lag is incorporated into the benefits calculations.)

The National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER 2004) program provides data on cancer rates (new cases per 100,000 population per year) as a function of age in 5-year intervals. EPA used this information in conjunction with population-by-age data from the 2000 U.S. Census to estimate the number of new cases of bladder cancer by age in one-year steps for ages 1 through 101:

$$BI_i = POP_i \times \frac{Br_i}{100{,}000} \qquad \text{(Equation E.1)}$$

where for any age *i*, BI_i is the number of new bladder cancer cases per year by age, POP_i is the population for that age, and Br_i is the background rate per 100,000 people for that age from the SEER data.

The results of these calculations and the SEER data upon which they are based are shown in Exhibit E.1. The number of new bladder cancer cases per year starts to increase at about age 35 and peaks at 1,500 to over 2,000 cases per one-year age group from about age 66 to 85. Although the annual rate of bladder cancer does not decline much after age 85, the incidence of bladder cancer does, because of the overall decline in the number of individuals alive after that age.

Note that the total cases obtained by this procedure, 56,506, is slightly lower than the prediction for 2004 from the American Cancer Society data noted above. This likely reflects EPA's use of the census population data from 2000. Though the American Cancer Society data uses more recent population data, it was necessary to use the U.S. Census population age group breakdown to estimate the age-group incidence. Using the SEER data with the 2000 census data may be a slight underestimate, but the impact on the benefits will be small.

E.3 Derivation of PAR and Bladder Cancer Incidence Associated with DBPs

This section first explains the general concepts of PAR, RR and OR.[1] It then presents the derivation of PAR for bladder cancer associated with DBPs and estimates the pre-Stage 1 occurrence of bladder cancer attributable to DBPs.

E.3.1 Introduction to Concepts of OR, RR and PAR

The risk assessment methodology used to estimate the number of cancer cases that are attributable to DBPs in chlorinated drinking water involves the estimation of a PAR value. PAR, which is also referred to frequently and perhaps more appropriately as Population Attributable Fraction, is a measure of the fraction of a disease that occurs in the population that is attributable to some specified risk factor. It can also be interpreted as a measure of the fraction of that disease that would be eliminated from the population if that risk factor were eliminated.

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[1] Additional background information on the concepts of PAR, OR, and RR is available in Rockhill et al. (1998) and Gordis (2000)

As stated in the previous section, EPA uses an estimate of 56,506 new cases of bladder cancer occurring each year for the purposes of modeling benefits. As described in Chapter 6, available epidemiological data indicate an association between bladder cancer and exposure to chlorinated (disinfected) drinking water. PAR in this case would be the fraction of those 56,506 new cases of bladder cancer occurring annually in the entire U.S. population that could be attributed to exposure to disinfected drinking water (i.e., the risk factor).

For the purposes of illustrating the derivation of PAR values, suppose that the distribution of the bladder cancer cases in the population were known with respect to those who are exposed to disinfected water and those who are not. Exhibit E.2 provides a hypothetical example of such a distribution. Several measures in Exhibit E.2 suggest that exposure to DBPs is a risk factor for cases of bladder cancer. For example, as shown in the last column, the bladder cancer risk for exposed individuals (2.03×10^{-4}) is higher than that for unexposed individuals (1.81×10^{-4}). This is further shown by the RR measure of 1.123 for exposed to unexposed individuals. RR is an important measure in evaluating epidemiological data.

Another important measure used in evaluating epidemiological data is the OR. The odds of an event occurring are simply the ratio of the number of events to the number of non-events. So, in the example used here the odds of a case being exposed is 10.61 (51,632 / 4,868) whereas the odds of a non-case being exposed is 9.44 (254,426,956 / 26,938,450). The OR for exposed to non-exposed cases is 1.123. If exposure were not related to the event, then we would expect an OR equal to one. If exposure is positively linked to the event, then the OR will be greater than one, and an odds ratio that is statistically significantly greater than one indicates that the positive association has not occurred by chance.

It is important to note that the identical value of 1.123 for both the OR and RR in this example does not imply that they are identical measures. As will be discussed further below, RR is the desired measure for calculating PAR from sample data; however, an OR is often more readily obtained from available studies and can under appropriate conditions be used as an approximation of RR (Rockhill et al. 1998, Gordis 2000).

One other indication of a relationship between exposure and increased incidence is that the probability of having been exposed for someone who has bladder cancer (0.914) is higher than the probability of having been exposed for someone who does not (0.904).

There are alternative ways to calculate PAR using various measures of risk (Gordis 2000). The most direct method would be to calculate PAR from the difference between the risk in the entire population (R_t) and the risk in the unexposed population (R_u) divided by the total risk:

$$PAR = \frac{R_t - R_u}{R_t} = \frac{(2.01 \times 10^{-4}) - (1.81 \times 10^{-4})}{2.01 \times 10^{-4}} = 0.0995 \approx 10\% \qquad \text{(Equation E.2)}$$

That is, this example would imply that 10% (i.e., approximately 5,650 cases) of the 56,506 bladder cancer cases are due to exposure to DBPs.

Exhibit E.1 Baseline Incidence of Bladder Cancer, Pre-Stage 1 Conditions

Age (years)	Number of Individuals in Age Group	Background Incidence Rate (per 100,000)	Baseline Cases (in Age Group)	Age (years)	Number of Individuals in Age Group	Background Incidence Rate (per 100,000)	Baseline Cases (in Age Group)
	A	B	C = A * B / 100,000		A	B	C = A * B / 100,000
1	3,805,648	0.0574	2	52	3,616,997	15.3155	554
2	3,820,582	0.0574	2	53	3,707,436	15.3155	568
3	3,790,446	0.0574	2	54	3,635,040	15.3155	557
4	3,832,799	0.0574	2	55	2,817,560	15.3155	432
5	3,926,323	0.0574	2	56	2,850,600	28.8233	822
6	3,965,103	0.0274	1	57	2,837,452	28.8233	818
7	4,019,705	0.0274	1	58	2,864,020	28.8233	826
8	4,118,147	0.0274	1	59	2,540,152	28.8233	732
9	4,179,230	0.0274	1	60	2,377,013	28.8233	685
10	4,267,320	0.0274	1	61	2,319,944	49.3850	1,146
11	4,274,056	0.0215	1	62	2,221,227	49.3850	1,097
12	4,115,093	0.0215	1	63	2,171,072	49.3850	1,072
13	4,075,842	0.0215	1	64	2,053,151	49.3850	1,014
14	4,010,850	0.0215	1	65	2,040,053	49.3850	1,007
15	4,052,231	0.0215	1	66	2,029,911	77.0165	1,563
16	4,019,404	0.0892	4	67	1,860,320	77.0165	1,433
17	3,975,021	0.0892	4	68	1,896,451	77.0165	1,461
18	4,046,012	0.0892	4	69	1,864,515	77.0165	1,436
19	4,051,598	0.0892	4	70	1,882,348	77.0165	1,450
20	4,127,855	0.0892	4	71	1,875,175	111.1442	2,084
21	4,049,448	0.2299	9	72	1,788,269	111.1442	1,988
22	3,841,082	0.2299	9	73	1,791,696	111.1442	1,991
23	3,758,648	0.2299	9	74	1,725,168	111.1442	1,917
24	3,673,582	0.2299	8	75	1,677,133	111.1442	1,864
25	3,641,241	0.2299	8	76	1,651,641	137.7068	2,274
26	3,744,539	0.4917	18	77	1,556,567	137.7068	2,143
27	3,619,660	0.4917	18	78	1,460,781	137.7068	2,012
28	3,789,800	0.4917	19	79	1,431,916	137.7068	1,972
29	3,984,812	0.4917	20	80	1,314,908	137.7068	1,811
30	4,242,525	0.4917	21	81	1,207,365	157.3246	1,899
31	4,289,970	0.7423	32	82	1,072,048	157.3246	1,687
32	4,011,575	0.7423	30	83	981,562	157.3246	1,544
33	3,994,121	0.7423	30	84	883,063	157.3246	1,389
34	4,026,573	0.7423	30	85	801,329	157.3246	1,261
35	4,188,149	0.7423	31	86	730,194	147.3673	1,076
36	4,516,118	1.8064	82	87	635,154	147.3673	936
37	4,511,168	1.8064	81	88	557,330	147.3673	821
38	4,517,060	1.8064	82	89	465,481	147.3673	686
39	4,553,814	1.8064	82	90	401,659	147.3673	592
40	4,608,504	1.8064	83	91	327,904	147.3673	483
41	4,711,434	3.8318	181	92	266,386	147.3673	393
42	4,466,676	3.8318	171	93	218,217	147.3673	322
43	4,547,220	3.8318	174	94	169,066	147.3673	249
44	4,407,870	3.8318	169	95	130,958	147.3673	193
45	4,308,663	3.8318	165	96	98,095	147.3673	145
46	4,341,460	7.7976	339	97	72,680	147.3673	107
47	4,087,563	7.7976	319	98	52,844	147.3673	78
48	4,019,692	7.7976	313	99	36,003	147.3673	53
49	3,885,145	7.7976	303	100	27,162	147.3673	40
50	3,758,544	7.7976	293	101	50,454	147.3673	74
51	3,808,515	15.3155	583	Total	281,421,906		56,506

Sources: (A) 2000 U.S. Census data
(B) National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER, 2004)

Exhibit E.2 Hypothetical Data for Example Derivation of PAR

	Cases	**Non-Cases**	**Totals**	**Risk**
Exposed to DBPs	51,632 (C_e)	254,426,956 (N_e)	254,478,588 (T_e)	$2.03x\ 10^{-4}$ ($R_e = C_e / T_e$)
Not exposed to DBPs	4,868 (C_u)	26,938,450 (N_u)	26,943,318 (T_u)	1.81×10^{-4} ($R_u = C_u / T_u$)
Totals	56,500 (C_t)	281,365,406 (N_t)	281,421,906 (T_t)	2.01×10^{-4} ($R_t = C_t / T_t$)
			Probability of Exposure 0.904 ($P_{e/t} = T_e / T_t$)	**Relative Risk (RR)** 1.123 ($RR = R_e / R_u$)
	Probability of DBP Exposure for Cases 0.914 ($P_{e/c} = C_e / C_t$)	**Probability of DBP Exposure for Non-Cases** 0.904 ($P_{e/n} = N_e / N_t$)		
	Odds of Cases Being Exposed 10.61 ($O_C = C_e / C_u$)	**Odds of Non-Cases Being Exposed** 9.44 ($O_N = N_e / N_u$)		
	Odds Ratio (OR) 1.123 ($OR = O_C / O_N$)			

One can also calculate PAR from the information provided by the *RR* and the probability of exposure in the overall population:

$$PAR = \frac{P_{e/t}(RR - 1)}{[P_{e/t}(RR - 1)]+1} = \frac{0.904 \times (1.123 - 1)}{[0.904 \times (1.123 - 1)]+1} = \frac{0.1112}{1.1112} = 0.1001 \approx 10\% \qquad \text{(Equation E.3)}$$

Equation E.3 is essentially a transformation of Equation E.2.

A third method for calculating PAR from these data is:

$$PAR = P_{e/c}\,[(RR - 1)/RR] = 0.914\,[(1.123 - 1)/1.123] = 0.914 \times 0.1095 = 0.1001 = 10\%$$

(Equation E.4)

In this third formulation for calculating PAR, the value obtained from the quantity [(*RR*-1) / *RR*] is a direct measure of the attributable fraction within the exposed group. That is, in this example, 10.95% of the cases within the exposed group are attributable to that exposure, or 0.1095 × C_e. The corresponding fraction of total cases due to exposure is, then, [(0.1095 × C_e) / C_t], or [0.1095 × (C_e / C_t)] which is 0.914 × 0.1095 = 10%.

A more detailed discussion of these alternative methods of calculating PAR is provided in Rockhill et al. (1998), who also provide some additional information regarding limitations on the use of these approaches. The major limitation the authors note is that Equations E.2 and E.3 are only valid as shown here when confounding is controlled for in the study, whereas Equation E.4 can be used to provide internally valid estimates when confounding exists (examples of possible confounding factors include age, sex, smoking history, occupation, socioeconomic status). "Confounding" refers to a factor that is associated with the exposure and independently affects the risk of developing the disease. More detail on basic epidemiological terms can be found in epidemiological texts, including Gordis (2000).

Of course, having information such as that presented in the hypothetical data above for the entire population is extremely rare, and PAR values are typically estimated from representative sample data provided in epidemiological studies. There are two primary types of epidemiological studies that can provide data for estimating PAR: cohort (prospective) studies and case-control (retrospective) studies.

Prospective cohort studies can most directly provide the data needed for PAR calculations. In these studies, sample populations are selected at random to be representative of exposure to the risk factor of interest without any prior consideration of the presence or absence of the disease in the sample. A major problem with prospective studies is that when the disease of interest is relatively rare, a very large sample group is required in order to obtain a sufficient number of cases of the disease for subsequent analysis.

For example, if one were to attempt a prospective study for a disease having a risk factor similar to those assumed for bladder cancer in this example (approximately 2×10^{-4}), it would be necessary to have a sample population of at least 1,000,000 people (and likely more than that) to ensure observation of enough cases to be able to estimate RRs and PAR values to a reasonable degree of precision. Exhibit E.3 provides a display of such a prospective study. In this example, the researchers would target a sample of

1,000,000 individuals whose exposure would be representative of the more than 281 million in the overall population who they are meant to represent.

Exhibit E.3 Hypothetical Data for a Prospective Study

	Cases	Non-Cases	Totals	Risk
Exposed to DBPs	184	905,876	906,060	2.03×10^{-4}
Not exposed to DBPs	17	93,923	93,940	1.81×10^{-4}
Totals	201	999,799	1,000,000	2.01×10^{-4}

Assuming also that the observed incidence of cases for the exposed and unexposed groups represent the actual risks in those underlying populations (as shown in Exhibit E.3), then one would expect a total of only 201 cases in the entire 1,000,000 sample group – 184 in the exposed subset and a mere 17 in the unexposed subset.

If one were actually able to carry out such a study, then PAR could be calculated using these data and the methods described previously. However, it should be obvious from the sample size requirements alone that prospective studies for diseases with such a low frequency of occurrence are highly impractical, and indeed they are rarely conducted.

The alternative study approach—and that which has been used in the epidemiological studies used in this Economic Analysis (EA)—is to use retrospective case-control studies. These have the advantage of a more practical sample size. Their potential disadvantage, however, is that one cannot calculate RR values for PAR calculations directly. However, it is possible to calculate an OR from a case-control study which, under appropriate conditions, can be used as an estimate of RR for PAR calculations.

In a typical case-control epidemiological study, a researcher would identify a group of cases, ideally selected in a manner that is unbiased with respect to the underlying exposure factor of interest. Similarly, a set of controls (non-cases) would be selected in a manner that is also unbiased with respect to the underlying exposure factor of interest. Exhibit E.4 presents a set of hypothetical data for such a case-control study. For this example, it is assumed that the study identifies 201 cases and that these are found (ideally) to be distributed as expected (based on our overall hypothetical data set) with respect to exposure. The researcher also selects a set of controls not having the disease (1,000 assumed here), also distributed ideally in a manner that is representative of exposure for non-cases.

Exhibit E.4 Hypothetical Data for a Case-Control Study

	Cases	**Non-Cases (Controls)**	**Totals**	**Risk**
Exposed to DBPs	184	904	1,088	Risk within exposure subgroups and for the entire sample group cannot be calculated.
Not exposed to DBPs	17	96	113	
Totals	201	1,000	1,201	
	Probability of DBP Exposure for Cases (P_d) 0.915 (184 / 201)	**Probability of DBP Exposure for Non-Cases** 0.904 (904 / 1,000)		
	Odds of Cases Being Exposed 10.82 (184 / 17)	**Odds of Non-Cases Being Exposed** 9.42 (904 / 96)		
	OR 1.149 (10.82 / 9.42)			

In a case-control study such as this, “Risk” (and therefore Relative Risk) would be meaningless and entirely an artifact of the number of cases and controls selected. Therefore, it is not possible to use Equation E.1 to calculate PAR values from a case-control study. However, it is possible to calculate the OR (that is, the ratio of the odds of a case being exposed to the odds of a non-case being exposed as shown in these examples) from a case-control study. The OR can be used as an estimate for RR, allowing PAR to be calculated from the alternative formulations, when the case-control study is designed and executed in a manner that meets three main conditions (Rockhill et al. 1998, Gordis 2000):

- The disease being considered occurs at a low frequency in the studied population.
- The cases have been selected in a manner that is representative with regard to the history of exposure of all people with the disease in the population from which they are drawn.
- The controls have been selected in a manner that is representative with regard to the history of exposure of all people without the disease in the population from which they are drawn.

If these conditions are met, then the OR will be a reasonable estimate of the RR and can be used in place of RR in Equations 3 or 4 for calculating PAR.

It is important to note, however, that the use of Equation E.3 is limited to circumstances where there is no confounding and ORs calculated directly, as shown here, are used (Rockhill et al. 1998). Usually, this is not the case and it is necessary in a case-control study to adjust for confounding factors. This is often done by computing ORs that take into account the interactions of multiple (potential) risk factors by the use of logistic regression techniques. In such cases, Equation E.4 is the appropriate equation to use to calculate PAR. Using the case-control example here, that calculation would be:

$$PAR = P_d\,[(OR - 1) / OR] = 0.915 \times [(1.149 - 1) / 1.149] = 0.915 \times 0.1297 = 0.1187 = 11.9\%$$

In the foregoing examples of PAR calculations, the population is stratified into two exposure groups only: those with and those without. More often, multiple exposure groups are used to represent potential relationships between exposure levels and risk. For PAR calculations involving multiple exposure groups, the PAR equations shown above as Equations E.3 and E.4 can be modified as follows:

$$PAR = \frac{\sum_{i=0}^{k} (p_{e/t(i)})(RR_i - 1)}{1 + \sum_{i=0}^{k} (p_{e/t(i)})(RR_i - 1)} \qquad \text{(Equation E.5)}$$

$$PAR = \sum_{i=0}^{k} p_{e/c(i)} \left(\frac{RR_i - 1}{RR_i} \right) \qquad \text{(Equation E.6)}$$

The first of these multiple-exposure-group forms of the PAR calculations corresponds to Equation E.3 and the second to Equation E.4. They both indicate that there are “*k*” exposure categories, including an unexposed referent group for which the RR = 1 (or OR = 1 if ORs are being used in place of RR). These equations are also addressed more fully in Rockhill et al. (1998). As indicated in the next section, Equation E.6 was used to compute PAR from the epidemiological data for bladder cancer associated with exposure to chlorinated drinking water.

It is useful to note that calculation of the ORs from epidemiological data where there are multiple exposure categories and where there is a need to adjust for confounding factors (e.g., age, sex, smoking, occupation, socioeconomic status, etc.) generally is performed using logistic regression methods rather than the simple method shown above. As noted in the following section in this Appendix, logistic regression methods were used to compute the ORs in the specific studies used in this EA to estimate PARs for pre-Stage 1 bladder cancer incidence.

E.3.2 Data Sources and Methods for the Pre-Stage 1 Bladder Cancer PAR Analysis

The relationship between bladder cancer and chlorinated DBP exposure has historically been the most strongly supported association among various cancers and chlorinated drinking water. The Stage 1 DBPR RIA (USEPA 1998a) presented EPA’s review of the large body of epidemiology literature for bladder cancer and its association with DBPs in drinking water. From that review, EPA concluded that although causality has not been established, the data support a weak association that is worthy of concern. The epidemiological studies used to support the Stage 1 DBPR, the Stage 2 DBPR proposal, and the

Stage 2 DBPR final rule are identified in the next two sections. A more detailed discussion of these studies is provided in Chapter 6.

The estimates of PAR for DBPs and bladder cancer necessarily reflect Pre-Stage 1 conditions. This is because the various epidemiology studies that are the sources of data used to estimate PAR were all conducted prior to promulgation and implementation of the Stage 1 DBPR. The risk and benefits analysis supporting the Stage 2 DBPR begins with the Pre-Stage 1 estimate of the number of new bladder cancer cases each year, that is, the annual cases that can be attributed to DBPs given the national occurrence and exposure conditions prior to the Stage 1 rule. Anticipated reductions in these occurrence and exposure levels due to the Stage 1 rule are then accounted for, and following that the anticipated reductions in occurrence and exposure due to the Stage 2 rule are considered in order to estimate the rule's benefits.

E.3.2.1 Data Sources Used for the Stage 1 and Stage 2 DBP Proposed Rule

Consistent with the approach used for the Stage 1 DBPR, the Stage 2 DBPR proposal (July 2003) EPA used data provided in five epidemiological studies to calculate the Pre-Stage 1 PAR values for bladder cancer associated with exposure to chlorinated drinking water:

- Cantor et al. (1985, 1987)[2]
- McGeehin et al. (1993)
- King and Marrett (1996)
- Freedman et al. (1997)
- Cantor et al. (1998)

These five peer-reviewed studies provided a range of estimates of PAR from 2 percent to 17 percent bounded by a 95 percent confidence interval ranging as high as 33 percent and truncated at 0 percent to maintain biological plausibility (USEPA 1998g). As discussed below, EPA is also using the data from these five studies for one of the approaches for calculating the Pre-Stage 1 PAR values in support of the Stage 2 Final Rule.

E.3.2.2 Data Sources Used for the Final Rule

Just prior to the publication of the Stage 2 DBPR proposal in 2003, a meta-analysis study of bladder cancer and the consumption of chlorinated drinking water that was published by Villanueva et al. (2003). Subsequent to the publication of the Stage 2 proposal, a study group comprised of some of the same investigators published another study using a pooled analysis that focused more specifically on bladder cancer related to TTHMs in drinking water.

In support of the final Stage 2 DBPR, EPA has considered three approaches to estimating the Pre-Stage 1 PAR value. These are based on the three sets of studies noted above:

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[2] Cantor et al. 1985 and Cantor et al. 1987 use the same epidemiological data

- Using the range of Population Attributable Risk (PAR) values derived from consideration of 5 individual epidemiology studies used for the Stage 1 EA and the Stage 2 proposal EA (yields a pre-Stage 1 range of best estimates for PAR of 2% to 17%).

- Using the Odds Ratio (OR) of 1.2 from the Villanueva et al. (2003) meta-analysis that reflects both sexes, ever exposed population from the studies considered (yields a pre-Stage 1 best estimate for PAR of ~16%)

- Using the Villanueva et al. (2004) pooled data analysis to develop a dose-response relationship for OR as a function of Average TTHM. The dose-response relationship was modeled as linear with an intercept of OR = 1.0 at TTHM exposure level = 0 (yields a pre-Stage 1 best estimate for PAR of ~17%)

EPA considers all three of these approaches to estimating the PAR for DBPs to be equally valid and to provide plausible quantitative estimates of bladder cancer risk, which are similar to each other. EPA has long recognized that while the several epidemiology studies described above indicate a potential association between exposure to DBPs in drinking water and bladder cancer incidence, uncertainty remains with respect to quantifying the number of new bladder cases that occur each year that can be attributed to that exposure.

Two basic methodologies for using the epidemiology data are represented in the three approaches. The first is to consider multiple studies separately rather than combining the information into a single estimate of the attributable risk. The second is to combine the information provided by multiple epidemiology studies using either a meta-analysis or a pooled data analysis. Each methodology has advantages and disadvantages.

One advantage to keeping estimates of individual studies separate and presenting them as a full range of plausible results, is that an explicit depiction of the extent of uncertainty that exists in the quantitative risk estimate is retained. EPA chose to consider studies separately in the economic analyses for both the Stage 1 DBP rule and the proposal for the Stage 2 DBP rule. EPA relied upon a range of risk estimates derived separately from 5 key studies, all of which were peer-reviewed, that were published in the 1980's and 1990's (USEPA 1998g). The individual estimates of the fraction of bladder cancer cases attributable to DBP exposure (or more specifically to chlorinated water exposure) obtained from each of these five studies covered a wide range: 2% to 17%. Further, as EPA noted, consideration of uncertainty for each of the individual estimates leads a wider range of values and, on the low end, includes the possibility of 0%.

One criterion to consider when deciding whether or not to combine multiple studies is the heterogeneity of the data. In developing the Stage 1 rule, EPA evaluated two meta-analyses available at that time (Poole et al., 1997 and Morris et al., 1992) and concluded that the existing studies were too heterogeneous to be combined in any way.

Meta-analyses and pooled data analyses are two approaches that are used to combine the information provided by multiple epidemiology studies. In a meta-analysis, the measures of an effect size obtained in the individual studies (such as the Odds Ratio) are weighted, typically by the inverse of the variance of the effect size, and the weighted values combined to obtain the overall estimate of that effect. In a pooled data analysis, the underlying data of the multiple studies are combined together, typically without weighting, and an estimate of the effect is made from the combined data as though it were obtained from a single study.

Meta-analysis is more commonly used for combining multiple epidemiology studies than is pooled data analysis. If heterogeneity is not properly controlled for across the studies used, pooled data analysis can be subject to outcomes that are greater, less, and often opposite that of the outcomes observed in the individual studies (Bravata and Olkin, 2001). Although the results of meta-analysis can also be affected by heterogeneity across the studies used, it is not as subject to these same effects. Meta-analysis can also combine data by weighting certain studies more than others, while pooled data analysis cannot do this. However, whereas meta-analysis is limited to consideration of the specific effect measures studied by the author's of the underlying studies, pooled data analysis can provide an opportunity to evaluate an effect that was not specifically considered in some or all of the underlying studies.

EPA determined that the meta-analysis published by Villanueva et al. (2003) and the pooled data analysis published by Villanueva et al. (2004), both of which combine the results of multiple select studies, offer reasonable approaches to arriving at a single, overall estimate of attributable risk while still retaining an appropriate characterization of the uncertainty in that risk estimate.

The Villanueva et al. (2003) meta-analysis, which considered four of the same five studies as EPA has used historically for its PAR analyses in addition to two other lower weighted studies, obtained results that are consistent with the five study estimates. The meta-analysis found a relationship between duration of exposure to DBPs (or chlorinated water) and risk of bladder cancer, which EPA used to inform the relationship between exposure and risk. With this approach to estimating risk, EPA assumes that the exposure of the study populations is characteristic of the National pre-Stage 1 exposure without knowing the exposure levels explicitly.

The Villanueva et al. (2004) pooled data analysis produced results that are consistent with the other approaches. The Villanueva et al. (2004) paper provided a dose response relationship between OR and TTHM concentrations that allowed EPA to estimate PAR values based specifically on the estimated average concentrations of TTHMs before and after implementation of the Stage 2 rule, a unique feature not possible with the other two approaches. A variety of methods, including modeling, were used to estimate TTHM concentrations. In using the Villanueva et al. (2004) analysis to estimate risk, EPA assumes that these estimated exposures represent the exposure of the study populations and that the study population exposures are characteristic of the National pre-Stage 1 exposure. In addition, the Villanueva et al. (2004) paper used different studies, one of which is unpublished, than the other approaches. In using the analysis, EPA assumes that the relationship found between exposure and risk is valid for the US population although the study populations in the pooled analysis are from Italy, Canada, France, and Finland as well as the US.

Additional discussion of the studies included in each of these approaches is provided in Chapter 6. The remainder of this section focuses primarily on the derivation of Pre-Stage 1 PAR estimates from these studies.

E.3.3 Derivation of Pre-Stage 1 PAR values for the Final Rule

Approach 1: Pre-Stage 1 PAR Range Based on Five Studies

Exhibit E.5 summarizes the key data from the five studies (note that Cantor et al. 1985 and Cantor et al. 1987 use the same epidemiological data) used to calculate PAR values for pre-Stage 1 bladder cancer incidence. These studies are discussed more fully in Chapter 6 of the EA. The ORs and their 95% confidence intervals for each exposure group were calculated by the researchers performing these studies.

EPA calculated PAR values from the data shown in Exhibit E.5 using the multiple-exposure-group form of Equation E.3 as described in Section E.2.1. These calculations and the resulting PAR values are shown in Exhibit E.6. The PAR estimates shown in Exhibit E.6 reflect the point estimates of the ORs for each exposure group in each study. As shown in Exhibit E.5, the researchers for those studies also presented 95% confidence intervals for those ORs, reflecting uncertainty in the values.

EPA has calculated corresponding 95% confidence intervals on the PAR point estimates shown in Exhibit E.6 using a Monte Carlo simulation analysis. The confidence intervals on the ORs reported by the researchers were used to parameterize each OR as a normal distribution. For each study, 10,000 iterations were run, and the OR for each exposure group was selected from its respective uncertainty distribution assuming independence among the groups (and among the studies). PAR values were calculated (using the computation as shown in Exhibit E.4) for each of the 10,000 iterations and collected.

Using the 10,000 PAR estimates for each study, lower and upper confidence bounds were derived. The upper 95% confidence limit is taken from the 97.5 percentile values. The lower limit is taken from the 2.5 percentile values of the 10,000 values, unless those values are below zero, in which case the lower confidence interval is assumed to be 0% because it is biologically implausible that the true PAR value should be less than 0%. The confidence intervals obtained from the Monte Carlo simulation are summarized in Exhibit E.7.

Exhibit E.5 Summary of Data from the Five Epidemiological Studies Relevant to PAR Calculations

Study	Location	Sex	Years of Exposure	# of Cases	# of Controls	OR[1] (95% C.I.)	$P_{c/e(i)}$[2]
Cantor et al. 1985, 1987	10 Geographic areas	Both	0	231	570	1.0	0.186
			1-19	141	285	1.1 (0.8-1.4)	0.113
			20-39	324	650	1.0 (0.8-1.3)	0.260
			40-59	437	849	1.0 (0.8-1.3)	0.351
			>59	111	196	1.1 (0.8-1.5)	0.089
				Total: 1,244	*Total: 2,550*		
			0	153	345	1.0	0.174
			1-19	107	173	1.2 (0.9-1.7)	0.122
			20-39	236	379	1.1 (0.8-1.6)	0.268
			40-59	310	430	1.3 (0.9-1.9)	0.352
			>59	74	91	1.4 (0.9-2.3)	0.084
				Total: 880	*Total: 1,418*		
Cantor et al. 1998	Iowa	Both	0	689	1275	1.0	0.614
			0-19	257	428	1.0 (0.8-1.2)	0.229
			20-39	87	139	1.1 (0.8-1.4)	0.077
			40-59	61	101	1.2 (0.8-1.7)	0.054
			>59	29	40	1.5 (0.9-2.6)	0.026
				Total: 1,123	*Total: 1,983*		
Freedman et al. 1997	Washington County, Maryland	Both	0	79	722	1.0	0.270
			1-10	91	701	1.0 (0.6-1.5)	0.311
			11-20	56	432	1.0 (0.6-1.6)	0.191
			21-30	38	266	1.1 (0.6-1.8)	0.130
			31-40	16	107	1.1 (0.6-2.2)	0.055
			>40	13	78	1.4 (0.7-2.9)	0.044
				Total: 293	*Total: 2,306*		
King and Marret 1996	Ontario, Canada	Both	0-9	157	413	1.0	0.226
			10-19	55	154	1.0 (0.7-1.5)	0.079
			20-34	169	433	1.2 (0.9-1.5)	0.243
			>35	315	545	1.4 (1.1-1.8)	0.453
				Total: 696	*Total: 1,545*		
McGeehin et al. 1993	Colorado	Both	0	104	102	1.0	0.318
			1-10	37	46[3]	0.7 (0.4-1.2)	0.113
			11-20	38	29[3]	1.1 (0.6-2.0)	0.116
			21-30	32	25[3]	1.3 (0.7-2.5)	0.098
			>30	116	50[3]	2.1 (1.4-3.2)	0.355
				Total: 327	*Total: 252*		

Notes: [1] ORs and 95 percent confidence intervals as reported in the studies.

[2] Probability of a case being in the indicated years of each ith exposure group.

[3] Actual number of controls for McGeehin *et al.* were not available, proportions were used.

Source: Quantification of Bladder Cancer Risk from Exposure to Chlorinated Surface Water (USEPA 1998h).

Exhibit E.6 Summary of PAR Calculations from OR Data for Five Epidemiological Studies

Study	Years of Exposure	OR	$P_{e/c(i)}$	$P_{e/c(i)}$x[(OR-1)/OR]	PAR
Cantor et al., 1985, 1987	0	1.0	0.186	0.000	2%
	< 19	1.1	0.113	0.010	
	20-39	1.0	0.260	0.000	
	40-59	1.0	0.351	0.000	
	>59	1.1	0.089	0.008	
				Sum = 0.018	
	0	1.0	0.174	0.000	15%
	< 19	1.2	0.122	0.020	
	20-39	1.1	0.268	0.024	
	40-59	1.3	0.352	0.081	
	>59	1.4	0.084	0.024	
				Sum = 0.149	
Cantor et al., 1998	0	1.0	0.614	0.000	3%
	< 19	1.0	0.229	0.000	
	20-39	1.1	0.077	0.007	
	40-59	1.2	0.054	0.009	
	>59	1.5	0.026	0.009	
				Sum = 0.025	
Freedman et al., 1997	0	1.0	0.270	0.000	3%
	1-10	1.0	0.311	0.000	
	11-20	1.0	0.191	0.000	
	21-30	1.1	0.130	0.012	
	31-40	1.1	0.055	0.005	
	>40	1.4	0.044	0.013	
				Sum = 0.029	
King and Marret, 1996	0-9	1.0	0.226	0.000	17%
	10-19	1.0	0.079	0.000	
	20-34	1.2	0.243	0.040	
	>35	1.4	0.453	0.129	
				Sum = 0.169	
McGeehin et al., 1993	0	1.0	0.318	0.000	17%
	1-10	0.7	0.113	-0.048	
	11-20	1.1	0.116	0.011	
	21-30	1.3	0.098	0.023	
	>30	2.1	0.355	0.186	
				Sum = 0.170	

Exhibit E.7 Summary of PAR Values with Confidence Intervals Obtained from Monte Carlo Simulation

Study	PAR Values Obtained from Simulation			Point Estimates from Studies
	Lower 95% CI	Mean	Upper 95% CI	
Cantor et al., 1985	0%	3%	15%	2%
Cantor et al., 1987	0%	17%	31%	15%
Cantor et al., 1998	0%	2%	8%	3%
Freedman et al., 1997	0%	3%	22%	3%
King and Marret, 1996	1%	17%	28%	17%
McGeehin et al., 1993	0%	17%	33%	17%

In addition to the uncertainty in the PAR values calculated for each of the individual studies as reflected by the confidence intervals, it is important to consider the uncertainty associated with the use of those studies—each of which was based upon a specific subset of the entire US population—to represent the PAR value for the US population as a whole.

One important consideration in this regard is the extent to which exposure in the study population groups is comparable to exposure in the overall US population. Exhibit E.8 provides an overall summary of the percent of cases and controls in each study who were in the DBP exposure groups (across all exposure durations). As shown in this exhibit, the exposure groups typically range from 65 – 80% of the study populations, with one instance (Cantor 1998) where only about 35 – 40% of the study population were exposed to DBPs. It is currently estimated that approximately 90% of the US population consumes water from public water supplies that are disinfecting, and the vast majority of these systems use chlorination (USEPA 2005k). As a result, it can be argued that the PAR values obtained from these five epidemiological studies under-represent exposure in the United States, and that the actual PAR values are higher than suggested by the values calculated and used in this EA.

Lastly, it is important to recognize that, notwithstanding the associations indicated by these studies, causality has not yet been established between bladder cancer and exposure to chlorinated water. Therefore, it is possible that the attributable risk from chlorinated water is zero, but not probable.

Exhibit E.8 Summary of Study Group DBP Exposure for Five Epidemiological Studies

Study	Total Cases	Cases in Exposed Group	% of Cases in Exposed Group	Odds of Case Being in Exposed Group	% of Controls in Exposed Group
	(a)	(b)	(b/a) %	(b) / (a-b)	
Cantor et al., 1985	1,244	1,013	81.4%	4.4	80%
Cantor et al., 1987	880	727	82.6%	4.8	76%
Cantor et al., 1998	1,123	434	38.6%	0.6	35%
Freedman et al., 1997	293	214	73.0%	2.7	70%
King and Marret, 1996	696	539	77.4%	3.4	75%
McGeehin et al., 1993	327	223	68.2%	2.1	65%

Approach 2: Pre-Stage 1 PAR Based on Villanueva et al. (2003) Meta-Analysis

As discussed in Chapter 6, the Villanueva et al. (2003) meta-analysis generated several estimates of the OR for bladder cancer as a function of sex (men, women, both) and exposure duration (mid-term, long-term, ever-exposed). Exhibit E.9 summarizes the OR values for these various combinations of exposure and population groups.

Of the various OR values shown in Exhibit E.9 from the Villanueva et al. (2003) meta-analysis, EPA determined that the estimates for the Ever Exposed, Both Sexes was the most appropriate to use for estimating an overall PAR for the Stage 2 benefits analysis since it includes both men and women, and it covers of the full range of exposure conditions experienced in the population being addressed by this analysis.

Using Equation E.3 for the PAR calculation, with the other assumptions noted below, EPA derived a PAR estimate from these data of 15.7%:

$$PAR = \frac{Pe \times (RR - 1)}{1 + (Pe \times (RR - 1))} = \frac{0.935 \times (1.2 - 1)}{1 + (0.935 \times (1.2 - 1))} = 0.157 \qquad \text{(Equation E.7)}$$

EPA has used the OR from Villanueva et al. (2003) as the estimate for RR in the PAR calculations (see earlier discussion) and including an estimate of 0.935 for P_e, the portion of the population exposed to chlorinated water obtained from the estimated 263 million people exposed to chlorinated water (see Chapter 3 for baseline estimates) and a total US population of 281 million (U.S. Census Bureau 2001).

Using the lower and upper 95% confidence interval estimates on the OR of 1.1 and 1.4, respectively, yields corresponding lower and upper bound PAR values of 8.5% and 27.2%.

Exhibit E.9 Combined OR Estimates from Villanueva et al. 2003

Exposure Category	Combined OR (95% CI)
Mid Term (1-40 years)	
Both Sexes	1.1 (1.0 - 1.2)
Men	1.3 (1.0 - 1.7)
Women	1.0 (0.7 - 1.6)
Long Term (> 40 years)	
Both Sexes	1.4 (1.2 - 1.7) *
Men	1.6 (1.2 - 2.2) *
Women	1.4 (0.6 - 3.6)
Ever-Exposed	
Both Sexes	**1.2 (1.1 - 1.4) ***
Men	1.4 (1.1 - 1.9) *
Women	1.2 (0.7 - 1.8)

Note: The Mid Term and Long Term OR estimates are based on the five case control studies; the Ever Exposed OR estimates are based on those five studies plus the Wilkins and Comstock cohort study.
* Statistically significant

Approach 3: Pre-Stage 1 PAR Based on Villanueva et al. (2004) Pooled Analysis

As discussed in Chapter 6, the Villanueva et al. (2004) study involved a pooled analysis using some of the same studies included in their 2003 meta-analysis and included among the “Five Studies” used for the Stage 1 rule and Stage 2 proposal. One notable aspect of the Villanueva et al. (2004) study is its focus on the relationship between OR and TTHM exposure measures specifically. Villanueva et al. (2004) included results showing a dose-response relationship of increasing OR as a function of average TTHM exposure and as a function of cumulative TTHM exposure.

For this approach to estimating the Pre-Stage 1 PAR value, EPA drew upon the information relating OR to average TTHM exposure concentrations to develop a dose-response relationship. Exhibit E.10 provides a summary of the information on this relationship that is presented in the Villanueva et al. (2004) study.

Exhibit E.10 Summary of Estimated OR Values Associated with Average TTHM Exposures for Both Sexes from Villanueva et al. (2004)

Average TTHM (ug/L)	OR	95% CI
0	1.00	NA
> 0	1.18	1.00 - 1.39
0 - 1	1.00	NA
> 1	1.18	1.06 - 1.32
0 - 1	1.00	NA
> 1 - 5	1.08	0.93 - 1.26
> 5 - 25	1.15	0.98 - 1.35
> 25 - 50	1.22	1.04 - 1.42
> 50	1.31	1.12 - 1.54

The authors of the Villanueva et al. (2004) also provided EPA with a more detailed data showing the relationship between OR and average TTHM level (Kogevinas and Villanueva, 2005). These are presented in Exhibit E.11.

Exhibit E.11 Detailed Data on OR as a Function of Average TTHM Exposure Level by Kogevinas and Villanueva (2005)

Average TTHM (ug/L)	Odds Ratio	Lower 95% CI	Upper 95% CI
0	1.00	--	--
10	1.13	0.96	1.33
20	1.16	0.98	1.38
30	1.17	1.00	1.37
40	1.19	1.02	1.39
50	1.22	1.04	1.43
60	1.26	1.08	1.47
70	1.32	1.12	1.55
80	1.38	1.14	1.68
90	1.46	1.13	1.89
100	1.55	1.11	2.17
110	1.66	1.07	2.55
120	1.77	1.03	3.06
130	1.90	0.98	3.66

EPA used the detailed data in Exhibit E.11 to derive a linear relationships between the average TTHM concentration and the OR. Since the OR at 0 ug/L TTHM is 1.0 by definition, the slope for the linear relationship was derived with the intercept forced to 1.0 and 0 ug/L. For the best estimates, the slope of the linear relationship was estimated to be 0.00581. Linear relationships were also derived from the data in Exhibit E.11 for the lower and upper 95% CI values. The slopes for these were estimated to be 0.00072 for the lower confidence bound and 0.01393 for the upper confidence bound. These linear relationships are shown in Exhibit E.12 along with the data used to derive them.

The Pre-Stage 1 OR values were estimated from these linear relationships using the estimated Pre-Stage 1 average TTHM concentration of 38.05 ug/L and the slopes noted above as OR = 1.0 + (slope * 38.05). The resulting OR values are shown in Exhibit E.13 below. Also shown are the corresponding Pre-Stage 1 PAR values for these OR estimates derived from the PAR calculation method show previously for Approach 2.

Exhibit E.12 OR as a Function of Average TTHM from Data Provided by Villanueva et al. (2004) Authors (Linear Regression with Intercept Forced to 1.0)

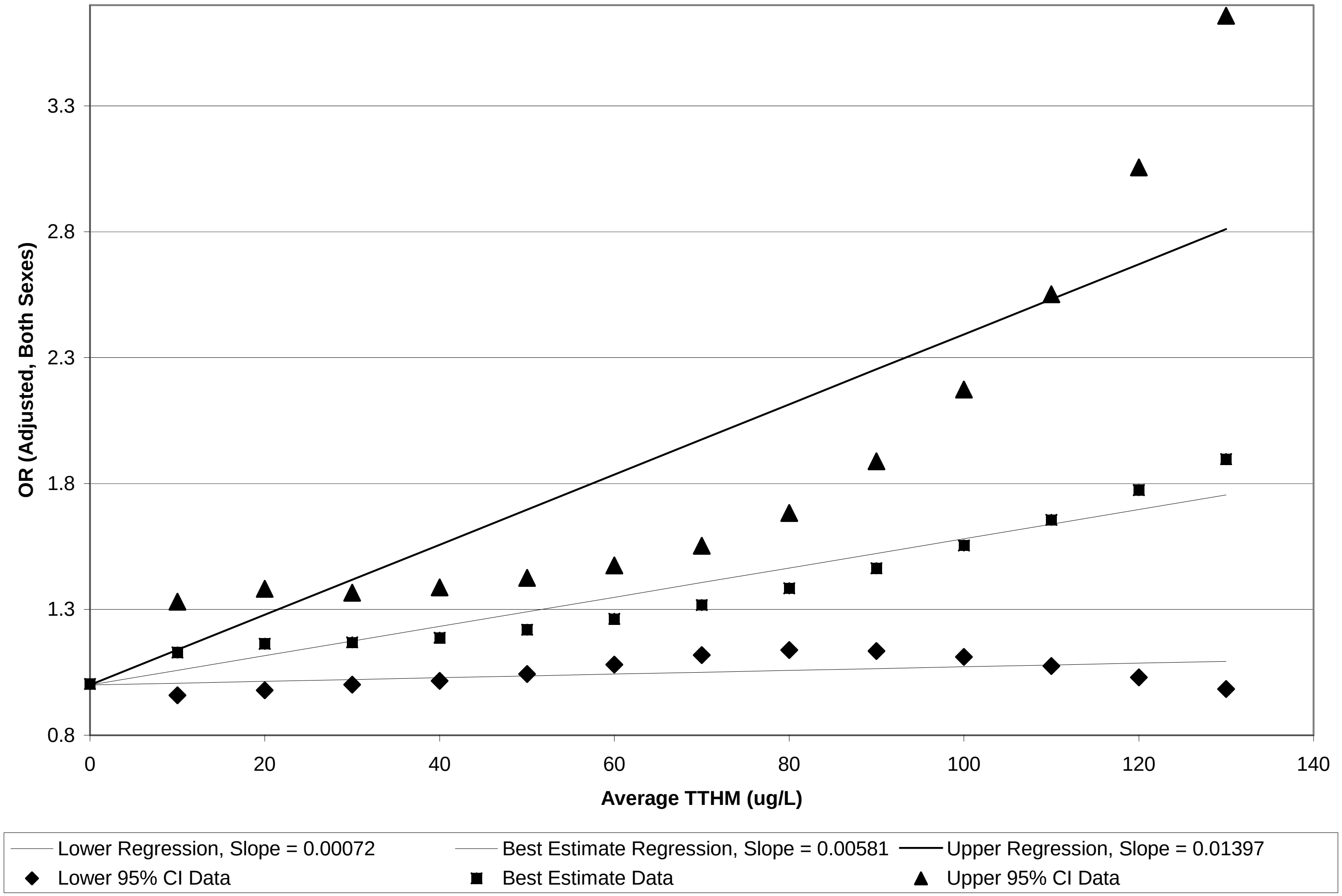


Exhibit E.13 Estimates of OR and PAR Values from Villanueva et al. (2004) Data

	Lower 95% CI	Best Estimate	Upper 95% CI
OR	1.03	1.22	1.53
PAR	0.025	0.171	0.331

E.3.4 Estimates of Pre-Stage 1 Annual Bladder Cancer Cases Attributable to DBPs

Using the Pre-Stage 1 PAR values described in the preceding section, estimates of the Pre-Stage 1 annual bladder cancer cases attributable to DBPs can be made by applying the PAR values to the estimated 56,506 new cases of bladder cancer per year from all causes. These estimates are shown in Exhibit E.14

Exhibit E.14 Estimated Pre-Stage 1 Annual Bladder Cancer Cases Attributable to DBPs Based on the Three Approaches to PAR

	Lower 95% CI	Best Estimate	Upper 95% CI
Approach 1	0	1,130 - 9,606	18,647
Approach 2	4,830	8,899	15,376
Approach 3	1,412	9,670	18,716

Note: The "Best Estimate" for Approach 1 reflects the 2% to 17% range of PAR values from the five studies used.

E.4 Derivation of Annual Bladder Cancer Cases Ultimately Avoidable

As discussed further in the Section E.5 below, there is an anticipated delay (cessation lag) between when the reductions in DBP occurrence and exposure levels begin following implementation of Stage 2 and when the full achievement of the reduction in annual bladder cases expected for that reduction in exposure occurs. The discussion in Section E.5 focuses on modeling this transition period from higher risks to lower risks following exposure reduction.

The end-point of that transition period is the realization of the full benefits of the rule in terms of annual bladder cancer cases avoided. The purpose of this section is to describe how EPA has quantified that end-point, which is referred to here as the annual bladder cancer cases ultimately avoidable for Stage 2. As discussed here, it is necessary to first determine the expected annual cases avoided from Stage 1, and then use the post-Stage 1 cases remaining that are attributable to DBPs to derive the annual bladder cancer cases ultimately avoidable for Stage 2.

Note that the example calculations shown in the text of this section for cases attributable and cases avoidable are intended to match the actual values shown in the accompanying exhibits. Due to rounding of some factors, the examples shown in the text do not always produce the exact result shown there. The result given, which corresponds with values shown in the exhibits, are the values generated in and carried thorugh the benefits model.

E.4.1 Relationship of Cases Avoided to Average DBP Reduction

The quantitative benefits calculations in this EA assume that there is a linear relationship between average DBP concentration and the cases of bladder cancer attributable to DBPs, at least within the general range of concentrations people will typically be exposed to, on average, before and after the rule. This implies that for a given percent reduction in the national average DBP concentration (for example, 10%) there will be a similar reduction in the annual cases of bladder cancer attributable to DBP exposure (that is, also 10% for this example). The amount of time it takes to achieve the full reduction in the number of attributable cases is called the cessation lag period.

EPA recognizes that this assumption of linearity is uncertain, and that there is limited data to establish and evaluate this relationship in detail. A key source of supporting data for this assumption is the Villanueva et al. (2004) pooled data analysis study which provided the basis for the linear dose-response relationship used in Approach 3 for PAR described in the proceeding section.

In the context of assuming linearity in this range, it is important to note the implications of what a non-linear relationship would be, relative to the assumption of linearity made here. A dose-response relationship for a carcinogen that is non-linear in lower dose ranges is typically sublinear. If that is the case for DBPs, then the assumption of linearity back to zero being used here would be conservative with respect to the estimation of benefits from the Stage 2 rule. That is, if the relationship is sublinear in this range, then the slope would be steeper and the estimated cases avoided for a given change in average DBP levels could be greater than that which is currently being estimated.

On the other hand, if the relationship were markedly supralinear in the range of interest, DBP reductions expected from the Stage 2 rule might result in a substantially lower reduction in attributable cases in the DBP concentration range of concern. However, supralinearity would also imply that at some lower DBP concentrations the reduction in attributable cases relative to the reduction in DBPs would become quite high as the slope for this relationship becomes very steep again.

EPA concluded that the assumption of a straight linear relationship back to zero, which falls between these two options of sublinearity and supralinearity, is a reasonable approximation given the uncertainty in knowing the actual dose-response relationship. This uncertainty is discussed further in Section 6.6.

To estimate bladder cancer cases avoided as a result of the Stage 2 DBPR, the average reduction in plant-mean TTHM and HAA5 concentrations is assumed to represent the range of reductions for all chlorination DBPs. A more detailed explanation of the derivation of the estimated reduction in concentration can be found in Chapter 5. Using these two DBP classes as indicators for all chlorination DBPs may overestimate or underestimate the true concentration reduction. However, because measurable halogen-substituted DBP concentrations, comprised primarily of TTHM and HAA5, are estimated to make up 30 to 60 percent of the measured total organic halide (TOX) concentration (Singer 1999), TTHM and HAA5 reductions are assumed to be reasonable indicators of the overall DBP reductions. Separate evaluations for TTHM and HAA5 are carried throughout the analyses.

The specific calculations to arrive at the annual bladder cancer cases ultimately avoidable from Stage 1 and Stage 2 for Approaches 1 and 2 are different from those for Approach 3. For Approaches 1 and 2, the linearity assumption used to estimate the effects of DBP reductions for Stage 1 and Stage 2 is applied to the estimated Pre-Stage 1 cases attributable to DBPs. First, the Pre-Stage 2 cases attributable are calculated as:

Pre-Stage 2 Cases Attributable = Pre-Stage 1 Cases Attributable * (1 - % DBP Reduction for Stage 1)

The % DBP Reduction for Stage 1 is calculated from the estimated Pre-Stage 1 and Post-Stage 1 national average DBP (either TTHM or HAA5) concentrations. If, for example, the Pre-Stage 1 cases attributable to DBPs is 8,899 and the %DBP reduction estimate for Stage 1 is 27.21%, the Pre-Stage 2 cases attributable are 6,477 (= 8,899* 0.7279). The Stage 1 cases avoided are then calculated as the difference between the Pre-Stage 1 and Pre-Stage 2 attributable cases.

Similarly, to estimate the annual bladder cancer cases ultimately avoidable for Stage 2, the Post-Stage 2 cases attributable are calculated as:

Stage 2 Cases Attributable = Pre-Stage 2 Attributable Cases * (1 - % DBP Reduction for Stage 2)

Using the example, if the % DBP reduction from Stage 1 to Stage 2 is 7.81%, then the Post-Stage 2 attributable cases would be 5,971 (= 6,477 * 0.9219). The Stage 2 cases avoided are then calculated as the difference between the Pre-Stage 2 and Post-Stage 2 attributable cases.

For Approach 3, the calculation of annual bladder cancer cases ultimately avoidable from Stage 1 and Stage 2 is different from that for Approaches 1 and 2. Whereas Approaches 1 and 2 can produce a PAR estimate for Pre-Stage 1 only, the dose-response function derived from the Villanueva et al. (2004) study used in Approach 3 allows for the PAR to be calculated explicitly for Pre-Stage 1, Pre-Stage 2 and Post-Stage 2 based on the corresponding estimated national average TTHM concentrations.

To calculate the PAR for these rule stages, it is first necessary to calculate the OR values for the national average TTHM concentrations estimated for each stage. Using the slope of 0.00581 (see earlier discussion of the Approach 3 dose-response function), and the indicated estimates of TTHMs, the OR values for each stage are calculated as:

$$
\begin{aligned}
OR_{\Pr eSt1} &= 1.0 + (0.00581 \times 38.05) = 1.221 \\
OR_{\Pr eSt2} &= 1.0 + (0.00581 \times 27.69) = 1.161 \\
OR_{PostSt2} &= 1.0 + (0.00581 \times 25.53) = 1.148
\end{aligned}
$$

The PAR value is then calculated from the PAR equation as discussed previously (where 0.935 is the fraction of the population exposed to disinfected drinking water):

$$PAR_{\Pr eSt1} = \frac{0.935 * \left(OR_{\Pr eSt1} - 1.0\right)}{1 + \left[0.935 * \left(OR_{\Pr eSt1} - 1.0\right)\right]} = 17.1\%$$

$$PAR_{\Pr eSt2} = \frac{0.935 * \left(OR_{\Pr eSt1} - 1.0\right)}{1 + \left[0.935 * \left(OR_{\Pr eSt1} - 1.0\right)\right]} = 13.1\%$$

$$PAR_{PostSt2} = \frac{0.935 * \left(OR_{\Pr eSt1} - 1.0\right)}{1 + \left[0.935 * \left(OR_{\Pr eSt1} - 1.0\right)\right]} = 12.2\%$$

For Pre-Stage 1, the attributable cases can be calculated by multiply the total bladder cancer cases by the Pre-Stage 1 PAR value. If, for example, using the Pre-Stage 1 total cases is 56,506, the attributable cases would be 9,670 (= 56,506 * 0.171).

The calculation of cases attributable after Stage 1 and after Stage 2 for Approach 3 requires that the total cases at each stage to which the PAR is applied appropriately reflects reductions in those total cases resulting from the DBP reductions for the stages. This is done by recognizing that:

$$PAR = \frac{\textit{Attributable Cases}}{\textit{Total Cases}} = \frac{\textit{Attributable Cases}}{\textit{(NonAttributable Cases + Attributable cases)}}$$

Rearranging this relationship yields:

$$\textit{Attributable Cases} = \frac{\textit{PAR * NonAttributable Cases}}{\textit{(1-PAR)}}$$

If 9,670 of the 56,506 Pre-Stage 1 cases are attributable to DBPs, then 46,836 (= 56,506 - 9,670) are not attributable to DBPs. Using that information and the formula above, the Pre-Stage 2 and Post-Stage 2 attributable cases would be calculated as:

$$AttribCases_{\Pr eSt2} = \frac{0.131 * 46{,}836}{\left(1 - 0.131\right)} = 7{,}063$$

$$AttribCases_{PostSt2} = \frac{0.122 * 46{,}836}{\left(1 - 0.122\right)} = 6{,}515$$

The cases avoided from Stage 1 and Stage 2 are then calculated by subtraction:

Stage 1 Cases Avoided = 9,670 - 7,063 = 2,607
Stage 2 Cases Avoided = 7,063 - 6,515 = 548

E.4.2 Results for Stage 1 and Stage 2

E.4.2.1 Estimates of Cases Attributable and Annual Bladder Cancer Cases Ultimately Avoidable Using the Three Approaches to Pre-Stage 1 PAR

This section provides detailed estimates of the Pre-Stage 1, Pre-Stage 2 and Post-Stage 2 attributable cases of bladder cancer, and the corresponding annual bladder cancer cases ultimately avoidable for the Stage 1 and Stage 2 (preferred option) rules. These estimates reflect the three approaches to estimating PAR described previously.

Exhibit E.15 presents estimates of the Pre-Stage 1 cases attributable to DBPs for the three approaches. As noted, these value are obtained by multiplying the indicated PAR values by 56,506, the estimated total annual bladder cancer cases due to all causes.

Exhibit E.15 Pre-Stage 1 Cases Attributable to DBPs from Three Approaches to PAR (Pre-Stage 1 PAR Estimates)

	Lower 95% CI for PAR	Best Estimate for PAR		Upper 95% CI for PAR
Approach 1: Five Studies	0 (0% PAR)	1,130 (2% PAR)	9,606 (17% PAR)	18,647 (33% PAR)
Approach 2: Villanueva et al. (2003)	4,830 (8.5% PAR)	8,899 (15.7% PAR)		15,376 (27.2% PAR)
Approach 3: Villanueva et al. (2004)	1,412 (2.5% PAR)	9,670 (17.1% PAR)		18,716 (33.1% PAR)

Note: Calculated from Pre-Stage 1 PAR * 56,506
Some numbers may reflect rounding

Exhibit E.16 presents the estimated Pre-Stage 2 attributable cases based on the estimated percent reduction in the national average TTHM concentration from Stage 1.

Exhibit E.16 Pre-Stage 2 Cases Attributable to DBPs from Three Approaches to PAR, Based on Stage 1 TTHM Reduction of 27.2%

	Lower 95% CI for Post-Stage 1 PAR	Best Estimate for PAR		Upper 95% CI for Post-Stage 1 PAR
Approach 1: Five Studies	0	823	6,992	13,572
Approach 2: Villanueva et al. (2003)	3,515	6,477		11,192
Approach 3: Villanueva et al. (2004)	1,028	7,063		13,623

Note: Approaches 1 and 2 are calculated from the Pre-Stage 1 values in Exhibit E.15 multiplied by 0.73 (that is, a 27.0% reduction in TTHMs implying a 27.2% reduction in attributable cases)
Approach 3 is calculated from the Post-Stage 1 PAR based on the OR for TTHM = 27.69 ug/L as described previously.
Some numbers may reflect rounding

Exhibit E.17 provides the estimated Stage 1 cases avoided for the three approaches based on the estimated Stage 1 TTHM reduction. As described previously, these are obtained by subtracting the Pre-Stage 2 attributable cases from the Pre-Stage 1 attributable cases.

Exhibit E.17 Stage 1 Cases Avoided from Three Approaches to PAR, Based on Stage 1 TTHM Reduction of 27.2%

	Lower 95% CI for Post-Stage 1 PAR	Best Estimate for Post-Stage 1 PAR		Upper 95% CI for Post-Stage 1 PAR
Approach 1: Five Studies	0	308	2,614	5,075
Approach 2: Villanueva et al. (2003)	1,314	2,422		4,185
Approach 3: Villanueva et al. (2004)	384	2,607		5,094

Notes: Some numbers may reflect rounding
These represent the difference between the Pre-Stage 1cases attributable (Exhibit E.15) and the Pre-Stage 2 cases attributable (Exhibit E.16).

Exhibit E.18 presents estimates of the Post-Stage 2 attributable cases based on the estimated percent reduction in the national average TTHM concentration from Stage 2. The % reduction values shown are the 5th percentile, mean, and 95th percentile values for TTHMs for the range reflecting uncertainty as described in Chapter 5.

Exhibit E.18 Post-Stage 2 Cases Attributable to DBPs from Three Approaches to PAR, Based on Stage 2 TTHM Reductions

	Lower 95% CI for Post-Stage 2 PAR	Best Estimate for Post-Stage 2 PAR		Upper 95% CI for Post-Stage 2 PAR
Approach 1: Five Studies				
4.5% Reduction	0	785	6,675	12,958
7.8% Reduction	0	758	6,446	12,512
11.2% Reduction	0	731	6,210	12,055
Approach 2:Villanueva et al. (2003)				
4.5% Reduction	3,356	6,184		10,685
7.8% Reduction	3,241	5,971		10,318
11.2% Reduction	3,122	5,753		9,940
Approach 3: Villanueva et al. (2004)				
4.5% Reduction	981	6,720		13,006
7.8% Reduction	948	6,515		12,559
11.2% Reduction	913	6,252		12,099

Note: Approaches 1 and 2 are calculated from the Post-Stage 1 values in Exhibit E.17 multiplied by 1 minus % Reduction indicated.
For Approach 3 is calculated from the Post-Stage 2 PAR based on the OR for TTHM = 25.53 ug/L as described previously.
Some numbers may reflect rounding

Exhibit E.19 provides the estimated Stage 2 cases avoided for the three approaches based on the estimated Stage 2 TTHM % reduction. As described previously, these are obtained by subtracting the Pre-Stage 2 attributable cases from the Pre-Stage 1 attributable cases.

Exhibit E.19 Stage 2 Cases Avoided from Three Approaches to PAR, Based on Stage 2 TTHM Reductions

	Lower 95% CI for Post-Stage 2 PAR	Best Estimate for Post-Stage 2 PAR		Upper 95% CI for Post-Stage 2 PAR
Approach 1: Five Studies				
4.5% Reduction	0	37	317	615
7.8% Reduction	0	64	546	1,060
11.2% Reduction	0	92	782	1,518
Approach 2:Villanueva et al. (2003)				
4.5% Reduction	159	293		507
7.8% Reduction	275	506		874
11.2% Reduction	393	724		1,252
Approach 3: Villanueva et al. (2004)				
4.5% Reduction	47	319		617
7.8% Reduction	80	548		1,064
11.2% Reduction	115	787		1,523

Note: Some numbers may reflect rounding

Exhibits E.20 through E.22 provide estimates of the Pre-Stage 2 cases attributable, Post-Stage 2 cases attributable and Stage 2 Cases avoided based on reductions in average HAA5 concentrations. As noted in these tables, Approach 3 is not used since it is based on a dose-response function involving TTHMs and not HAA5s.

Exhibit E.20 Pre-Stage 2 Cases Attributable to DBPs from Three Approaches to PAR, Based on Stage 1 HAA5 Reduction of 28.8%

	Lower 95% CI for Post-Stage 1 PAR	Best Estimate for Pre-Stage 1 PAR		Upper 95% CI for Post-Stage 1 PAR
Approach 1: Five Studies	0	804	6,836	13,270
Approach 2: Villanueva et al. (2003)	3,437	6,333		10,942
Approach 3: Villanueva et al. (2004)	Approach 3 not applicable to HAA5 reductions			

Notes: Approaches 1 and 2 are calculated from the Pre-Stage 1 values in Exhibit E.19 multiplied by 0.712 (a 28.8% reduction in HAA5s implying a 28.8% reduction in attributable cases).
Some numbers may reflect rounding

Exhibit E.21 Post-Stage 2 Cases Attributable to DBPs from Three Approaches to PAR, Based on Stage 2 HAA5 Reductions

	Lower 95% CI for Post-Stage 2 PAR	Best Estimate for Post-Stage 2 PAR		Upper 95% CI for Post-Stage 2 PAR
Approach 1: Five Studies				
5.2% Reduction	0	763	6,482	12,584
9.2% Reduction	0	731	6,210	12,054
13.7% Reduction	0	694	5,900	11,452
Approach 2:Villanueva et al. (2003)				
5.2% Reduction	3,259	6,005		10,376
9.2% Reduction	3,122	5,753		9,940
13.7% Reduction	2,966	5,465		9,444
Approach 3: Villanueva et al. (2004)				
Approach 3 not applicable to HAA5 reductions				

Notes: Approaches 1 & 2 are calculated from the Post-Stage 1 values in Exhibit E.20 multiplied by 1 minus % Reduction indicated.
Approach 3 is calculated from the Post-Stage 2 PAR based on the OR for the TTHM concentration resulting from the indicated Stage 2 % reduction
Some numbers may reflect rounding

Exhibit E.22 Stage 2 Cases Avoided from Three Approaches to PAR, Based on Stage 2 HAA5 Reductions

	Lower 95% CI for Post-Stage 2 PAR	Best Estimate for Post-Stage 2 PAR		Upper 95% CI for Post-Stage 2 PAR
Approach 1: Five Studies				
5.2% Reduction	0	42	354	686
9.2% Reduction	0	74	626	1,216
13.7% Reduction	0	110	936	1,817
Approach 2:Villanueva et al. (2003)				
5.2% Reduction	178	327		566
9.2% Reduction	315	580		1,003
13.7% Reduction	471	867		1,499
Approach 3: Villanueva et al. (2004)				
Approach 3 not applicable to HAA5 reductions				

Note: Some numbers may reflect rounding

E.4.2.2 Annual Bladder Cancer Cases Ultimately Avoidable Estimated in Benefits Model

As discussed in Chapter 6, for the sake of simplicity, EPA has selected Approach 2 based on Villanueva et al. (2003) to estimate Pre-Stage 1 PAR values to carry through the full benefits modeling. That is, the Monte Carlo simulation used to generate the benefits of the Stage 2 rule used only the inputs from Approach 3 to estimate Pre-Stage 1 PAR values. This simulation included uncertainty in the OR values reported by Villanueva et al. (2003) for the PAR calculations, and also included uncertainty in the predicted DBP reductions for Stage 2. The resulting estimate of Pre-Stage 1 cases attributable to DBPs are 10,159 (95% Conf Bounds = 5,575 – 14,642).

Exhibits E.23 and E.24 summarize the estimated annual bladder cancer cases ultimately avoidable for both Stage 1 and Stage 2 derived from the benefits simulation model.

Exhibit E.23 Annual Bladder Cancer Cases Ultimately Avoidable for the Stage 1 DBPR

	Post-Stage 1 (Pre-Stage 2) Cases Attributable to DBPs			Annual Cases Ultimately Avoidable by the Stage 1 DBPR		
DBP	Mean	5th	95th	Mean	5th	95th
TTHM	7,394	4,058	10,657	2,765	1,517	3,985
HAA5	7,229	3,968	10,420	2,929	1,608	4,222

Sources: Stage 2 DBPR Benefits Model. The 90 percent confidence bounds reflect uncertainty in PAR and DBP reduction.

Exhibit E.24 Annual Bladder Cancer Cases Ultimately Avoidable for the Stage 2 DBPR

DBP	Post-Stage 2 Cases Attributable to DBPs			Annual Cases Ultimately Avoidable by the Stage 2 DBPR		
	Mean	5th	95th	Mean	5th	95th
TTHM	6,813	3,796	9,765	581	232	1,084
HAA5	6,550	3,634	9,401	680	261	1,288

Sources: Stage 2 DBPR Benefits Model. The 90 percent confidence bounds reflect uncertainty in PAR and DBP reduction.

E.5 Adjustments to Account for Cessation Lag

E.5.1 Background

If the reduction in bladder cancer risk for individuals exposed to DBPs from drinking water were to begin immediately when the DBP levels in drinking water are reduced as result of these regulations, then the benefits of the regulations in terms of annual bladder cancer cases avoided would simply be the annual bladder cancer cases ultimately avoidable (as described in the preceding section) starting when those exposure reductions begin and continuing each year thereafter.

Cancer risk reductions (in terms of annual individual risk) are, generally not expected to occur instantaneously when exposure to a carcinogen is reduced or eliminated. Rather, it is expected that the risks for those individuals having had previous higher exposures will decline over time, eventually reaching or at least approaching the risk level associated with the lower exposure levels. The rate may depend upon a combination of the carcinogen, its particular end-point and mode of action, and other factors as mentioned in Chapter 6.

The term "cessation lag" is used to refer to this transition period between higher risks from higher exposures and lower risks from lower exposures. Cessation lag models, based on available empirical data of cancer risk reduction following exposure reduction to carcinogens, have been used in this benefits analysis to quantify the rate of the risk reduction following rule implementation and reduction in exposure to DBPs from drinking water.

This section of Appendix E provides some additional background on cessation lag and describes the specific data sources and model-fitting procedures used to derive the cessation lag models included in the Stage 2 benefits analysis. It also describes the calculations performed in the benefits model to compute the annual cases avoided each year following exposure reduction that draw upon the cessation lag models.

When considering cessation lag and its incorporation into the benefits modeling, it is important to separate the exposed population into two groups: (1) those who are alive at the time that the rule is implemented and who have, therefore, already been exposed for some portion of their lifetime at the higher pre-rule DBP levels, and (2) those who are born after the rule is implemented who will only ever be exposed to the lower post-rule DBP levels.

Cessation lag enters into the calculation of benefits only for the first of these two groups. Cessation lag does not enter into the calculation of benefits for the second group since there is no change from a higher to a lower exposure level for that population, and therefore there is no transition period from the higher to the lower risk level. (Note: It is to accommodate these two different populations in each year following the implementation of the rule that it is necessary to have bladder cancer cases from all causes available as a function of age as presented in Exhibit E.1.)

At some point following rule implementation, the annual cases avoided will become equal to the annual bladder cancer cases ultimately avoidable. The time that it takes for this to occur depends mainly upon the cessation lag model and how it describes the transition to the lower risks. It is also influenced by the turn-over in the population from being composed primarily of those alive prior to rule implementation to being composed primarily of those born after rule implementation. It is useful to note that the absolute upper bound on the time that it will take for the annual cases avoided to become equal to the annual cases ultimately avoidable described in the preceding section is when the population is composed solely of those who were born after the rule has gone into effect. For the purposes of the Stage 2 benefits modeling, it is assumed that this will be 100 years after the rule is implemented. At that time (and from that point forward) the annual bladder cancer cases ultimately avoidable is achieved for the exposed population.

E.5.2 Data Sources for Cessation Lag Models

As noted above, the bladder cancer risk reductions are not expected to be instantaneous; Rather, it is assumed that there is a transition period from the risk associated with the higher DBP exposure levels to the risk associated with the lower exposure levels. The challenge is to estimate the rate at which this transition occurs.

No epidemiological or other empirical data are available that specifically address the rate or pattern of achieving the bladder cancer benefits of DBP exposure reductions. In lieu of using data specific to DBPs, EPA is drawing upon empirical data from three epidemiology studies that address the rate at which cancer risk reduction occurs for individuals following exposure reduction to other carcinogens. The three studies used, and the cancer end-points and risk factors they consider, are:

1. Hrubec and McLaughlin (1997a): smoking and lung cancer
2. Hartge et al. (1987): smoking and bladder cancer
3. Chen and Gibb (2003): arsenic (in drinking water) and bladder cancer

Each study provides information on how the cancer risk for individuals having some high level of exposure to the risk factor for a substantial portion of their lifetime transitions over time to the risk for individuals at some lower level of exposure following exposure reduction. The first two data sets involve a change from smoking to not-smoking (complete cessation) while the third involves a change from a high arsenic exposure level of 50 micrograms per liter (ug/L) in drinking water to a lower exposure level of 10 ug/L.

In all cases, the risk reduction in these studies is considered over time in terms of changes in the RR of cancer where “relative” refers to the lower exposure group (for example, never-smokers for the first two studies; and those always exposed to 10 ug/L of arsenic for the third study). For these lower exposure groups, referred to as the referent group, the RR is set equal to 1.0. That is, the risk for the exposed individuals is measured relative to the risk of those who have not been exposed (or who are at a lower exposure). This referent group therefore represents the lowest possible risk that can be reached following the exposure reduction.

E.5.3 Model Specification Using Cessation Lag

The benefits model incorporates cessation lag by using the concept of % Maximum Relative Risk Reduction (%MRRR) which is expressed as:

$$\%MRRR_j = \frac{RR_0 - RR_j}{RR_0 - 1.0} \times 100 \qquad \text{(Equation E.8)}$$

That is, the %MRRR achieved in any year j following exposure cessation or reduction is computed as the Relative Risk for those at the higher exposure level (RR_0) minus the Relative Risk observed in year j for those whose exposure has been reduced (RR_j), divided by the maximum Relative Risk reduction, which is the Relative Risk for those at the higher exposure (RR_0) minus 1.0 (since 1.0 is the lowest value of Relative Risk that can be achieved under this formulation).

The empirical Relative Risk reduction data in these studies typically provides the changes in RR for several time periods (usually ranges) representing years following exposure reduction. To be incorporated in the Stage 2 benefits modeling, continuous functions were fit to the empirical data from each of the three studies and those functions were then used to calculate the %MRRR for each year after exposure reduction begins.

E.5.3.1 Model Fitting Process

Based on a set of analyses performed, two general functional forms were found to provide the most suitable fits to the data from each of these studies. These are a Weibull function and a Pareto function, as shown below:

Weibull Function:

$$LF_j = 1 - e^{-\left(\frac{j}{r}\right)^q} \qquad \text{(Equation E.9)}$$

Pareto Function:

$$LF_j = 1 - \left(1 + \frac{j}{r}\right)^q \qquad \text{(Equation E.10)}$$

As discussed later in this section, EPA initially evaluated nine different functions for the cessation lag model form from which these two were selected.

Here the term LFj refers to the “Lag Function” value for year j after rule implementation and is the modeled equivalent to the %MRRR noted above for – and derived from – the empirical data sets. All LFj values fall between 0 and 1. The parameters q and r in these functions are estimated from the curve fitting procedures using the data from the individual studies.

All model fitting procedures were carried out in SAS.

Smoking and Bladder Cancer

The smoking and bladder cancer data used to parameterize the cessation lag models for smoking and bladder cancer is derived from Table 1 of Hartge et al. (1987) and shown in Exhibit E.25. The study provides values for RR and years following cessation, and %MRRR was calculated from these data using the RR for never smokers as the referent value (RR = 1.0).

Exhibit E.25 Summary of Smoking / Bladder Cancer Data from Hartge et al. (1987) Used to Model Cessation Lag

Years After Cessation	Estimated RR (95% CI)	%MRRR (Using Estimated RR Value)
< 1 (RR_0)	2.9 (2.6 - 3.3)	0.0%
1 - 10	2.2 (1.9 - 2.6)	36.8%
10 - 20	1.6 (1.4 - 1.9)	68.4%
20 - 30	1.7 (1.4 - 2.1)	63.2%
30 - 40	1.3 (1.0 - 1.7)	84.2%
> 40	1.5 (1.1- 2.1)	73.7%
Never Smokers	1.0	NA

Exhibit E.26 is a graph of the Weibull form using parameters fit to the best estimates of the RR in the study and the mid-point of the years after cessation together with the empirical data for those inputs. The estimated parameters for the Weibull form for these inputs are q = 0.520; r = 17.539.

Exhibit E.26 Graph of the Weibull Form for Smoking / Bladder Cancer Data

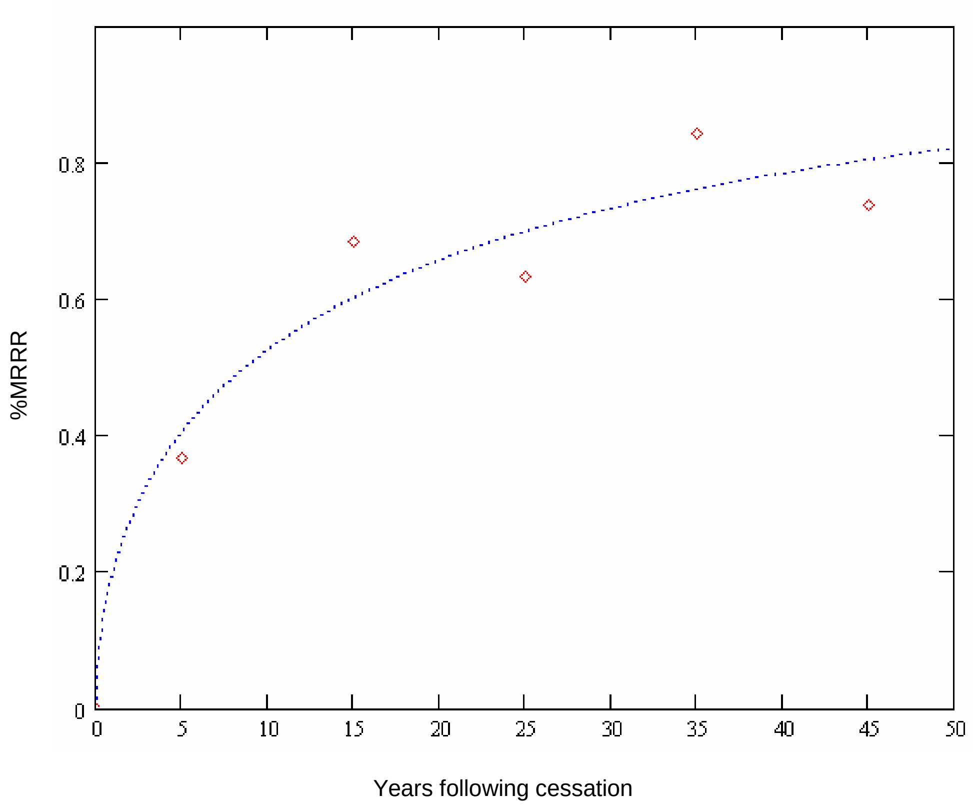
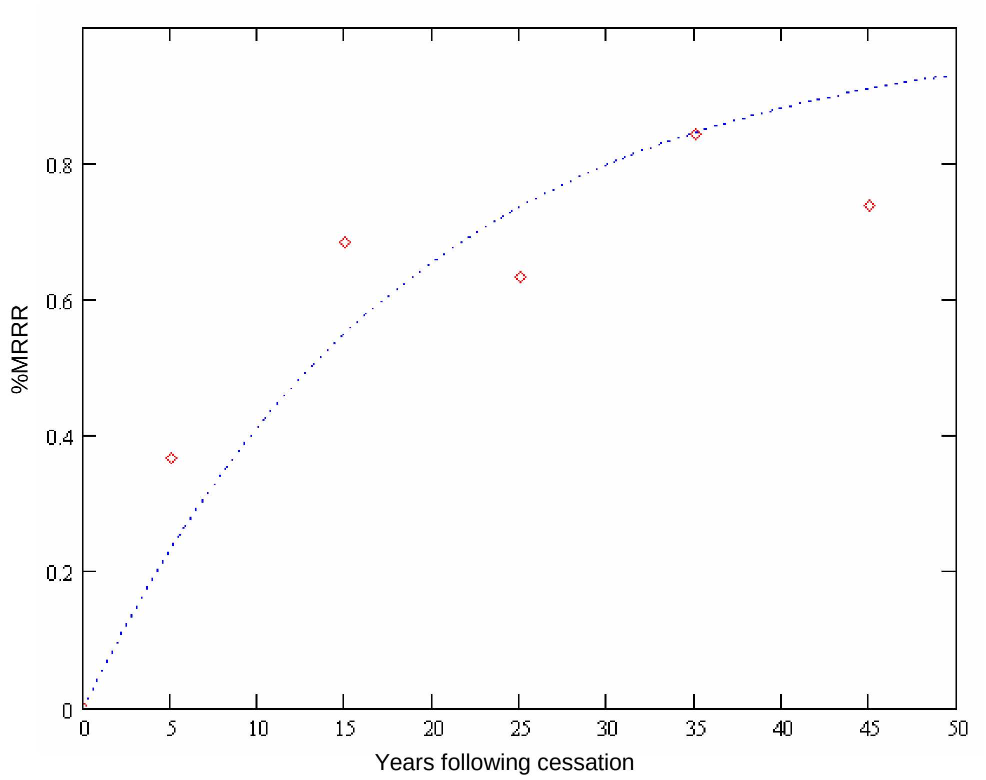


Exhibit E.27 is a graph of the Pareto form using parameters fit to the best estimates of the RR in the study and the mid-point of the years after cessation together with the empirical data for those inputs. The estimated parameters for the Pareto form for these inputs are a = - 4.110 x 10^7; b = 7.703 x 10^8.

Exhibit E.27 Graph of the Pareto Form for Smoking / Bladder Cancer Data



Smoking and Lung Cancer

The smoking and lung cancer data used to parameterize the cessation lag models for smoking and lung cancer is derived from Table 4 of Hrubec and McLaughlin (1997a) and are presented in Exhibit E.28. The study provides values for RR and years following cessation, and %MRRR was calculated from these data using the RR for never smokers as the referent value (RR = 1.0). The Hrubec and McLaughlin study did not provide an estimate of RR for current smokers for the RR_0 value. The range of values used, as shown in Exhibit E.28, were obtained from two sources: The American Cancer Society (2004) and Halpern et al. (1993).

Exhibit E.28 Summary of Smoking / Lung Cancer Data from Hrubec and McLaughlin (1997b) used to Model Cessation Lag

Years After Cessation	Estimated RR (95% CI)	%MRRR (Using Estimated RR Value)
< 1 (RR0)	22.1 (16.6 - 29.5)*	0.0%
1 - 5	16.1 (10.0 - 25.2)	28.4%
5 - 10	7.8 (5.6 - 10.6)	67.8%
10 - 20	5.1 (4.2 - 6.1)	80.6%
20 - 30	3.3 (2.8 - 4.0)	89.1%
30 - 40	2.0 (1.6 - 2.6)	95.3%
> 40	1.5 (1.1- 2.0)	97.6%
Never Smokers	1.0	NA

*RR_0 values for current smokers were not provided in Hrubec and McLaughlin (1997b). The values used here were obtained from relative risks for current smokers reported by American Cancer Society (2004) and Halpern et al. (1993)

Exhibit E.29 is a graph of the Weibull form using parameters fit to the best estimates of the RR in the study and the mid-point of the years after cessation together with the empirical data for those inputs. The estimated parameters for the Weibull form for these inputs are q = 0.821; r = 7.788.

Exhibit E.29 Graph of the Weibull Form for Smoking / Lung Cancer Data

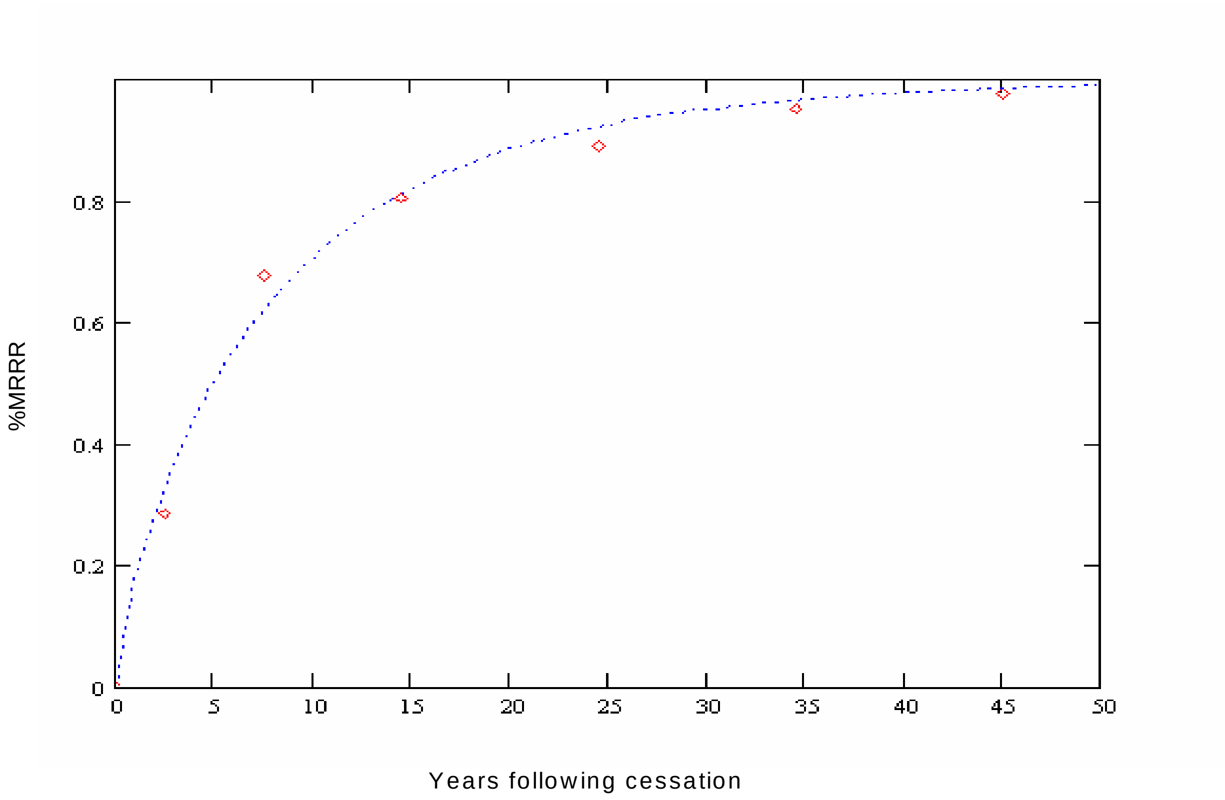
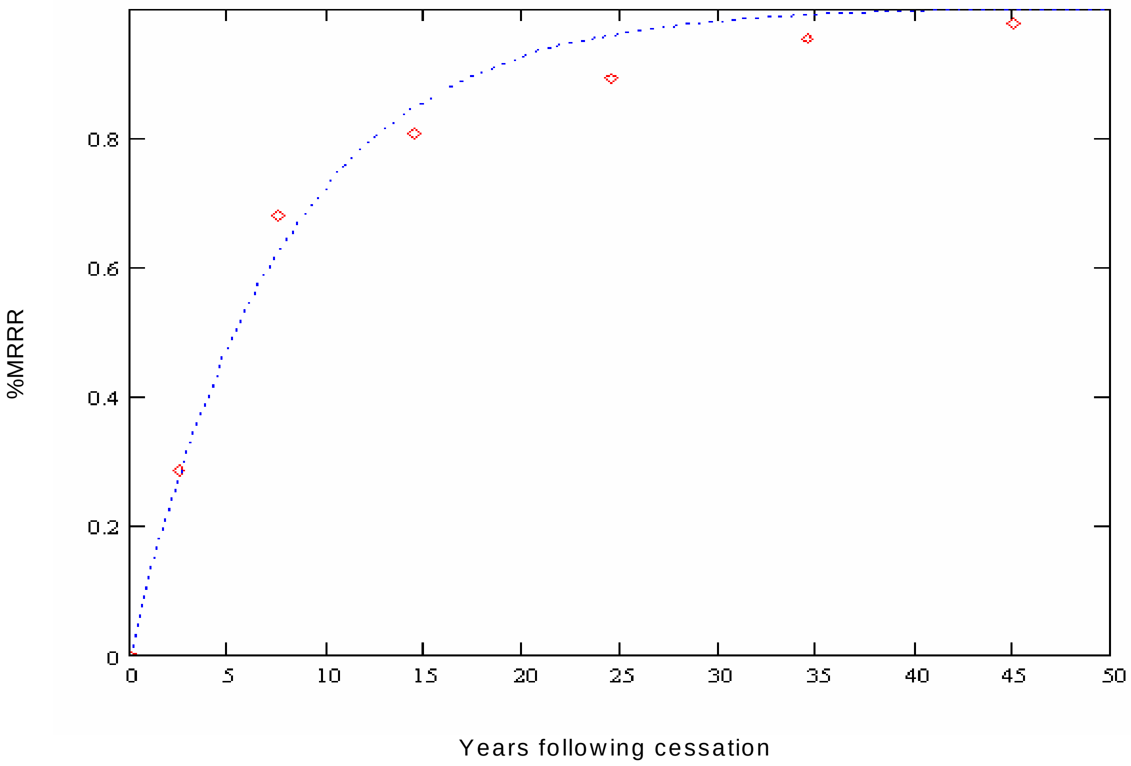


Exhibit E.30 is a graph of the Pareto form using parameters fit to the best estimates of the RR in the study and the mid-point of the years after cessation together with the empirical data for those inputs. The estimated parameters for the Pareto form for these inputs are q = - 1.597 x 10^9; r = 1.235 x 10^{10}.

Exhibit E.30 Graph of Pareto Form for Smoking / Lung Cancer Data



Arsenic (from drinking water) and Bladder Cancer

The data used to parameterize the cessation lag models for arsenic from drinking water and bladder cancer is derived from Table 5 of Chen and Gibb (2003) and are shown in Exhibit E.31. Data are shown separately for the smokers and non-smokers. However, parameters for the Weibull and Pareto functions were estimated using both the smoker and non-smoker data together. The data were not weighted to reflect smoking because the results were so similar between the two groups and information on the proportion of smokers in the study group was not available.

The arsenic and bladder cancer data did not provide ranges for either the RR or the years following arsenic exposure reduction, and therefore it was not possible to generate uncertainty sets of parameters for this cessation lag model as was done for the smoking and bladder cancer and the smoking and lung cancer cessation lag models.

Exhibit E.31 Summary of Arsenic / Bladder Cancer Data from Chen and Gibb (2003) used to Model Cessation Lag

Years After Exposure Reduction from 50 to 10 ug/L	Estimated RR for Smokers	%MRRR for Smokers	Estimated RR for Non-Smokers	%MRRR for Non-Smokers
0 (RR0)	1.0360	0.0%	1.0396	0.0%
8	1.0141	60.80%	1.0096	75.69%
12	1.0065	81.85%	1.0087	77.89%
20	1.0044	87.82%	1.0098	75.26%
22	1.0050	86.25%	0.9989	102.77%
23	1.0012	96.74%	1.0000	100%
25	1.0000	100%	1.0000	100%
Always at 10 ug/L	1.0	NA	1.0	NA

Exhibit E.32 is a graph of the Weibull form using parameters fit using both the smoker and non-smoker data on RR in the study and the years after cessation, together with the empirical data for those inputs (smokers are diamonds; non-smokers are circles). The estimated parameters for the Weibull form for these inputs are a = 1.079 b = 6.635.

Exhibit E.32 Graph of Weibull Form for Arsenic / Bladder Cancer Data

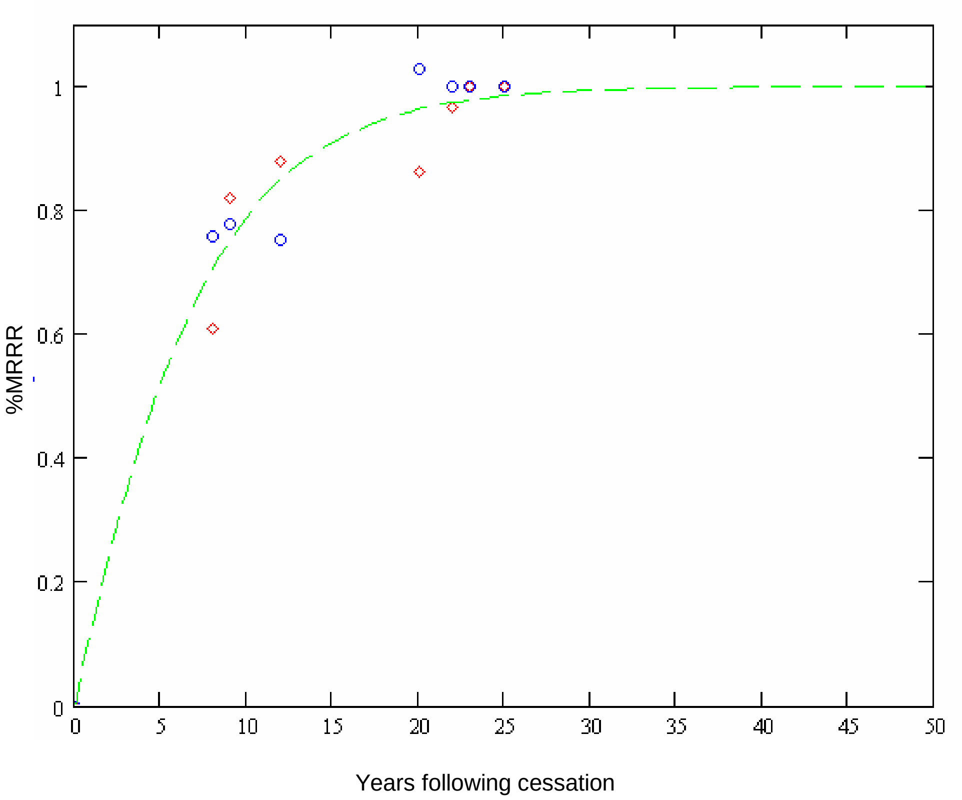
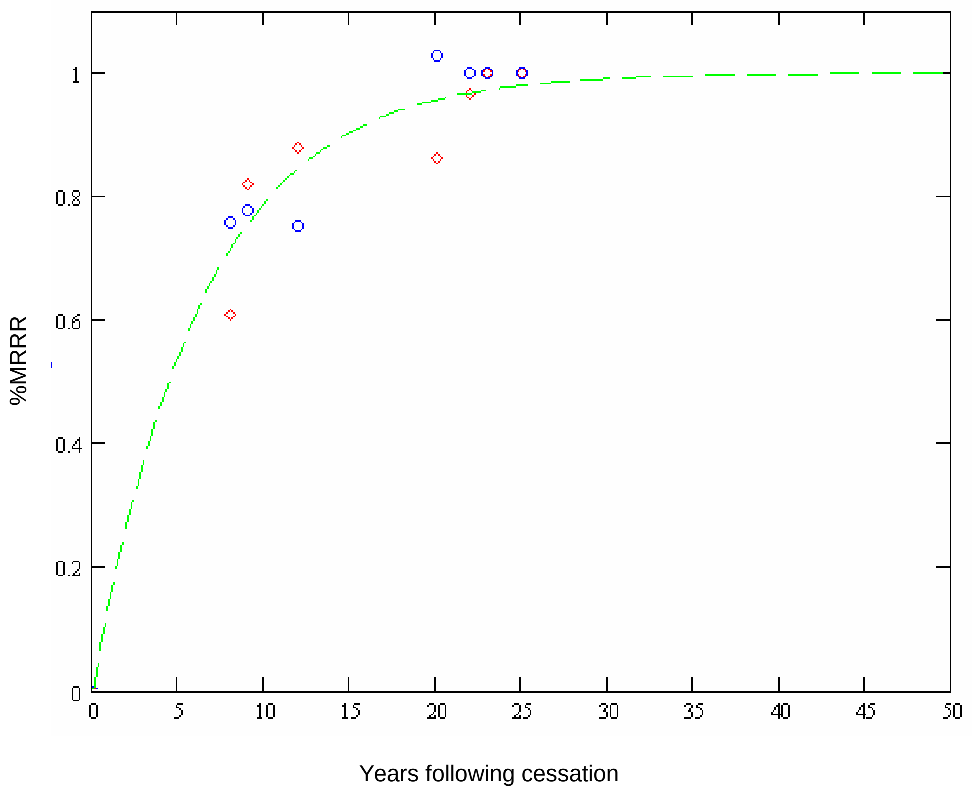


Exhibit E.33 is a graph of the Pareto form using parameters fit to %MRRR using both the smoker and non-smoker data on RR in the study and the years after cessation, together with the empirical data for those inputs (smokers are diamonds; non-smokers are circles). The estimated parameters for the Pareto form for these inputs are a = -7.224 x 10^6; b = 4.629 x 10^7.

Exhibit E.33 Graph of Pareto Form for the Arsenic / Bladder Cancer Data



E.5.3.2 Other Model Forms Evaluated for the Cessation Lag Function

There were a total of nine functional forms initially considered for the cessation lag models. The general shape of the cessation lag (as %MRRR over time) was expected to be an increasing function on the range of 0 to 1 over the domain of years following cessation, reaching or becoming asymptotic to 1 as the number of years following cessation increases. Therefore, a set of general functional forms were identified that exhibit this pattern. The specific set of function forms evaluated was (x is time after cessation, a, b, and c are model parameters):

Weibull (3 parameters):

$$f(x) = 1 - e^{-\left(\frac{x-c}{b}\right)^{a}}$$

Weibull (2 parameters):

$$f(x) = 1 - e^{-\left(\frac{x}{b}\right)^{a}}$$

Pareto I:

$$f(x) = 1 - \left(\frac{b}{x}\right)^{a}$$

Pareto II:

$$f(x) = 1 - \left(1 + \frac{x}{b}\right)^{a}$$

Log n:

$$f(x) = a \cdot \ln(x) + b$$

Logistic:

$$f(x) = \left(1 + e^{-\frac{(x-a)}{b}}\right)^{-1}$$

Exponential:

$$f(x) = a \cdot e^{-b \cdot x} + c$$

LgS:

$$f(x) = a \cdot \left(1 + b \cdot e^{-c \cdot x}\right)^{-1}$$

Extreme:

$$f(x) = e^{-e^{\frac{a-x}{b}}}$$

All of these functions were evaluated using the best estimates of the RR values and the mid-points of the ranges of years following cessation provided in the three studies. For the Stage 2 benefits modeling, the objective of exploring several various model forms was to select two forms for each data set rather than a single "best fit" to capture some measure of model uncertainty.

For uniformity in running the benefits analysis, it was desired that the same two models forms be used for all three cessation lag data sets, so model selection was not strictly the best fits for each data set, although the two models ultimately selected were among the best fits in all cases. Goodness of fit tests performed included average-square-residuals, sign test and run test.

Because it was also desired that uncertainty in the parameter values for each of the two model forms selected be considered in the benefits modeling, it was also necessary that a large set of parameters for the models reflecting that uncertainty (by considering the reported ranges of values in years following cessation for each group and the range of RR values reflected by the 95% CI reported for the RR values) were able to be readily estimated in SAS using its nonlinear curve fitting procedures. Some model forms were found not to converge or to do so with great difficulty with certain input data; generally, these were cases where the models also did not fit well.

Another desired characteristic of the cessation lag functions was that the curves that were fit to the data would pass through the origin - that is, it would predict 0% maximum relative risk reduction at 0 years after cessation. Not all of these model forms did that with the estimated parameters for all of the data sets.

The parameters for these various functional forms were estimated in SAS using the NLIN SAS procedure. Estimation of a nonlinear model is an iterative process that begins with a set of initial parameter value estimates as inputs and explores alternative values around them. The procedure evaluates the residual sum of squares at each combination of parameter values to determine the set of parameter values producing the lowest residual sum of squares. The numerical method used obtain the alternative parameter estimates was the Modified Gauss-Newton for nonlinear least squares (the SAS default procedure)..

Based on the results of these model fits together with the other general criteria and characteristics described above, it was determined that the 2-parameter Weibull and the Pareto II model forms were the most suitable for these data sets.

E.5.3.3 Benefit Model Calculation Using Cessation Lag Function

The number of cases avoided among that part of the population born before the rule goes into effect for a specific age group i in any j years after implementation is computed in the benefits model as:

$$CAVS2_{bij} = (CAVS2MAX_i) \times (LF_i) \text{ for all } i > j \qquad \text{(Equation E.11)}$$

Here, the subscript *b* refers to those born before the Stage 2 rule is implemented, *i* refers to each of the one-year age groups and *j* refers to the number of years after exposure reduction. The total cases avoided across all age groups born before rule implementation in any given year *j* is:

$$CAVS2_{b,j} = \sum_{i=j+1}^{100} (CAVS2MAX_i) * (LF_j) \qquad \text{(Equation E.12)}$$

So, for example, 25 years after the rule goes into effect (j = 25) the age groups comprising those born before the rule went into effect are ages 26 (i = j + 1) to 100. (As noted previously, 25 years after the rule is implemented those in age groups 25 years old or younger will all have been born after the rule went into effect.)

The annual bladder cancer cases ultimately avoidable for each age group born before the rule goes into effect (and exposure reduction begins) is reduced according to the fraction of the maximum relative risk reduction that is estimated from the Lag Function to be attained j years (25 in this example) after exposure to the lower levels of DBPs began (based on the particular cessation lag function used).

E.6 Computational Procedures for Predicting Cases of Bladder Cancer Avoided

The purpose of this section is to provide all necessary equations and background information for computing the final number of annual cancer cases avoided.

E.6.1 Estimating Cases Avoided for Populations Born Before and After the Rule

The calculation of annual benefits for the portion of the population born after the rule is implemented is relatively straightforward. For any specific age group born after the rule is implemented, the annual benefits are simply based on the cases ultimately avoidable for that age group. The total for all age groups born after the rule is implemented is the sum across all the appropriate age groups.

So, for example, 10 years after the rule goes into effect, this part of the population consists only of those who are 10 years old or younger; the benefit of the rule is calculated as the sum of the cases ultimately avoidable for each age group 1 through 10. Similarly, 25 years after the rule goes into effect, the benefits for this portion of the population are the sum of the annual cases ultimately avoidable for each age group 1 through 25. In the modeling performed for Stage 2, the population is considered in one-year age groups through age 100. Therefore, 100 years after the rule is implemented, the entire population is composed of individuals born after the rule is implemented and at that time– at the latest – and from that time on the cases ultimately avoidable will be achieved.

While the modeling for the Stage 2 benefits is set up for the full 100-year time horizon, the focus for the comparison of benefits with costs is limited to the first 25 years after the rule is implemented. Nevertheless, for the sake of completeness, these benefits (cases avoided) are computed in the model for each year after the rule and are combined with the benefits (cases avoided) obtained for the other portion of the population: those who are born before the Stage 2 is implemented.

The calculation of annual benefits for the portion of the population born before implementation of the rule must account for cessation lag. To provide initial insight into how the annual benefits are computed each year for this part of the population born, consider the group of people who are 50 years old at the time the rule goes into effect. One year after the rule is implemented, that group has become the 51-year-old group, two years after the rule they are the 52-year-old group, and so on. For example, if the annual cases ultimately avoidable from Stage 2 for the 51-year-old age group is 5.3 cases, the number for the 52-year-old group would be approximately 5.1 cases. Again, if the benefits of the Stage 2 exposure reduction to those who have had some years of exposure to the pre-Stage 2 levels of DBPs (in this case 50 years of such exposure) were instantaneous, then one year after the rule is implemented the expected benefits would be all of those 5.3 cases and two years after they would be all of the 5.1 cases – just as if those individuals had spent their entire lives exposed only to the lower, post-Stage 2 levels.

As we have discussed in Section E.5, however, cancer risk reductions are not instantaneous; there is a transition period from the risk associated with the higher exposure levels to the risk associated with the lower exposure levels (referred to as cessation lag). Section E.5 provides a discussion of how cessation lag is accounted for in the population born before the rule is implemented.

Cases avoided for the two populations (those born before and those born after the rule is implemented) are added to produce total cases avoided for the rule.

E.6.2 Accounting for Uncertainties in the Benefits Model

The calculation of bladder cancer cases avoided is carried out as a Monte Carlo simulation where uncertainty in several of the key inputs is considered quantitatively. Three separate benefits estimates are modeled, each representing the use of one of the three studies serving as the basis for the cessation lag function as noted above (smoking/lung cancer; smoking/bladder cancer; and arsenic/bladder cancer). Each model is run independently for percent DBP reduction based on TTHM and HAA5.

Each of these three separate cessation lag models is, as noted, a Monte Carlo simulation in which several specific inputs will be incorporated as uncertainty variables. These are:

1. Three approaches were used to estimate the baseline number of bladder cancer cases attributable to DBP exposure. For the sake of simplicity, one approach using data from Villanueva et al. (2003) was carried through the full benefits model.

2. The PAR value for Pre-Stage 1 that is derived from the Villanueva et al. (2003) study is input as an uncertain variable. Specifically, the OR and its 95% confidence interval reported by Villanueva et al. (2003) were used to parameterize a triangular uncertainty distribution with minumum = 1.0725, mode = 1.2, and maximum = 1.4359. The minimum was estimated from the lower 95% bound of 1.1 multiplied by 0.975; the maximum was estimated from the upper 95% confidence bound of 1.4 divided by 0.975; the mode of 1.2 was taken from the best estimate of the OR reported by the authors. Note that the expected value of this distribution of 1.24 is higher than the mode of 1.2 because of the asymmetry of the 95% confidence interval reported by Villanueva et al. (2003). The confidence bounds from Villanueva et al. (2003) capture a significant portion of the confidence intervals of the other two approaches.

3. Percent DBP (TTHM or HAA5) reductions for Stage 1 and Stage 2. These values are derived using the SWAT model and the ICR Matrix Method. For the estimates of DBP reduction as a result of the Stage 2 DBPR, EPA produces two separate estimates of percent reduction to account for the potential impact of the IDSE on the compliance forecast. Also, the uncertainty in SWAT-predicted equations is incorporated into the model.

4. Model form uncertainty for cessation lag functions. As noted above, two functional forms have been used to model the Lag Function values: Weibull and Pareto. In the

Monte Carlo simulation, one or the other of these functions is selected randomly (with equal probability) on a given iteration.

5. Model parameter uncertainty for cessation lag functions. For the Lag Functions based on the smoking/lung cancer and the smoking/bladder cancer data sets, the two parameters for the Weibull and Pareto functions (q and r as shown above) are uncertain values; that uncertainty is accounted for in the simulation. One thousand parameter pairs were estimated for each function reflecting uncertainty in the time following cessation and in the reported RR values in those studies. On a given iteration, once one of the two functional forms has been selected at random, a parameter pair for that function is selected at random and used for the subsequent calculations in that uncertainty loop. Note that for the arsenic/bladder cancer data provided in the Chen and Gibb study, there was insufficient information to estimate the uncertainty around these parameters (Chen and Gibb 2003). In the model runs using the arsenic/bladder cancer data, only the single best estimates of those parameters are used once the model function is randomly selected.

E.6.3 Benefits Model Equations

The function and flow of the model is presented in Exhibit E.34. The upper portion presents the model inputs and distributions for uncertain values. The bottom portion shows the progression of the model.

The model is run independently to produce PAR values for TTHM and HAA5 as indicators of DBP reduction, and for each of three cessation lag functions based on smoking and lung cancer, smoking and bladder cancer, and arsenic and bladder cancer data (a total of 6 estimates of PAR). The PAR values are generated by using the triangular distribution of OR values estimated from Villanueva et al. (2003) and Equation E.3 , as described earlier.

The set of PAR values for each run are used to generate sets of cases attributable to chlorination DBPs (CATT) as in Equation E.13 by using the background incidence of bladder cancer (BI) from Equation E.1.

$$CATT_i = BI_i \times PAR_i \qquad \text{(Equation E.13)}$$

The sets of values for CATT are then used to generate sets of the cases ultimately avoidable due to Stage 1 (CAVS1Max) by using the following equation:

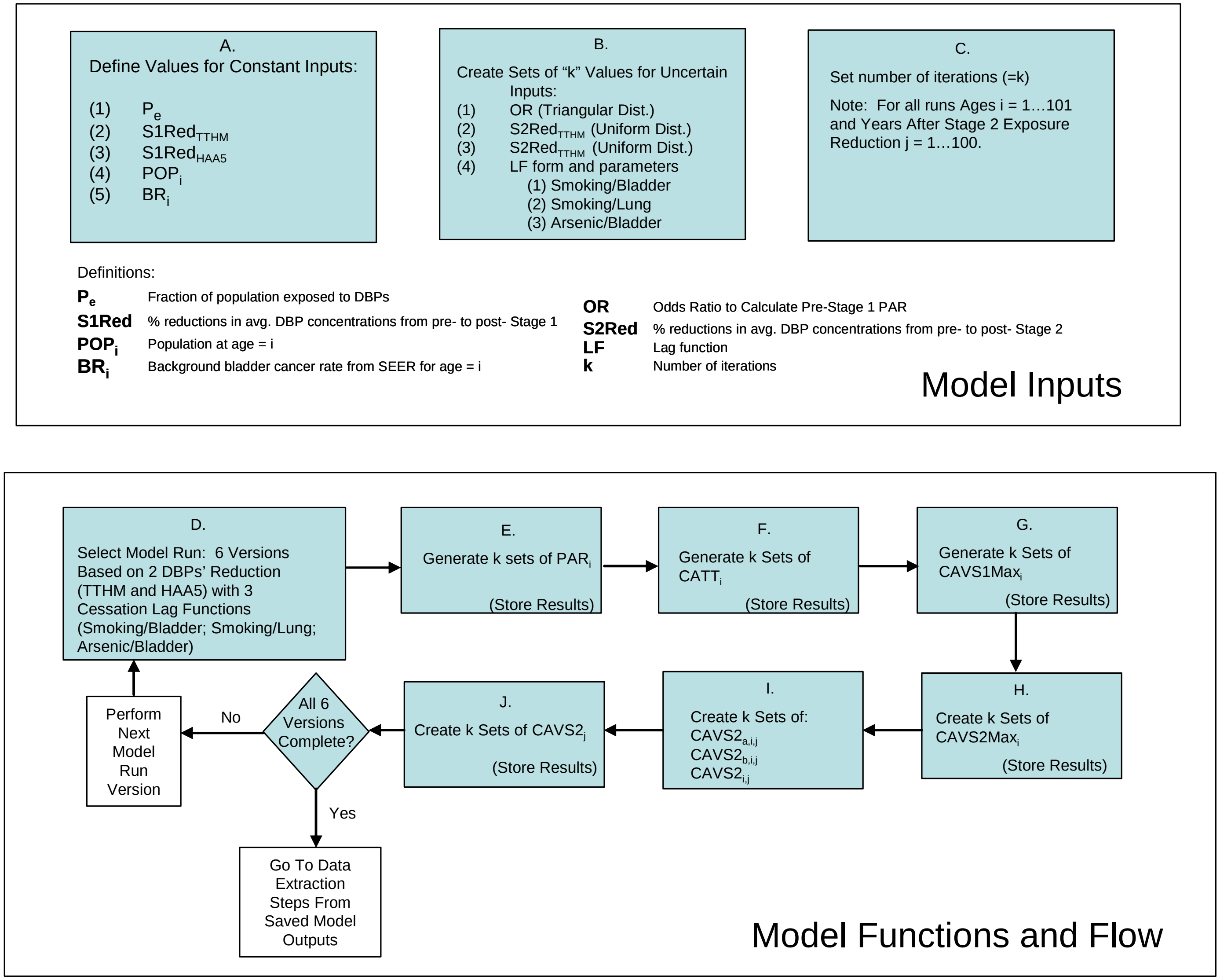
$$CAVS1Max=CATT \times (S1Red) \qquad \text{(Equation E.14)}$$

The percent reduction in average DBP (TTHM or HAA5) concentration from Pre-Stage 1 to Post-Stage 1 (S1Red) is applied to the cases attributable to DBPs.

These ultimately avoidable values are used to calculate sets of cases avoided for Stage 1. The total of cases consists of cases avoided for two different populations, those born before the rule and those born after the rule. Since the group that is born after the rule only experiences post-rule exposure levels, the cases avoided for this group are equal to the cases ultimately avoidable (CAVS1a = CAVS1Max). For the population alive when the rule is promulgated, there will be a cessation lag effect, as described in Section E.5. The cases avoided for this group is some fraction of the ultimate value, each year after the rule is promulgated. This is referred to as the lag function (LF). The cases avoided for this group is

CAVS1b = (CAVS1Max × LF). The lag function is explained in more detail in Section E.5.3.1. To estimate the total cases avoided by the Stage 1 rule, the cases avoided for each of the two populations is summed to come up with sets of cases avoided (CAVS1). The model then repeats this process for all 6 combinations of the two DBPs and three cessation lag models.

Exhibit E.34 Benefits Model Process Flow Chart



Definitions:

P_e	Fraction of population exposed to DBPs	**OR**	Odds Ratio to Calculate Pre-Stage 1 PAR
S1Red	% reductions in avg. DBP concentrations from pre- to post- Stage 1	**S2Red**	% reductions in avg. DBP concentrations from pre- to post- Stage 2
POP_i	Population at age = i	**LF**	Lag function
BR_i	Background bladder cancer rate from SEER for age = i	**k**	Number of iterations

A similar process is performed for the annual cases ultimately avoidable due to Stage 2 (*CAVS2Max*), and is built on the *CAVS1Max* in the following equation:

$$CAVS2Max = [CATT - CAVS1Max] \times S2Red \qquad \text{(Equation E.15)}$$

The percent reduction in average DBP (TTHM or HAA5) concentration from Pre-Stage 2 to Post-Stage 2 is applied to the cases available after Stage 1 (S2Red). Note that while the percent DBP reduction for Stage 1 is a point estimate, the percent DBP reduction for Stage 2 incorporates uncertainties (see previous section).

These estimates of annual cases ultimately avoidable are used to calculate the cases avoided for Stage 2 following rule implementation. As was the case for Stage 1, the total cases avoided from Stage 2 consist of those for two different populations, those born before the rule and those born after the rule. Since the group that is born after the rule only experiences post-rule exposure levels, the cases avoided for this group equal the cases ultimately avoidable ($CAVS2a = CAVS2Max$). As described for Stage 1 above, the lag function is used to obtain the cases avoided for the population alive when the rule is promulgated, $CAV2b = CAVS2Max \times LF$. To estimate the total cases avoided by the Stage 2 rule (*CAVS2*), the cases avoided for each of the two populations is. The model then repeats this process for all 6 combinations of the two DBPs and three cessation lag models.

Additional details for the Stage 2 DBPR benefits model are provided in Appendix K.

E.6.4 Allocating Cases Avoided to Different System Size and Source Water Categories

The total number of bladder cancer cases avoided as a result of the Stage 2 DBPR includes those from all system sizes and source water categories. To adjust the projection of cases over 25 years to account for the rule implementation schedule (see next Section), the total cases are allocated to the following system categories:

- Large and medium surface water systems
- Small surface water systems
- Large and medium ground water systems
- Small groundwater systems

The cases are allocated in proportion to 1) total population served in each category and 2) reduction in TTHM or HAA5 concentrations. The percent of cases allocated to the four system categories is shown in Exhibit E.35 for the Stage 1 DBPR, and Exhibit E.36 for the Stage 2 DBPR.

Exhibit E.35 Allocation of Cases Avoided by the Stage 1 DBPR to System Categories

System Size and Type:	Population Served	Population (Percent of Total)	Pre-Stage 2 DBP Concentration (µg/L)	Pre-S2 Population Weighted Average Concentration	Percent Reduction in DBP Concentration	Amount Reduced (µg/L)	Population Weighted Amount Reduced	Allocation of Cases Avoided
	A	B = A / 263,024,518	C	D = B * C	E	F = C * E	G = F * B	H = G/G total
TTHM								
SW > 10,000	160,935,736	61.2%	48.70	29.80	27.17%	13.23	8.10	78.2%
SW < 10,000	8,422,403	3.2%	82.80	2.65	57.16%	47.33	1.52	14.6%
GW > 10,000	65,152,168	24.8%	15.36	3.80	14.31%	2.20	0.54	5.3%
GW < 10,000	28,514,211	10.8%	16.53	1.79	11.08%	1.83	0.20	1.9%
Total	263,024,518	100.0%					10.35	100%
HAA5								
SW > 10,000	160,935,736	61.2%	35.48	21.71	29.54%	10.48	6.41	84.7%
SW < 10,000	8,422,403	3.2%	45.32	1.45	44.83%	20.32	0.65	8.6%
GW > 10,000	65,152,168	24.8%	8.45	2.09	17.63%	1.49	0.37	4.9%
GW < 10,000	28,514,211	10.8%	9.09	0.99	13.65%	1.24	0.13	1.8%
Total	263,024,518	100.0%					7.57	100%

Note: Allocation of cases to system sizes within the size classes noted above (<>10,000) are consistent with the available DBP information and calculations on a finer level must be based upon population only.

Sources: (A) Exhibit 3.3.
(C) & (E) Exhibit 5.22.

Exhibit E.36 Allocation of Cases Avoided by the Stage 2 DBPR to System Categories

System Size and Type:	Population Served	Population (Percent of Total)	Pre-Stage 2 DBP Concentration (µg/L)	Pre-S2 Population Weighted Average Concentration	Percent Reduction in DBP Concentration	Amount Reduced (µg/L)	Population Weighted Amount Reduced	Allocation of Cases Avoided
	A	B = A / 263,024,518	C	D = B * C	E	F = C * E	G = F * B	H = G/G total
TTHM (20% SM)								
SW > 10,000	160,935,736	61.2%	35.47	21.70	7.30%	2.59	1.58	90.7%
SW < 10,000	8,422,403	3.2%	35.47	1.14	7.30%	2.59	0.08	4.7%
GW > 10,000	65,152,168	24.8%	13.16	3.26	1.44%	0.19	0.05	2.7%
GW < 10,000	28,514,211	10.8%	14.70	1.59	2.04%	0.30	0.03	1.9%
Total	263,024,518	100.0%					1.75	100%
HAA5 (20% SM)								
SW > 10,000	160,935,736	61.2%	25.00	15.30	7.69%	1.92	1.18	85.9%
SW < 10,000	8,422,403	3.2%	25.00	0.80	7.69%	1.92	0.06	4.5%
GW > 10,000	65,152,168	24.8%	6.96	1.72	4.47%	0.31	0.08	5.6%
GW < 10,000	28,514,211	10.8%	7.85	0.85	6.31%	0.50	0.05	3.9%
Total	263,024,518	100.0%					1.37	100%
TTHM (25% SM)								
SW > 10,000	160,935,736	61.2%	35.47	21.70	11.16%	3.96	2.42	93.7%
SW < 10,000	8,422,403	3.2%	35.47	1.14	7.30%	2.59	0.08	3.2%
GW > 10,000	65,152,168	24.8%	13.16	3.26	1.44%	0.19	0.05	1.8%
GW < 10,000	28,514,211	10.8%	14.70	1.59	2.04%	0.30	0.03	1.3%
Total	263,024,518	100.0%					2.58	100%
HAA5 (25% SM)								
SW > 10,000	160,935,736	61.2%	25.00	15.30	12.23%	3.06	1.87	90.7%
SW < 10,000	8,422,403	3.2%	25.00	0.80	7.69%	1.92	0.06	3.0%
GW > 10,000	65,152,168	24.8%	6.96	1.72	4.47%	0.31	0.08	3.7%
GW < 10,000	28,514,211	10.8%	7.85	0.85	6.31%	0.50	0.05	2.6%
Total	263,024,518	100.0%					2.06	100%

Note: Allocation of cases to system sizes within the size classes noted above (<>10,000) are consistent with the available DBP information and calculations on a finer level must be based upon population only.

Sources: (A) Exhibit 3.3.
(C) Exhibit 5.22.
(E) For SW, Percent Reduction = [(SWAT predicted reduction) + ICR/SWAT ratio * (SWAT predicted reduction)]/2. See Exhibit 5.18. For GW, see Exhibit 5.23.

E.6.5 Adjusting the 25-year Projection of Cases Avoided to Account for the Rule Implementation Schedule

Reduction in exposure to DBPs does not begin immediately when the Stage 2 DBPR is promulgated. Water systems are given a certain amount of time to make treatment technology changes to come into compliance with the rule. Appendix D shows estimates of when systems will install treatment technology changes (in the form of cumulative percentages) based on the required compliance schedule. Exhibit E.37 shows the estimated schedule for large and medium surface water systems, small surface water systems, large and medium ground water systems, and small ground water systems, as derived from Appendix D. The projected total estimate of bladder cancer cases avoided is multiplied by the percentages in Exhibit E.37 to generate the final stream of bladder cancer cases avoided for 25 years after the rule is promulgated.

Exhibit E.37 Estimated Schedule for Systems Making Treatment Technology Changes to Comply with the Stage 2 DBPR

Year after Rule Promulgation	% Surface Water Systems		% Ground Water Systems	
	Small	Large	Small	Large
1	0%	0%	0%	0%
2	0%	0%	0%	0%
3	0%	0%	0%	0%
4	0%	0%	0%	0%
5	0%	0%	0%	0%
6	15%	22%	15%	24%
7	31%	43%	31%	47%
8	46%	65%	46%	71%
9	62%	87%	62%	95%
10	77%	96%	77%	99%
11	92%	100%	92%	100%
12	100%	100%	100%	100%
13	100%	100%	100%	100%
14	100%	100%	100%	100%
15	100%	100%	100%	100%
16	100%	100%	100%	100%
17	100%	100%	100%	100%
18	100%	100%	100%	100%
19	100%	100%	100%	100%
20	100%	100%	100%	100%
21	100%	100%	100%	100%
22	100%	100%	100%	100%
23	100%	100%	100%	100%
24	100%	100%	100%	100%
25	100%	100%	100%	100%

Note: Small systems serve less than 10,000 people and large system serve greater than or equal to 10,000 people.

Source: O&M schedule in Appendix D, system size categories combined in proportion to population.

E.7 Detailed Results Output from Models

This section presents detailed results for annual cancer cases avoided (adjusted for cessation lag and rule implementation schedule) for the Stage 2 DBPR Preferred Regulatory Alternative (includes a requirement for the IDSE), all other regulatory alternatives, and all sensitivity analyses. Results for TTHM are shown for each alternative; however, detailed results for HAA5 are shown only for the Preferred Regulatory Alternative. The derivation of results using HAA5 occurrence data is exactly the same as the calculations using TTHM occurrence data. The percent reductions are similar.

Appendix E2

Calculation of PAR, Attributable Cases and Cases Avoided for the Colon and Rectal Cancer Sensitivity Analyses

Appendix E2 Calculation of PAR, Attributable Cases and Cases Avoided for the Colon and Rectal Cancer Sensitivity Analyses

Section 6.7 of Chapter 6 presents, as a sensitivity analysis, estimates of potential benefits associated with the reduction of colon and rectal cancer. As indicated there, the colon cancer estimates are based on a calculation of PAR derived from data presented in the King et al. (2000) study; the rectal cancer estimates are based on a calculation of PAR derived from data presented in the Hildesheim et al. (1998) study. The purpose of this appendix is to provide additional information on the calculation of these PAR values and on the estimation of attributable cases and cases avoided from Stage 1 and Stage 2.

The PAR calculations for colon and rectal cancer were carried out identically to those discussed in Appendix E Section E.3.3 for bladder cancer using Equation E.6 (for calculating PAR from multiple exposure groups) as applied to the five bladder cancer epidemiology studies under Approach 1. The form of that equation, as used here, is:

$$PAR = \sum_{i=1}^{k} P_{e/c(i)} \left(\frac{OR_i - 1}{OR_i} \right)$$

where there are k exposure groups and where $P_{e/c(i)}$ refers to the fraction of all cases observed in the ith exposure group.

Exhibit E2.1 presents the data from the two studies and the resulting PAR estimates.

Exhibit E2.1 Data and PAR Calculations for Colon and Rectal Cancer Sensitivity Analysis

Study	Exposure Group (Years of Chlorinated Water)	Cases	$P_{e/c(i)}$	OR_i	$P_{e/c(i)}*[(OR_i-1)/OR_i]$
King et al. (2000) Colon Cancer (Males Only)	0 – 9	101	0.240	1.0	0.000
	10 – 19	41	0.097	1.7	0.040
	20 – 34	107	0.254	1.33	0.063
	35+	172	0.409	1.53	0.142
	Total:	**421**		**PAR (S):**	**0.245**
Hildesheim et al. (1998) Rectal Cancer (Both Sexes)	0	119	0.222	1.0	0.000
	1 – 19	101	0.188	0.88	-0.026
	20 – 39	136	0.253	1.11	0.025
	40 – 59	136	0.253	1.41	0.074
	60+	45	0.084	2.13	0.044
	Total:	**537**		**PAR (S):**	**0.118**

The SEER data provides an estimate of 148,723 total new colon and rectal cancers per year based on 1997 – 2001 data. The American Cancer Society (2005) indicates that approximately 72.2% of these are colon cancers and 27.7% are rectal cancers, or 107,430 and 41,293 respectively. The American Cancer Society also indicates that of the colon cancers, 46% (i.e., 49,418) occur in men.

Applying the PAR values shown above to these values of colon and rectal cancer incidence from all causes results in estimate of Pre-Stage 1 DBP attributable cases of 12,093 colon cancers (men only) and 4,852 rectal cancers (both sexes).

Using TTHM average reductions for Stage 1 of 27.2% results in estimates of Post-Stage 1 colon cancers (men only) of 8,800 and of rectal cancers of 3,531.

Using TTHM average reductions for Stage 2 of 7.8% results in estimates of Post-Stage 2 colon cancers (men only) of 8,114 and of rectal cancers (both sexes) of 3,255. Therefore, the estimated annual cases avoided for Stage 2 are 686 colon cancers and 275 rectal cancers. These estimates are the annual cancer cases ultimately avoidable as discussed in Chapter 6 and Appendix E. The estimates of the annualized monetary benefits for reduction of colon and rectal cancers as presented in Exhibit 6.31 include cessation lag based on the smoking / lung cancer cessation lag model.