United States Environmental Protection Agency
Office of Water (4601)
EPA 815-B-06-002
January 2006

INITIAL DISTRIBUTION SYSTEM EVALUATION GUIDANCE MANUAL

FOR THE FINAL STAGE 2 DISINFECTANTS AND DISINFECTION BYPRODUCTS RULE

CHAPTER 6

http://www.epa.gov/safewater/disinfection/stage2/compliance.html

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6.0 System Specific Study Using a Distribution System Hydraulic Model

This chapter covers:

One of two options for the system specific study (SSS) involves the use of a detailed, comprehensive, and well-calibrated distribution system hydraulic model to help select Stage 2 DBPR compliance monitoring locations. Systems using a distribution system hydraulic model will be required to submit a modeling study plan and IDSE Report describing the modeling analysis, selection of monitoring sites, and sampling data.

Distribution system hydraulic models can be used for the SSS provided the minimum model requirements are met. An overview of requirements is given in Exhibit 6.1 and detailed guidance is provided in Section 6.1 The option of using a distribution system hydraulic model is intended to allow systems that have models to use their ***existing technical resources*** to perform the IDSE. For many systems, developing a detailed and well-calibrated distribution system hydraulic model ***from scratch*** and training staff to use it could cost more than conducting standard monitoring (see Chapter 7). If the model will be used for other purposes after the completion of the SSS, such as optimizing system operations and prioritizing capital improvements, then the cost of the model development may be justified. If a system's existing model **does not** meet the minimum requirements in Exhibit 6.1 at the beginning of the IDSE period, the system may be able to upgrade the model to complete the modeling SSS or instead use it in combination with other data and/or analyses for selecting sites for standard monitoring (see Chapter 7). Exhibit 6.2 includes a list of minimum reporting requirements for the modeling SSS.

Exhibit 6.1 Minimum Distribution System Hydraulic Model Requirements

To meet the minimum model requirements, your model must include:

Physical System Data

- At least 50 percent of total pipe length in the distribution system.
- At least 75 percent of the pipe volume in the distribution system.
- All 12-inch diameter and larger pipes.
- All 8-inch diameter and larger pipes that connect pressure zones, mixing zones from different sources, storage facilities, major demand areas, pumps, and control valves, or are known or expected to be significant conveyors of water.
- All 6-inch diameter and larger pipes that connect remote areas of a distribution system to the main portion of the system or are known or expected to be significant conveyors of water.
- All storage facilities, with controls or settings applied to govern the open/closed status of the facility that reflect standard operations.
- All active pump stations, with realistic controls or settings applied to govern their on/off status that reflect standard operations.
- All active control valves or other system features that could significantly affect the flow of water through the distribution system (e.g., interconnections with other systems, pressure reducing valves between pressure zones).

Demand Data

- Extended period simulation with representative diurnal variations in demand
  - Represent total system demand for the peak month of TTHM formation

Calibration

- A calibration verification using data for the peak month of TTHM formation and current system configuration
  - Operational controls to represent typical operation during the peak month of TTHM formation
- Evaluation of actual system performance compared to modeled performance at all storage facilities in the system
- Ability to complete all required calibration no later than 12 months after your required plan submission date

Modeling Analysis

- The ability to simulate water age during the peak month of TTHM formation using a sufficient simulation length to overcome initial conditions and produce a consistent, repeating pattern of 24-hour water age

Exhibit 6.2 Minimum Reporting Requirements for Modeling Study Plan

The following information must be provided in your Modeling Study Plan. You may use the Modeling Study Plan Form (Form 4) found in this chapter or the IDSE tool to help you prepare your submission.

1. Tabular or spreadsheet data demonstrating that your model meets the physical system data requirements in Exhibit 6.1.

2. A description of all calibration activities undertaken (or to be undertaken). This must include, if calibration is complete,

- A graph of predicted tank levels versus measured tank levels for the storage facility with the highest residence time in each pressure zone.
- A time series graph of water age results for the storage facility with the highest residence time in your system showing predictions for the entire EPS simulation period (i.e. from time zero until the time it takes for the model to reach a consistently repeating pattern of residence time).

3. Preliminary results of the modeling analysis showing showing 24-hour average water age predictions throughout the distribution system.

4. Timing and number of samples planned for at least one period of TTHM and HAA5 monitoring at a number of locations no less than that required for your system under standard monitoring during the month of high TTHM.

5. Description of how all requirements will be completed no later than 12 months after your required plan submission date.

6. Distribution system schematic showing entry points and their sources, storage facilities, and locations of all completed SSS monitoring and all subpart L compliance monitoring.

7. Population served and system type (subpart H or ground water).

Notes:

- You must respond to any state or EPA inquiries regarding your model and your SSS plan submission.
- If you have already completed your required monitoring, it is highly recommended that you submit your IDSE report at the same time as your study plan.

For the purposes of the modeling SSS, water age is used as a surrogate for TTHM concentration. Thus, the minimum requirements for the modeling SSS are focused only on the hydraulic component of distribution system models. A well-calibrated water quality model may provide a better understanding of the behavior of the distribution system, leading to superior selections of Stage 2 DBPR compliance monitoring locations compared to hydraulic models without water quality calibration. However, proper calibration of the water quality component can be a difficult task and is typically done with much less accuracy than calibration of the hydraulic component. In addition, the data needed to properly calibrate and verify the water quality concentrations predicted by the model may exceed data collection requirements under the IDSE standard monitoring option. If systems decide to use water quality modeling, they are encouraged to provide information on the water quality calibration to EPA or the state in addition to the required information for the underlying hydraulic components of the model.

A variety of public domain and commercial software packages are available for distribution system modeling. Public domain software includes EPANET and PipelineNET, which are both available for free download. EPANET is available from www.epa.gov/ORD/NRMRL/wswrd/epanet.html and PipelineNET is available from http://eh2o.saic.com/iwqss/. Systems should verify that the software used to model the distribution system can provide the output required to demonstrate the model's calibration and performance (Section 6.1).

If you have not already done so, you should complete the flowchart in Exhibit 2.3 of this guidance manual. The flowchart will direct you to a 2-page ***Requirements Summary Sheet*** for your schedule. You will also be directed to the ***System Specific Study Requirements - Attachment*** sheet containing detailed requirements for Stage 2 compliance monitoring (e.g., number of samples and sampling frequency). You should keep these sheets handy as you work through this chapter. It is important that **consecutive and wholesale systems** communicate with each other throughout the IDSE process. If you are a consecutive or wholesale system, refer to Appendix D for specific issues that you should consider.

If you plan to conduct an SSS using a model, you must submit a modeling study plan for state or EPA review in accordance with the schedule on your requirements summary sheet. You have the option of submitting the modeling study plan and IDSE report together (which must include selection of Stage 2 DBPR compliance monitoring sites) by the study plan deadline if all required elements have been completed. If you choose this option, you have no further requirements under the IDSE unless you are contacted by EPA or your state. Below is a list of conditions under which you should consider submitting the report at the same time as the plan, and conditions under which you would want to submit your modeling study plan first, then your report at the end of the IDSE monitoring period.

Option 1: Submitting a Completed Modeling Study Plan and IDSE Report at the Same Time

You should consider Option 1 if:

- You have completed calibration of your model, and
- You have completed one monitoring period of additional TTHM and HAA5 monitoring meeting the criteria in Section 6.3.

You need to:

- Submit both the modeling study plan and the IDSE report by the deadline for the modeling study plan that is provided on your requirements summary sheet.

Option 2: Submitting a Separate Modeling Study Plan and IDSE Report

You should consider Option 2 if:

- You have not completed calibration of your model, or
- You have not completed one monitoring period of additional TTHM and HAA5 monitoring meeting the criteria in Section 6.3.

You need to:

- Submit the modeling study plan by the deadline for the modeling study plan on your requirements summary sheet.
- Conduct additional monitoring and/or perform calibration by the date listed in your requirements summary sheet.
- Submit the IDSE report for a modeling SSS by the deadline in your requirements summary sheet.

6.1 Minimum Model Requirements and Calibration

Exhibit 6.1 summarizes the minimum model requirements for the SSS. In general, a system's distribution system hydraulic model should be more comprehensive for the purpose of an SSS than models typically used for long-range capital improvement program analysis of transmission capacity (e.g., master planning). A calibrated hydraulic model intended for detailed distribution system design or operational studies is likely to be adequate. A well-calibrated water quality model is also likely to be acceptable. In either case, the model **must** be an extended period simulation (EPS) model. Also, the model must be calibrated for the **peak month for TTHM formation**. Consequently, the model will need to incorporate operational and demand conditions for the peak month for TTHM formation**.** See Section 6.3 for guidance on selecting the peak month.

Distribution systems are always changing (e.g., population growth, new industrial users, aging of mains), so it is important that the model reflect system conditions and demand at the time of the SSS. If your model is not current, it **must** be updated and calibrated before it could be considered adequate for the SSS. Your model must be calibrated for the current configuration of the distribution system.

Sections 6.1.1 through 6.1.4 provide additional guidelines to help you determine if your model meets the minimum requirements. Note that the guidelines in this section are not comprehensive—every distribution system is unique. Systems should always use their best professional judgment when determining model adequacy for the SSS. You should note that EPA or your state can still require you to conduct standard monitoring even if you meet minimum requirements. AWWA Manual M32, *Computer Modeling of Water Distribution Systems*, 2^{nd} Edition, 2005, may be a useful reference that goes into greater detail on the distribution system modeling presented in this chapter.

6.1.1 Physical System Data

Most distribution system models do not include every pipe in a distribution system. Typically, small pipes near the periphery of the system and other pipes that affect relatively few customers are excluded to a greater or lesser extent depending on the intended use of the model. This process is called *skeletonization*. Models including only transmission networks (e.g. pipes larger than 12 inches in diameter only) are highly skeletonized while models including many smaller diameter distribution mains (e.g. 4 to 6 inches in diameter) are less skeletonized. In general, water moves quickly through larger transmission piping and slower through the smaller distribution mains. Therefore, the simulation of water age or water quality requires that the smaller mains be included in the model to fully capture the residence time and potential water quality degradation between the treatment plant and the customer. Increases in computing capabilities are making it possible to include many more pipes in hydraulic models than was previously feasible.

To be used for the purposes of conducting the SSS, the model should be relatively detailed (less skeletonized) and include the majority of pipes in the distribution system. Minimum requirements for physical system data are provided in Exhibit 6.1.

System inventory information can be used to determine the adequacy of the model, including pipe information in GIS or on water atlas maps. Documentation of the ability of the model to meet the minimum requirements **must** be submitted with the modeling study plan. Most modeling software provides the ability to calculate and export data on the total length of the pipes within the model. GIS, water system inventory data, or water atlas sheets can be used to calculate the length of pipes that exist in the distribution system but are not included in the model. Systems should use their best professional judgment in the estimation of the coverage of the distribution system that is included in the model. An example of these calculations is provided in Appendix F.

6.1.2 Demand Data

A key set of input data to a hydraulic model is the demand data used to simulate consumption of water throughout the system. The demand data dictates the flow through each pipe and therefore is an important part of the model. Water demand should be allocated among the nodes in the model in a manner that reflects the actual spatial distribution of such demand throughout the system, with a level of detail appropriate for the system size. A proper demand allocation will help ensure that the model provides a realistic simulation of water flow throughout the system.

In general, it is desirable to have demand allocated to as many nodes as possible in the model. The calculation of water age at nodes on dead end mains with zero demand is not accurate because the water age will equal the simulation time at each time step, so often model results will show the highest water age at dead ends. While this is a realistic representation of the distribution system, you should take these results into consideration when selecting sampling locations. Much of the modeling and GIS software available contains tools to assist with demand allocation based on geocoding of customer accounts, processing of census population data, or spatial analysis of land use patterns. Alternatively, it is possible to allocate customer demands manually based on system knowledge of meter locations, meter reader routes, or zone flow meters.

To ensure that your model is calibrated well for the period of high TTHM formation potential, include all significant users in the system in your model. Many skeletonized models will exclude dead ends in the system even though they may serve a subdivision or other area with a sizable number of customers. Systems should make an effort to include dead end pipes that serve significant populations to capture the full system demand as well as any potential degradation of water quality within the dead end area. Exhibit 6.3a shows a typical subdivision layout with dead ends that are not included in the model (more skeletonized) and Exhibit 6.3b shows that model with all pipes included (less skeletonized).

Systems with rapidly changing populations and water usage should verify that the demands in the hydraulic model reflect the distribution system conditions under which the SSS will be evaluated. Particular attention should be paid to large users in the system, which are often industrial or institutional and can have a significant impact on flows. Seasonal trends in demand variation should also be considered so that the model reflects the correct water usage for the month with the highest TTHM formation potential (see Section 6.3 for more information on determining peak month for TTHM formation). For example, many commercial properties have automatic irrigation systems that operate during summer months only and some systems may have seasonal users such as campgrounds or swimming pools.

System water loss should also be reflected in the demands in the hydraulic model. Many systems calculate a non-revenue water percentage based on the difference between their monthly production records and customer billing data. This water loss should be included in the model. Many systems apply a constant rate of water loss across their system by using a global demand multiplier. However, if more detailed information on losses is available, such as measured losses in a particular zone in the system, that data could be used to allocate the total water loss to specific areas in the model.

Exhibit 6.3a Sample Subdivision Layout in a Less Skeletonized Model

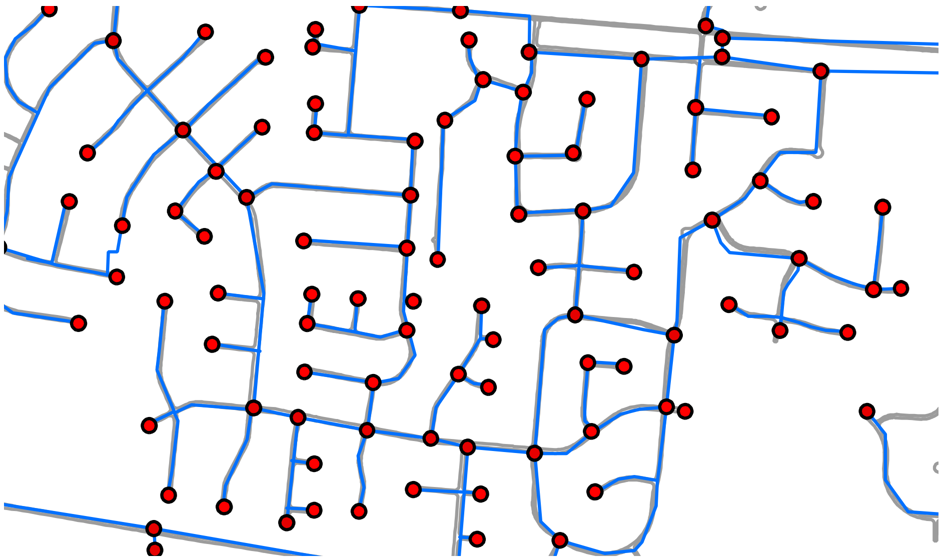
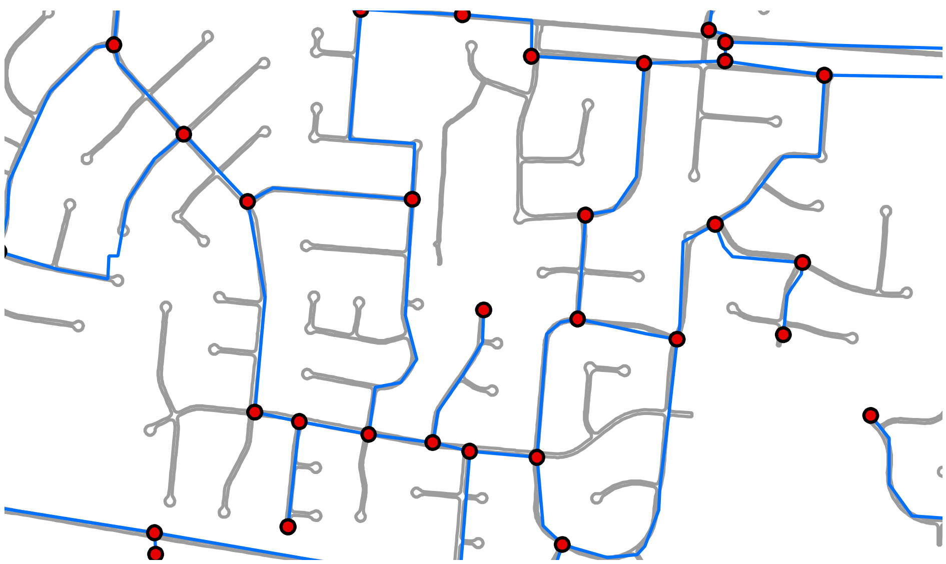


Exhibit 6.3b Sample Subdivision Layout in a More Skeletonized Model



Diurnal Demand Variation

The prediction of water age or water quality requires an extended period simulation (EPS). To run a hydraulic model EPS, demand patterns showing the variation in usage over time are required. Therefore, models must not only include realistic base demands but must also reflect the variation in demand over time. For water age or water quality simulation in the modeling SSS, a minimum of a 24-hour EPS is required and therefore this discussion will refer to diurnal demand variations.

Residential customers typically show a diurnal variation of water use with a peak in the morning (before work) and in the evening (after work), with little use during the night. Large users, such as industries, may use water on a different schedule than residential users. For example, a factory running full production 24 hours per day will not decrease its water usage during the night. In order to simulate realistic water movement throughout the distribution system and calibrate your model, capture the different patterns of usage, particularly for large users. Systems are encouraged to verify the diurnal water usage patterns for large users and to include separate demand variation categories for these users if they differ from a typical residential user.

Diurnal curves will also vary by season. For example, residential use will often increase in the evening and night hours during the summer due to lawn watering. Other systems may experience seasonal population shifts that will affect the demand patterns.

Demand patterns can be derived from a mass balance calculation using water production and pumping records, tank levels, and other operational data. Most reference books on hydraulic modeling include an explanation of diurnal demand variation calculations. The pattern is a series of multipliers that represent the ratio of instantaneous demand to the average daily demand at a given point in time. The average of all multipliers is equal to 1.0. Exhibit 6.4 shows an example of a diurnal demand variation pattern.

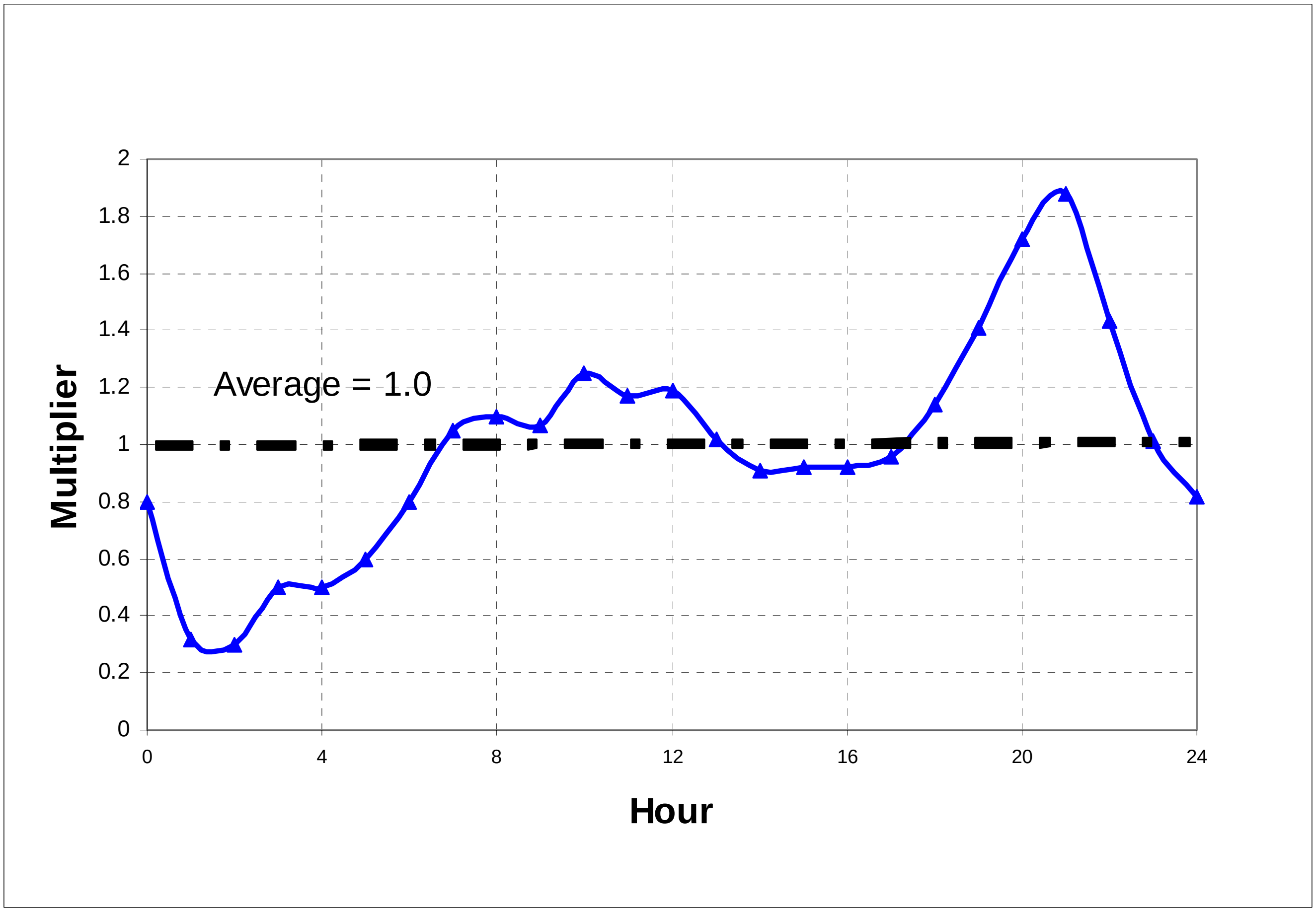
The IDSE requires modeling of the peak month of TTHM formation and therefore systems **must** ensure that their model adequately simulates demand variation during that month for the purposes of the SSS. In addition to diurnal demand patterns, the total demand in the model must match the typical demand for the peak month of TTHM formation. The base demand in the model may need to be adjusted by using a global demand multiplier to better represent the peak month of TTHM formation. See Section 6.3 for guidance on selecting the peak month for TTHM formation.

6.1.3 Operational Controls

Another important feature of a good EPS model is the ability to simulate system operation using controls. Controls are used within the model to turn on or off pumps, open or close valves, and perform other operations to mimic the real-life operations that occur in a system. The ability of the model to simulate the actual operation of the system requires the specification of controls.

Hydraulic modeling software offers several options for controls. In general, controls are either time-based or logical. Time-based controls perform a specific operation (e.g. turn on a pump) at a specified time in the simulation. Logical controls perform a given operation based on an evaluation of conditions in the system (e.g. turn on a pump when the tank is half empty). For large systems, a series of conditions must often be met before a change in status of operation can occur. To simulate these cases, complex logical controls can be created in the model.

Exhibit 6.4 Example Diurnal Demand Variation Pattern



The simulation of water age and water quality throughout a distribution system is heavily impacted by the modeled behavior at the storage facilities. The behavior of the storage facilities is in turn greatly affected by the operational rules used to control levels and fill rates. Therefore it is important that systems ensure that the controls used in the hydraulic model provide a simulation of true system operation.

For the SSS using a distribution system model, you must simulate the conditions during the period with the highest TTHM formation potential in your model.

6.1.4 Calibration

Once a base model for a distribution system has been developed, the model must be calibrated to match the simulated system performance to actual operating conditions. Calibration is generally an iterative process where model parameters are adjusted until simulation results match field conditions. Systems must demonstrate that their model is either calibrated using data collected during the peak month for TTHM formation or, if previously calibrated to a different time period, can satisfactorily simulate operation during the period with the highest TTHM formation potential through model verification. Calibration of a model for steady-state simulations only is not adequate for the modeling SSS. The model **must** be calibrated in extended period simulation for at least a 24-hour period. Because storage facilities have such a significant impact upon water age and reliability of water age predictions throughout the distribution system, you **must** compare and evaluate the model predictions versus the actual water levels of **all storage facilities** in the system to meet calibration requirements. However, you are only required to submit the graph for the storage facility with the highest water age in each pressure zone.

Calibration is never exact and there are no official calibration standards or guidelines in the United States. There is general agreement in the modeling profession that the extent of calibration should reflect the intended uses of the model. For example, a more rigorous model calibration would be necessary when the model is used to make detailed design calculations versus general master planning, where a larger margin of error in calibration may be acceptable. Calibration performed several years ago for the purposes of general master planning **is not acceptable** for the modeling SSS. For more information regarding the calibration of distribution system hydraulic models, refer to *Modeling Water Quality in Drinking Water Distribution Systems* (Clark and Grayman, 1998), *Advanced Water Distribution Modeling and Management* (Walski et al., 2003), or other reference books.

Calibration Data Collection

Calibration data will vary by system depending on the type and number of facilities involved. In general, calibration data will include:

- Flow and discharge pressure at each pump and/or pumping facility
- Water level in each storage facility (elevated and ground storage)
- Pressure data, either at facilities or other locations in the distribution system
- Flow tests at hydrants
- Friction factor (C-factor) tests
- System-wide demand and diurnal pattern information

Many systems collect operational data using supervisory control and data acquisition (SCADA) systems, chart recorders, or other types of dataloggers. It is important to obtain operational data over a 24-hour time period so that the EPS model can be calibrated for each time step. This data must represent the actual operating conditions during the peak historical month for TTHM formation.

Field studies may also be conducted to obtain flow test and friction factor test data. If possible, such tests should coincide with operational data collection to provide a robust data set. Reference books can provide instructions for conducting these tests.

If the model was previously calibrated to a time that does not coincide with the peak month for TTHM formation (e.g., calibrated to an average day in March and the peak month for

TTHM formation is August), additional data will need to be collected to verify the performance of the model during the peak month for TTHM formation.

The operation of storage facilities in distribution systems has a significant impact on water retention and potential for water quality degradation. Therefore, a simulation of the behavior of all storage facilities during the peak month for TTHM formation is required as part of the modeling SSS. The ability of the calibrated model to predict actual water levels in all storage facilities must be verified.

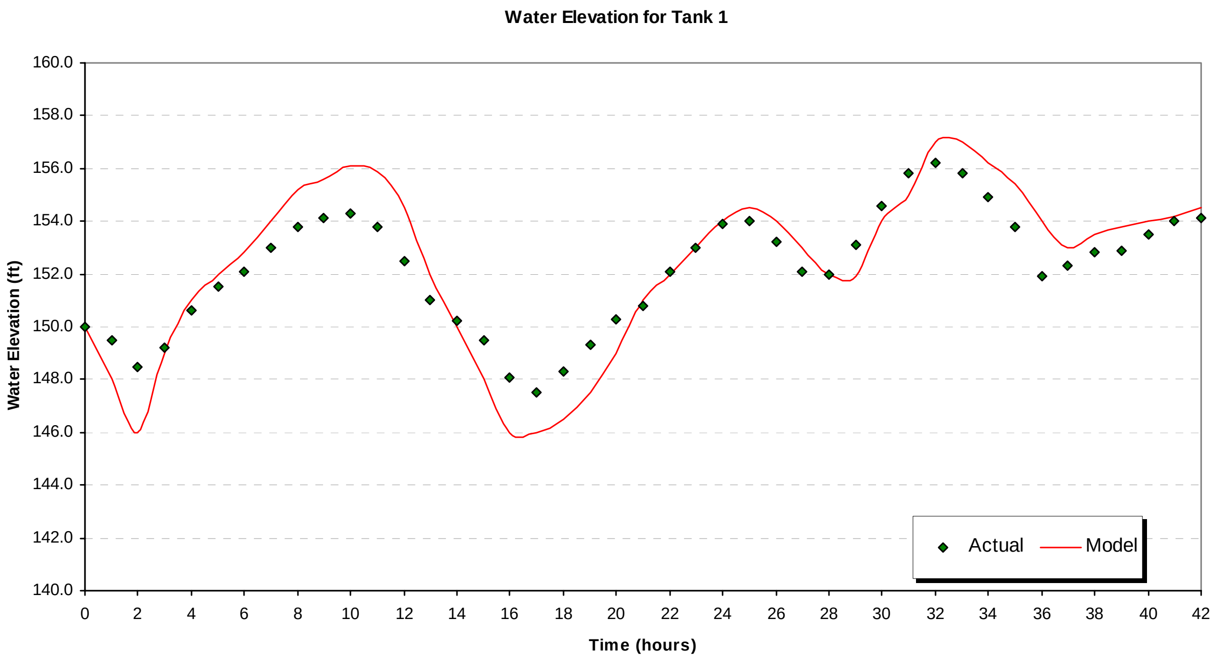
In your modeling study plan you are required to describe your calibration process to verify the adequacy of the model for the purposes of the SSS. If your model is not calibrated at the time you submit your Modeling SSS Plan, you **must** describe the calibration activities that are proposed to take place. You will then be required to submit your final calibration documentation as part of your IDSE report. If you have already completed your calibration, you **must** include the following in your modeling study plan:

- A model results graph of water level versus time for the storage facility with the highest water age in each pressure zone of the system. If a pressure zone has no storage facilities located within its boundaries, no graph is required for that zone. The graph must include both simulated (model) and observed (actual) water levels during the period of highest TTHM formation potential. The submitted graph should show results for a minimum simulation length of 24 hours, with time increments no greater than 1 hour. An example of an acceptable graph is shown in Exhibit 6.5.

- A time series graph of the residence time at the longest residence time storage facility in the distribution system showing the predictions for the entire EPS simulation period (i.e., from time zero until the time it takes for the model to reach a consistently repeating pattern of residence time). An example of an acceptable graph is shown in Exhibit 6.7. This graph will be produced as part of your water age modeling analysis. Guidance on conducting the water age modeling analysis is given in Section 6.2.

If your model simulation results do not match the observed water level variations in the storage facility but you feel that your model is sufficiently calibrated to be used in the SSS, additional justification should be provided in your modeling study plan.

Exhibit 6.5 Sample of an Acceptable Graph for Demonstration of Model Calibration



6.2 Modeling Analysis

Using your calibrated hydraulic model of the distribution system, a water age simulation must be run and analyzed to show 24 hour average residence time predictions throughout the distribution system. Consecutive systems and systems with multiple sources with different water quality should consider how the water age entering the distribution system and differing DBP formation potential will influence model predictions and analysis. Appendix G discusses approaches that can be used to analyze hydraulic models in these situations.

If your model calibration is not complete, a preliminary modeling analysis using the existing model must be conducted and submitted with your modeling study plan. All required calibration activities must then be completed **within 12 months of your required plan submission date**. Documentation of your calibration along with the final modeling analysis using the calibrated model must then be submitted as part of your IDSE Report. If your model is calibrated, you should submit your final water age results in your modeling study plan (see Section 6.4 for guidance).

The following sections provide guidance for the modeling analysis and the completion of the modeling study plan.

6.2.1 Water Age Modeling

For the modeling SSS, water age is being used as a surrogate for TTHM concentration. A water age analysis can be conducted using a hydraulic model without additional input of water quality data. This simulation option calculates the length of time that each parcel of water has been in the system after leaving the source(s). The water age calculation is highly dependent on the operational controls in the model (e.g., tank water levels used to control pump settings). Therefore, the model must be set up to match the operating conditions during the peak month for TTHM formation. This may require adjustments to model demands and controls.

Each water age simulation begins with an initial age of zero at all model nodes. The water age increases as the simulation time increases until fresh water from the source arrives at a given node. Nodes with zero or very small demand, especially at dead ends, will not receive fresh water and therefore will not have an accurate simulation of water age. Similarly, the water age for tanks will be equal to the simulation time until the entire volume of the tank has been refreshed with water from the source. Depending on operating conditions in the simulation, this may take as long as several weeks.

To overcome the effects of the initial conditions in a water age analysis, ensure that the simulation runs for a sufficient length of time. The required length of the water age simulation will vary depending on system characteristics, but can be approximated by the time it would take to fully turn over all water in the worst case storage facility. The average water age for a given storage facility is approximately equal to the inverse of the percent turnover. For example, a tank with an average daily volume turnover of 33% has an average water age of 3 days (100/33 = 3); a tank with an average daily volume turnover of 25% has an average water age of 4 days (100/25 = 4). However, hydraulic models have limited ability to account for tank mixing characteristics. Storage facilities with poor mixing characteristics may have water that is significantly older than the average water age.

An appropriate simulation time should generate a consistent, repeating pattern of water age in the storage facility with the highest average water age. An example of a repeating pattern is shown in the case study example in Section 6.2.2. Once the simulation has been completed, only results from the stable, repeating portion of the simulation (e.g., the last 24 hours) should be used in subsequent analyses. The intent of using a long simulation time for water age is not to replicate multiple different days of operation of the system but only to overcome the effects of initial water age settings (zero at all nodes) on the results.

Because of the length of the simulation for water age, controls should be checked to ensure that they will perform properly throughout the simulation. Time-based controls that refer to the simulation time (e.g. turn on Pump 1 at hour 11) will need to be adjusted to cover the full length of the simulation. Many software packages have an option to use clock time rather than simulation time for controls. The use of clock time (e.g. turn on Pump 1 at clock time 11) will repeat the operation on each day of the simulation at the same time while the use of simulation time will only perform the operation only once during the entire run. Logical controls (e.g. turn on Pump 1 when Tank 1 level is 20 feet) will generally perform fine in a longer simulation, but should be checked.

Water age simulation is also sensitive to the time step used for calculations. In most software packages this is referred to as the water quality time step. In general, the accuracy of the simulation increases as the time step is decreased. However, the use of very small time steps can result in longer processing time for larger models. A time step on the order of 1 to 5 minutes is generally good for water age simulation, depending on the system configuration. Trial runs with different time steps can be conducted to determine if the water age simulation is sensitive to the time step selected.

Once the water age simulation is completed, the model results from the stable (repeating) part of the simulation can be used to calculate an average water age at each node in the distribution system. If your model calibration is not complete, the results of a modeling analysis showing the preliminary (over 24 hours) water age results throughout the distribution system **must** be submitted with your model study plan. In this case, the modeling analysis must be verified after model calibration and the revised results must be submitted with your IDSE report. If your model calibration is complete, you should submit your final water age results with the model study plan (in lieu of the preliminary results). In either case, EPA recommends that you submit water age results in tabular format to minimize security risks to your system.

6.2.2 Modeling Analysis Example

This case study is based on the NET3.NET example from the EPANET 2 modeling package. This package can be downloaded from: www.epa.gov/ORD/NRMRL/wswrd/epanet.html. The same analysis can be completed using most modeling software packages, although the exact process may differ slightly.

The system, shown in Exhibit 6.6, contains two sources and three storage tanks. The treatment plant at the LAKE source operates only from 6 AM to 8 PM while pumping from the RIVER source is controlled by the level in Tank 1. The sources have similar DBP concentrations and formation potentials and therefore can be considered to have the same effect on the final concentrations observed in the distribution system. For a more complex example for a system with different source characteristics, see Appendix G.

The model was already calibrated for summer conditions. The system data were then modified to reflect the demands and operating conditions that were expected to occur during the peak month for TTHM formation. This required the following change to the Simple Control rule (time based) that was applied to the hours of operation for the pump at the LAKE source (Link 10):

```
Link 10 OPEN AT CLOCKTIME 6 AM
Link 10 CLOSED AT CLOCKTIME 8 PM
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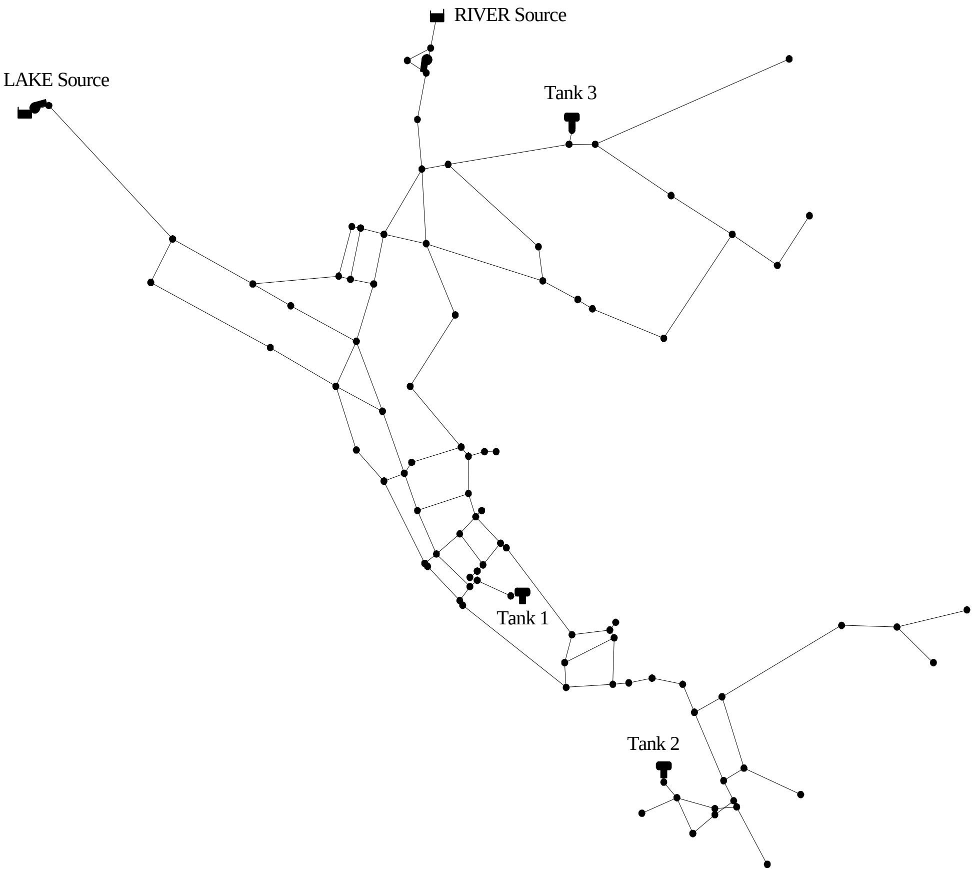
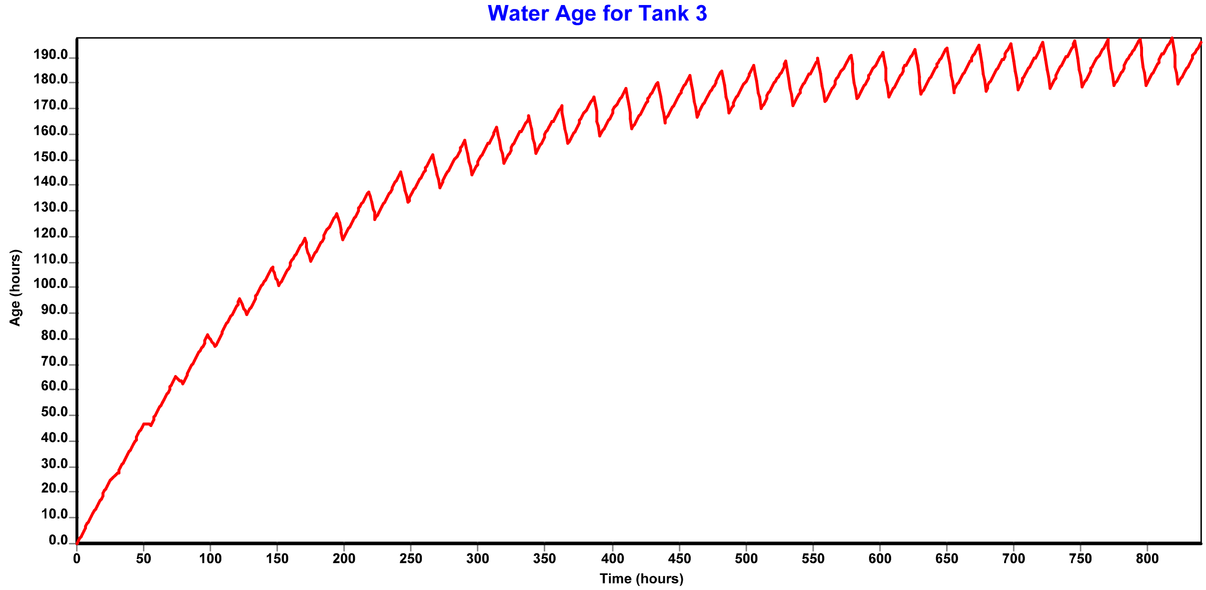
The calibration was verified for the peak month for TTHM formation by producing the tank level graph depicted in Exhibit 6.5. The fit in this graph verifies that the previous calibration is adequate to simulate operations during the peak month of TTHM formation.

Exhibit 6.6 Schematic of the Case Study Distribution System



Water age simulations were then completed using increasing simulation durations (e.g., 120 hours, 240 hours, etc.) until it was apparent that the water age in the storage tanks had equilibrated. The default water quality time step of 5 minutes was used for each of these simulations. The largest tank, Tank 3, was found to take the longest time to equilibrate. Exhibit 6.7 shows the time history of water age in this tank over an 840 hour simulation period.

Exhibit 6.7 Water Age Graph for the Tank with the Highest Water Age



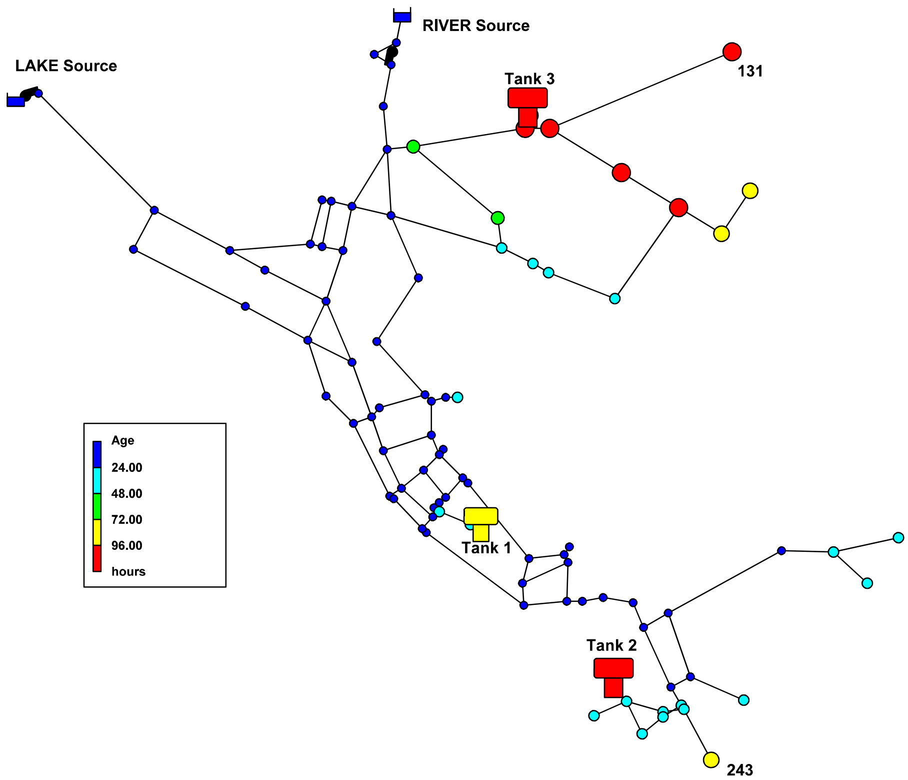
To make sure that this result was not sensitive to the water quality time step used, an additional run was made using a reduced time step. Results from the smaller time step matched those for the 5 minute time step.

Next, an analysis was conducted to find the average water age at each location in the network. To do this, the following modifications were made to the network's data:

1. the water quality time step was kept at 5 minutes
2. the simulation duration was kept at 840 hours
3. the Report Start Time was set to 792 hours (i.e., 48 hours before the end of the simulation)
4. the Statistic being reported by the program was set to AVERAGE (so that the average age over the last 48 hours of the simulation would be reported).

The resulting average water age throughout the network is displayed graphically in Exhibit 6.8. EPA suggests that you submit your 24 hour average residence time predictions in tabular format without identifying all nodes on your distribution system schematic to avoid creating a security risk for your system. An example of this is provided in Appendix F. However, you will probably want to rely on graphic output (e.g., Exhibit 6.8) as you evaluate your model to select SSS monitoring locations as described in Section 6.3.

Exhibit 6.8 Locational Average Water Age Throughout the Study Area



6.3 Determining SSS Monitoring Requirements and Schedule

As part of the SSS using a distribution system hydraulic model, you must collect TTHM and HAA5 samples from the distribution system during the peak month for TTHM formation. The number of monitoring locations must equal or exceed the required number of locations required for IDSE standard monitoring. Stage 1 DBPR compliance monitoring locations can <u>not</u> be selected as locations for your SSS monitoring. The types of locations (near entry point, high TTHM, high HAA5, and average residence time) must also match the requirements for IDSE standard monitoring. See Exhibit 6.9 to determine your monitoring location criteria according to your system size and source water type.

Exhibit 6.9 Requirements for Modeling SSS Sampling

Source Water Type	Population Size Category[1]	Distribution System Monitoring Locations[2]				
		Total Number of Samples	Near Entry Points	Average Residence Time	High TTHM Locations	High HAA5 Locations
Subpart H	<500 consecutive systems	2	1	....	1	....
	<500 non-consecutive systems	2	....	....	1	1
	500-3,300 consecutive systems	2	1	....	1	....
	500-3,300 non-consecutive systems	2	....	....	1	1
	3,301-9,999	4	....	1	2	1
	10,000-49,999	8	1	2	3	2
	50,000-249,999	16	3	4	5	4
	250,000-999,999	24	4	6	8	6
	1,000,000-4,999,999	32	6	8	10	8
	≥5,000,000	40	8	10	12	10
Ground Water	<500 consecutive systems	2	1	....	1	....
	<500 non-consecutive systems	2	....	....	1	1
	500-9,999	2	....	....	1	1
	10,000-99,999	6	1	1	2	2
	100,000-499,999	8	1	1	3	3
	≥500,000	12	2	2	4	4

[1] Your monitoring requirements (locations and frequency) are based on the population served by your system.
[2] A dual sample set (i.e., a TTHM and an HAA5 sample) must be taken at each monitoring location during each monitoring period.

You should review all available compliance, study, or operational data to determine the peak historical month for TTHM formation for your system. If you have monthly or quarterly TTHM monitoring data, EPA recommends that you use this data as the basis for your historical month. If you do not have monthly or quarterly data, EPA recommends that you select the month with warmest water temperature as your peak month for TTHM formation. In some cases, you may find data in addition to TTHM and temperature data helpful in selecting your peak historical month. For example, some systems may regularly see an increase in total organic carbon (TOC) levels in the spring or fall. If your TTHM monitoring does not capture a seasonal increase in TOC, you may want to consider the month with highest TOC when selecting your peak historical month.

You should include the basis for selecting your peak month for TTHM formation in your Modeling Study Plan (see Section 6.4 for guidance on completing the modeling study plan).

Systems have different requirements for describing sampling plans in their modeling study plans depending on whether they have completed calibration of their models.

- If you have not completed model calibration you must provide the number of samples you plan to take and the planned sampling month in your modeling study plan.

- If your calibration and modeling analysis are complete but sampling is not yet done, you should indicate the proposed SSS sampling locations on your distribution schematic in your modeling study plan.
- If you have completed calibration and sampling, you must indicate the sampled locations on your distribution schematic in your study plan. You should strongly consider submitting the IDSE report along with your modeling study plan.

Note that sampling must be completed by the deadline in your requirements summary sheet.

6.4 Preparing your Modeling Study Plan

After you have verified that your model meets the criteria in Section 6.1.1 through 6.1.4 and have determined the number and timing of your SSS samples, you are ready to prepare your modeling study plan. Every system that conducts a modeling SSS **must** prepare and submit a modeling study plan. You should submit your plan to the Information Processing and Management Center (IPMC) for review by EPA or your state. See Section 1.4 of this guidance manual for information on how to submit your plan to the IPMC.

EPA has developed a **Modeling Study Plan Form (Form 4)**, presented in this section and available electronically as part of the **IDSE Tool.** You are not required to use this form; however, if you choose not to use it, refer to Exhibit 6.2 for a list of the minimum elements you must include in your modeling study plan.

The IDSE Tool creates a custom form for your system and provides links to technical guidance from this manual. The tool is available on EPA's website at http://www.epa.gov/safewater/disinfection/stage2 .

IDSE Tool

If your model is not calibrated but you plan to calibrate your model and complete the modeling analysis as part of the SSS, you must submit your plan with a description of the proposed calibration work to be done. You must also indicate how all requirements will be completed within 12 months of your required plan submission date and provide a description of how you intend to use your model to select monitoring locations. This will allow time to correct deficiencies that might become apparent during the calibration process. A preliminary water age analysis must also be conducted with your existing model and submitted as part of the plan (if your model is calibrated, this should be your final water age analysis). If your model does not meet the requirements in Exhibit 6.1 and you are unable to address all of the questions on Form 4, you should provide information about how you plan to address those issues during the SSS.

Your deadline for submitting your study plan can be found on your requirements summary sheet in Chapter 2. If EPA or your state does not approve or request modifications to your plan, or notify you that your plan is still under review within 12 months after the deadline for plan submission, you may consider the plan approved. **If you have not yet completed calibration of your model, you must continue calibrating your model while your plan is**

being reviewed to meet the requirement that all required calibration must be completed no later than 12 months after your plan submission deadline.

Form 4 includes the following sections:

I. General Information
II. IDSE Requirements
III. Model Description
IV. Peak Month for TTHM Formation
V. Modeling Information
VI. Planned Stage 1 Compliance Monitoring Schedule
VII. Distribution System Schematic
VIII. Attachments

Sections of the form with an asterisk (*) are required by the Stage 2 DBPR. An example of a completed modeling study plan using this form is provided in Appendix F.

I. General Information

I.A. PWS information* - Important definitions for classifying your system are provided in the **definitions section** at the beginning of this guidance manual. If you have any questions on this section, contact EPA or your state.

PWSID - Enter your PWSID identification number here. This number is typically assigned by your state.

PWS Name - Enter the name of your system here.

PWS Address - Enter the primary mailing address for your water system here.

Population Served - Enter the number of people served by your PWS. Remember, this is your RETAIL population served, not including the population served by consecutive systems that purchase water from you.

System Type - Put a check mark in the appropriate box to identify whether your system is a CWS or a NTNCWS. Definitions for CWS and NTNCWS can be found in the **definitions section** at the beginning of this guidance manual.

Source Water Type - Put a check mark in the appropriate box to identify whether your system is a subpart H system or a ground water system. If you use any surface water or GWUDI as a source, mark the subpart H box. Definitions for subpart H system (including GWUDI) and ground water system can be found in the **definitions section** at the beginning of this guidance manual.

Buying/Selling Relationships - Put a check mark in the appropriate box to identify whether your system is a consecutive system, a wholesale system, or neither. If you are both a consecutive and wholesale system (e.g., you buy and sell water), check both boxes. Definitions for consecutive system and wholesale system can be found in the **definitions section** at the beginning of this guidance manual and in **Appendix D**.

I.B. Date submitted* - Enter either the date that you are submitting the form electronically, putting it in the mailbox, or dropping it off with an express delivery service. Be sure to submit your modeling study plan before the deadline found on your requirements summary sheet.

I.C. PWS Operations - This section asks questions about your system to help inform EPA and state personnel during the plan review process.

Residual Disinfectant Type - Put a check mark in the appropriate box to identify the type of disinfectant you most often use **to maintain a residual in your distribution system** (not necessarily the same disinfectant used for primary disinfection at the treatment plant). If you use chloramine but switch to free chlorine for a short time, you should still check chloramine only. If you use chloramine and chlorine regularly in your system (e.g, 4 months of free chlorine and 8 months of chloramines), check both chlorine and chloramine. If you maintain your residual with a disinfectant other than chlorine or chloramines (e.g., chlorine dioxide), you should place a check next to the box marked "Other" and enter the type of disinfectant you use in the blank next to "Other".

Number of Disinfected Sources - Enter the total number of sources that deliver disinfected water to your distribution system. If you connect to a single wholesale system at a number of locations in your distribution system, consider this one source. Multiple wells that are disinfected at a common treatment plant should also be considered one source. Do not count wells that are not disinfected or are disinfected by UV only.

I.D. Contact Person* - Enter the contact information of the person who is submitting the form. This should be the person who will be available to answer questions from EPA and/or the state reviewers.

II. IDSE Requirements*

II.A. SSS Monitoring - Copy the required number of samples from the table in Exhibit 6.9 that corresponds to your source type and the population served by your system.

II.B. IDSE Schedule - Enter the schedule for your system based on the letter that you received from EPA or your state. See Chapter 2 for more information on the letter.

II.C. SSS Monitoring Frequency - You are required to monitor during the peak month of TTHM formation. If you plan to conduct additional monitoring, describe it here.

III. Model Description

III.A. Yes/No Questions* These questions refer to the physical data contained in your model. Circle Y or N to indicate if your model complies with the requirements.

III.B. Model Development and Calibration* Provide a description of the history of development and calibration of your model. Describe what the model has been used to do, such as evaluating operational scenarios, capital improvements planning, or water quality assessment. Discuss the types of decisions that were based on results from the model. An example of this type of description is:

The model was developed in 2004 using GIS data for the water system. The model was calibrated to maximum day flow conditions during July 2004. The calibrated model has been used by our staff to identify improvements needed to serve a new subdivision and to change our tank operating procedures to minimize water age and maintain chlorine residual.

III.C. Demand Data For each question, provide a brief description of the data and methods used to assign customer demands to the model.

III.D. Calibration Activities* For each question, provide a brief description of the data and methods used to calibrate your model. If your model is not currently calibrated but you propose to calibrate the model as part of the SSS, provide a description of the calibration effort you plan to undertake to ensure that calibration is completed within 12 months of your required plan submission date.

If calibration is complete:

- Submit a graph that documents your model calibration by showing simulated tank levels versus observed levels for the storage facility with the highest water age in each pressure zone of your system (see Exhibit 6.5 for an example)*.

IV. Peak Month for TTHM Formation

IV.A. Peak Month for TTHM Formation* - Enter the month that you determined to be your peak month for TTHM formation. See Section 6.3 for guidelines for selecting your peak month for TTHM formation.

IV.B. Justification of Peak Month for TTHM Formation - Describe how you determined in which month TTHM formation is highest in your system. You should describe the types of data used to reach your conclusion.

V. **Modeling Information*** - For each question, provide a brief description of the methods used (or planned) to perform modeling for water age.

- If your model calibration has been completed, the modeling analysis should be described in this section. Submit a graph of water age versus time for the entire simulation duration for the tank with the highest overall water age in the system*

- If your model calibration is not complete, a preliminary modeling analysis must be conducted with your existing model and the results must be submitted with your SSS plan. In this case, the modeling analysis must be verified after model calibration and revised results must be submitted with your IDSE report.

All systems must submit model output showing preliminary (or final) average water age results over a 24-hour period as part of their modeling study plan. The 24-hour period used for the average water age results table should represent a simulation time after the model has achieved a stable, repeating water age pattern (e.g. the last 24 hours of the simulation). EPA recommends that you submit this in tabular format to not pose a security risk to your system.

VI. **Planned Stage 1 DBPR Compliance Monitoring Schedule* -** Enter the projected sampling schedule for the number of Stage 1 DBPR monitoring periods in which you will conduct Stage 1 DBPR monitoring during your system specific study. Verify that site IDs in this table match the IDs on your distribution system schematic. If you are required to monitor at more than 8 Stage 1 DBPR locations you will need to attach additional sheets. You may also want to attach your Stage 1 DBPR monitoring plan.

VII. **Distribution System Schematic*** - Attach a distribution system schematic to your study plan. The schematic must include the location of entry points and their sources, all storage facilities, and locations of completed SSS monitoring (if applicable) and all subpart L compliance monitoring. If you have not selected your SSS sample sites, you must show these sites on a revised version of the schematic when you submit your IDSE report.

Modeling study plans will not be considered confidential business information (CBI) and are subject to the Freedom of Information Act (FOIA). *Therefore**, your distribution system schematic should not contain information that poses a security risk to your system.*** EPA suggests that you submit a **Distribution system schematic with no landmarks or addresses indicated.** In addition to the required information indicated above, you should also include pressure zone boundaries, locations of pump stations, and the map scale.

Schematics should be as clear and easy to read as possible. They should typically be submitted on a scale of between 1:4,000 and 1:8,000; however, larger-scale drawings are acceptable as long as systems components can still be clearly shown. All sizes from 8½ inches x 11 inches to larger, plan-sized sheets are acceptable. If electronic versions are submitted, use one of the following file types:

- Adobe PDF file (*.pdf)
- Microsoft Word (*.doc)
- WordPerfect (*.wpd)
- Image file (*.gif, *.bmp, *.jpg, *.jpeg)

VIII. Attachments - Put a check mark in each of the boxes corresponding to any attachments that you have included in your report.

Note that some of the attachments are required by the Stage 2 DBPR:

- Distribution System Schematic*
- Tabular or spreadsheet documentation that your model meets minimum requirement*
- Graph of predicted tank levels vs. measured tank levels for the storage facility with the highest residence time in each pressure zone* (Required if calibration is complete)
- Time series graph of water age at the longest residence time storage facility in the distribution system showing the predictions for the entire EPS simulation period* (Required if calibration is complete)
- Model output showing preliminary 24 hour average water age predictions for all nodes throughout the distribution system* (Required for all submissions. If your model is calibrated, this should be your final water age predictions.)

If you submit your study plan electronically, you also have the option to submit attachments in hard copy. Include a note in your electronic study plan explaining that attachments are being submitted in hard copy, and mail the hard copy to the IPMC mailing address in your Requirements Summary Sheet. The IPMC will match the hard copy submission with your electronic submission when it is received.

Enter the total number of pages in your study plan (including attachments) in the blank at the bottom of this section. This will allow EPA or your state to ensure that all pages were received.

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Form 4: Modeling Study Plan

I. GENERAL INFORMATION

A. PWS Information*

B. Date Submitted* ___________

PWSID: ____________________

PWS Name: ____________________

PWS Address: ____________________

City: ______________ State: _____ Zip: ____________

Population Served: ____________________

System Type:	Source Water Type:	Buying / Selling Relationships:
☐ CWS	☐ Subpart H	☐ Consecutive System
☐ NTNCWS	☐ Ground	☐ Wholesale System
		☐ Neither

C. PWS Operations

Residual Disinfectant Type: ☐ Chlorine ☐ Chloramines ☐ Other:_____________

Number of Disinfected Sources: ___ Surface ___GWUDI ____ Ground ___ Purchased

D. Contact Person*

Name: ____________________

Title: ____________________

Phone #: ______________ Fax #: ______________

E-mail: ____________________

II. IDSE REQUIREMENTS*

A. SSS Monitoring		B. Schedule	C. SSS Monitoring Frequency
Number of Samples per Monitoring Period	___	☐ Schedule 1	☐ During peak month of TTHM formation (1 monitoring period)
Number of Monitoring Periods	___	☐ Schedule 2	
		☐ Schedule 3	☐ Additional (describe) _____________
Total	___	☐ Schedule 4	_________________________________

Form 4: Modeling Study Plan

III. MODEL DESCRIPTION

A. Answer Yes or No to the following questions*
(provide documentation in attached sheets)

1. Is your model an Extended Period Simulation model? Y / N

2. Does your model meet the minimum requirements described below? Attach tables or spreadsheets to demonstrate that your model meets these requirements.

Include 75% of pipe volume	Y / N
Include 50% of pipe length	Y / N
Include all pressure zones	Y / N
Include all pipes 12" and larger	Y / N
Include all 8" and larger pipes that connect pressure zones, influence zones from different sources, storage facilities, major demand areas, pumps, and control valves, or are known or expected to be significant conveyors of water	Y / N
Include all 6" and larger pipes that connect remote areas of a distribution system to the main portion of the system	Y / N
Include all storage facilities with standard operations represented in the model	Y / N
Include all active pump stations with realistic controls	Y / N
Include all active control valves	Y / N

3. Is your model (or will it be) calibrated to simulate actual water levels at all storage facilities and represent the current distribution system configuration during the period of high TTHM formation? Y / N

4. If calibration is complete, does the model simulate 24 hour variation in demand and show a consistently repeating 24 hour pattern of residence time? Y / N

B. Provide a history of your model development and calibration*, including dates ***(attach additional sheets if needed)***

____

____

Form 4: Modeling Study Plan

III. MODEL DESCRIPTION (Continued)

C. How was demand data assigned to the model? ***(attach additional sheets if needed)***

1.	What method was used to assign demands throughout the system?	
2.	How did you estimate diurnal demand variation? How did you determine total system demand?	
3.	How many demand categories did you use?	
4.	How did you address large water users?	

D. Describe all calibration activities* If your model is not currently calibrated, describe how calibration will be completed within 12 months of the required plan submission date using the questions 1-8 as guidance ***(attach additional sheets if needed).***

1.	When was the model last calibrated?	
2.	What types of data were used in the calibration?	
3.	When was the calibration data collected?	
4.	What field tests have been performed to collect calibration data?	

Form 4: Modeling Study Plan

III. MODEL DESCRIPTION (Continued)

D. (Continued)

5.	How did you determine friction factors (C-factors)?	
6.	Was the calibration completed for the peak month for TTHM formation? If not, was the model performance verified for the peak month for TTHM formation?	
7.	How well do actual tank levels correlate with predicted tank levels during the peak month for TTHM formation? **See Attachments (Section VIII) for additional submission requirements.**	
8.	If you are using a water quality model, what parameters are modeled? How was the model calibrated?	

IV. PEAK MONTH FOR TTHM FORMATION

A. Peak Month For TTHM Formation* ______________

B. Justification of Peak Month for TTHM Formation

Describe how your system determined which month is the peak month for TTHM formation (*attach additional sheets if needed*):

____

____

____

____

____

____

Form 4: Modeling Study Plan

V. MODELING INFORMATION *

How was the SSS modeling performed? *(attach additional sheets as needed)*

1.	Was modeling done for the operating conditions during the peak month for TTHM formation?	
2.	How were operational controls represented in the model?	
3.	How was water age simulated during the peak month for TTHM formation (time steps, length of simulation, etc.)? If not yet done, indicate how this will be addressed in the IDSE report.	
4.	What are the average water age results for your distribution system? **See Attachments (Section VIII) for additional submission requirements.**	

VI. PLANNED STAGE 1 DBPR COMPLIANCE MONITORING SCHEDULE*

Stage 1 DBPR Monitoring Site ID (from map) [1]	Projected Sampling Date (date or week) [2]			
	Period 1	Period 2	Period 3	Period 4

[1] Verify that site IDs match IDs on your distribution system schematic (See Section VII of this form). Attach additional copies if you are required to monitor at more than 8 Stage 1 DBPR sites.

[2] period = monitoring period. Complete for the number of periods in which you must conduct Stage 1 DBPR monitoring during IDSE monitoring. Can list exact date or week (e.g., week of 7/9/07)

Form 4: Modeling Study Plan

VII. DISTRIBUTION SYSTEM SCHEMATIC*

ATTACH a schematic of your distribution system.

Distribution system schematics are not confidential and should not contain information that poses a ***security risk*** to your system. EPA recommends that you submit the following:

> **Distribution system schematic with no landmarks or addresses indicated.** Show locations of sources, entry points, storage facilities, locations of completed monitoring, and Stage 1 compliance monitoring locations (required). Also include pressure zone boundaries and locations of pump stations. Provide map scale.

VIII. ATTACHMENTS

- ☐ Distribution System Schematic* (Section VII).
- ☐ Tabular or spreadsheet documentation that your model meets minimum requirements***** (Section III.A).
- ☐ Additional sheets for explaining your model (Section III.B).
- ☐ Graph of predicted tank levels vs. measured tank levels for the storage facility with the highest residence time in each pressure zone* (Section III.D). **Required if calibration is complete.**
- ☐ Time series graph of water age at the longest residence time storage facility in the distribution system showing the predictions for the entire EPS simulation period* (Section V). **Required if calibration is complete.**
- ☐ Additional sheets for explaining how you selected the peak historic month for TTHM formation (Section IV).
- ☐ Model output showing preliminary 24 hour average water age predictions for all nodes throughout the distribution system* (Required for all submissions. If your model is calibrated, this should be your final water age predictions.) (Section V).
- ☐ Additional sheets describing the planned Stage 1 DBPR Compliance Monitoring Schedule (Section VI).

Total Number of Pages in Your Plan _____

Note: All items marked with an asterisk (*) are required by the rule.

6.5 Selecting SSS Monitoring Sites and Conducting Monitoring

If EPA or your state does not approve or request modifications to your plan, or notify you that your plan is still under review **within 12 months** after the deadline for plan submission, **you may consider the plan approved**. Follow your approved study plan as you select SSS monitoring sites and conduct monitoring. Once your calibration and modeling analysis is completed (Sections 6.1.4 and 6.2) the next step is to select your SSS monitoring locations using the model results and supplemental data. After the locations are selected, you will collect samples during the peak month of TTHM formation and use this data, along with your model results, to select your Stage 2 DBPR Sites.

6.5.1 Select SSS Monitoring Locations

As discussed in Section 6.3, systems should determine the number of SSS monitoring locations for their system type and size based on the information provided in Exhibit 6.9.

You should keep track of your decision making process as you select SSS monitoring locations and then select Stage 2 DBPR compliance monitoring locations because it will help you justify your Stage 2 compliance monitoring site selection. When you prepare your IDSE report, you will be required to provide justification for the selection of each Stage 2 DBPR compliance monitoring site based on model results, monitoring results and additional data analysis.

Depending on your system size and source water type, you will select up to four different kinds of SSS monitoring sites: near entry point sites, average residence time sites, high TTHM sites, and high HAA5 sites. Guidance for near entry point sites is provided in Section 6.5.1.1. Section 6.5.1.2 provides guidelines for using water age estimates from your model to select average residence time and high TTHM sites. Section 6.5.1.3 provides additional considerations for selecting high HAA5 sites. Lastly, Section 6.5.1.4 provides a discussion of overarching issues for consideration when you select your final SSS monitoring sites.

6.5.1.1 Identify Near Entry Point Monitoring Locations

Data from sites near the entry points to the distribution system represent minimum residence time and can be used as a baseline for interpreting changes in water quality as water travels through the system. EPA recommends that you use the following procedure to select near entry point monitoring sites.

Step 1. Determine How Many Near Entry Point Sites You Need for SSS Monitoring

Determine how many near entry point monitoring sites you are required to have by referring to Exhibit 6.9. Remember that SSS sampling requirements for models are based on the population served by your individual system, not the largest population in your combined distribution system.

Step 2. Determine How Many Entry Points are in Your System

For the purposes of the IDSE, entry points are the locations where disinfected water enters your distribution system. Entry points can convey treated surface water, disinfected water from wells, or purchased water from a wholesale system (as long as it has been disinfected). Entry points generally include seasonal or intermittent connections. If a well is not disinfected or is disinfected using ultraviolet light (UV) only, you should not consider it an entry point for the purposes of the IDSE.

Step 3. Compare Results from Step 1 to Step 2

- If the number of near entry point sites required matches the number of entry points in your system, select a sampling location near each entry point.

- If your system has FEWER entry points than required near entry point SSS monitoring locations, you **must** replace the unassigned near entry point sites with high TTHM and HAA5 sites to maintain the required total number of SSS monitoring sites for models. If you have an odd number of unused near entry point sites, select an additional high TTHM site. See Chapter 7, Section 7.1.1 of this guidance manual for an example of how systems used this procedure to replace near entry point sites with high TTHM and high HAA5 sites.

- If your system has MORE entry points than required near entry point SSS monitoring locations, you **must** take samples near entry points to the distribution system having the highest annual water flows. Section 7.1.1 of this guidance manual also includes an example of selecting entry points with the highest annual water flows.

The Stage 2 DBPR does not define near entry point sites explicitly. EPA recommends that you locate your near entry point sites ***between the entrance to the distribution system and no later than first customer***. If you are a consecutive system, a sample tap at the master meter would be an appropriate near entry point site. If you do not have a sample tap at your master meter, consider using the first customer as your near entry point site.

6.5.1.2 Use Your Model to Identify Average Residence Time and High TTHM Locations

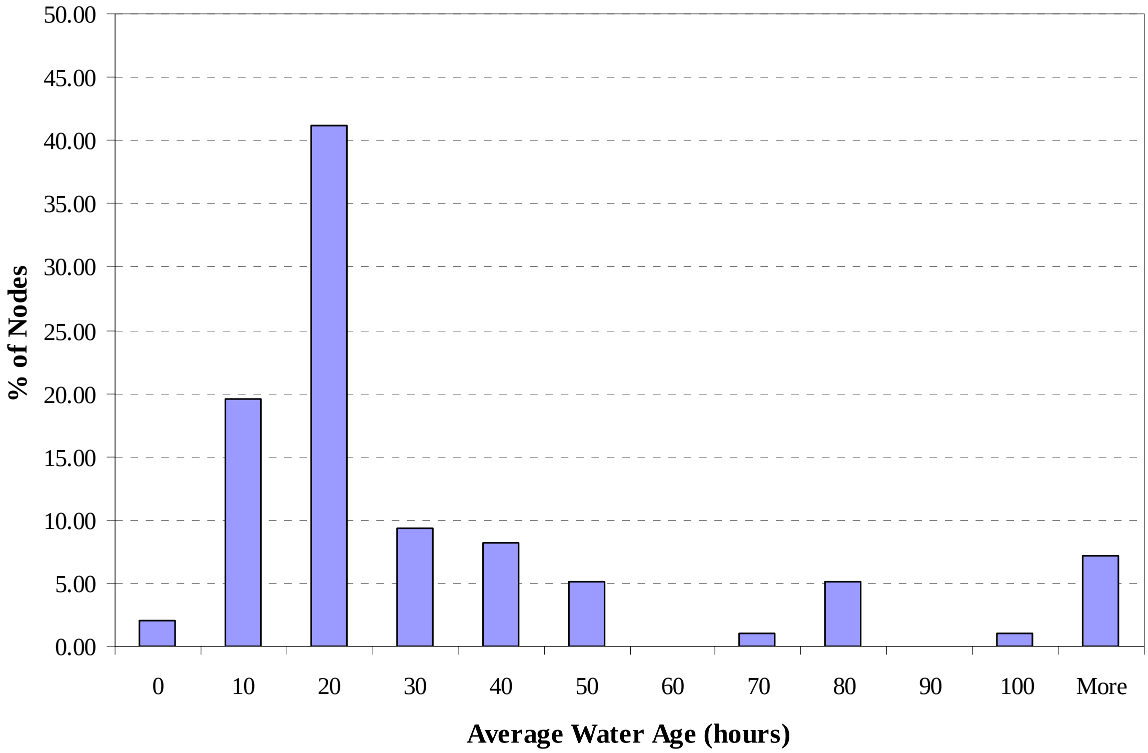
Identifying Average Residence Time Sites

Average residence time is the average age of water delivered to customers in a distribution system. Average residence time is *not* simply one-half the maximum residence time. Ideally, it should be a flow-weighted or population-weighted estimate. The model results for water age/DBP concentration can be used to determine the average residence time for your system. One option for doing this is to list the water age/DBP concentration results in ranked order for the entire system, as shown in Exhibit 6.10. This will help you to plot a histogram of the results as shown in Exhibit 6.11. A histogram plot sorts the water age results into groups and shows the percentage of nodes with water ages falling within the given range. From the histogram it can be seen that the greatest number of nodes have water ages falling in the 20 hour bin (bin range = 15 to 25 hours) and therefore the most frequently occurring water age is 20 hours. Using this method, 20 hours would be a reasonable average water age estimate for the system.

Exhibit 6.10 Ranking of Water Age Results

Rank	Node ID	Water Age (hours)
1	RIVER	0
2	LAKE	0
3	10	0.03
4	60	0.08
	...	
25	267	10.36
26	275	10.39
27	159	10.54
	...	
47	197	12.26
48	211	14.70
49	181	14.87
	...	
71	149	30.58
72	247	30.62
73	231	31.31
	...	
95	Tank 2	122.41
96	131	135.44
97	Tank 3	189.26

Exhibit 6.11 Histogram of Water Age Results



Identify High TTHM Sites

It is not the intent of IDSE monitoring to identify sites with maximum daily or hourly TTHM concentrations. Instead, you should choose candidate sites to represent areas of the distribution system that you expect to have high average TTHM concentrations as compared to other areas in the system. Increased water age typically leads to higher TTHM concentrations. This principle is the basis of the guidance provided for selecting high TTHM sites using your model. If you choose to consider additional factors in identifying high TTHM locations, Section 7.1.1 Step 4 describes typical water quality characteristics of high TTHM sites.

High TTHM sites can be identified by ranking the average water age results for nodes in the model. For model results that directly simulate TTHM concentration, nodes can be ranked by concentration to identify representative high locations. Areas in the distribution system where water is mixed or blended from two different supply points can result in an area of stagnant water, often with high water age and potential for high TTHM concentration. You should select sites from your model with the highest water age or TTHM concentration.

Color coded maps such as those shown in the case study example in Section 6.2.2 can be helpful in interpreting the model results to identify representative high TTHM locations. Many software and GIS packages can be used to plot water age/TTHM concentration results along with other water quality data to produce a graphical representation of the system.

You should also consider the following issues as you use your model to select high TTHM locations:

- Water age at zero-demand nodes, particularly dead ends, may not be accurate.

- The accuracy of water age estimates from a model generally decreases as the model moves from large diameter mains to small diameter mains to subdivision piping and dead-ends. This is due to the increasing uncertainty in water usage rates as the system moves away from large, aggregate demands to smaller demands exerted by a few customers or a single customer.

If the model is skeletonized, the model results for high water age/TTHM concentration areas should be compared to maps of the actual distribution system piping and to actual customer locations in those areas before sample locations are selected. You should try to assure that the sample location is representative of the actual distribution system, not the model, in cases where actual pipes may not all be included in the model in the high residence time areas.

6.5.1.3 Use Your Model and Other Data to Identify High HAA5 Sites

As with high TTHM SSS monitoring sites, it is not the intent of IDSE monitoring to identify sites with maximum daily or hourly HAA5 concentrations. Instead, you should choose high HAA5 SSS monitoring sites to represent areas of the distribution system that you expect to have high average HAA5 concentrations as compared to other areas in the system. Higher temperatures and increased residence time can lead to higher HAA5 concentrations. However, HAA5 can biodegrade when disinfectant residual levels are low or non-existent. Therefore, a high HAA5 site will not necessarily be the site with the longest residence time. This principle is the basis for the guidance provided for selecting candidate sites. If you choose to consider additional factors in identifying high HAA5 locations, Section 7.1.1 Step 5 describes typical water quality characteristics of high HAA5 sites. You may use the 3-step procedure below to select high HAA5 sites.

Step 1: Identify areas with high water age

Similar to high TTHM sites, the sites with high water age can be identified by ranking the water age results for nodes in the model. For model results that simulate HAA5 formation, nodes can be ranked by concentration to identify representative high locations. Areas in the distribution system where water is mixed or blended from two different supply points can result in an area of stagnant water, often with high water age. You should select sites from your model with the representative high water age or HAA5 concentration that were not already selected as high TTHM sites. The next paragraph will provide guidance on eliminating those locations where biodegradation is likely.

Color coded maps such as those shown in the case study example in Section 6.2.2 can be helpful in interpreting the model results to identify representative high HAA5 locations. Many software and GIS packages can be used to plot water age/HAA5 concentration results along with other water quality data to produce a graphical representation of the system.

Step 2: Eliminate sites where you suspect biodegradation

Analysis of disinfectant residual is important in determining potential for biodegradation of HAA5. Sources of disinfectant residual data may include regular compliance monitoring sites (e.g., SWTR or Stage 1 DBPR compliance monitoring sites), operational sample sites, or special sites sampled in response to customer complaints.

Low disinfectant residuals relative to the system average generally indicate longer residence times, and may correlate with higher HAA5 concentrations. However, you should eliminate any areas that regularly or typically in the summer months have free chlorine residuals less than **0.2 mg/L** or with chloramine residuals less than **0.5 mg/L**. Sites with residuals below these minimum levels are more likely to have significant biological activity and are therefore more likely to have biodegradation of HAA5. Because disinfectant residuals typically decay faster during the summer, a review of data from the summer months may be more useful in identifying areas with consistently low residuals. HPC data may also be helpful in determining whether biodegradation of HAA5 is occurring in your system.

Step 3. Verify Sites Using a Map

If the model is skeletonized, the model results for high water age/DBP concentration areas should be compared to maps of the actual distribution system piping and to actual customer locations in those areas before sample locations are selected. Systems should try to assure that the sample location is representative of the actual distribution system, not the model, in cases where actual pipes may not all be included in the model in the high residence time areas.

6.5.1.4 Finalize SSS Monitoring Locations

To finalize the selection of SSS monitoring locations, you should plot all your sites on a map and check that the sites meet all the criteria shown in the following steps. Color-coding and other mapping options may be helpful in this process.

Step 1: Confirm that sites match expectations

The purpose of this step is to confirm that your sites cover key areas. The following questions may be useful as you evaluate all SSS monitoring sites together on the map:

- Are high TTHM SSS monitoring sites located in the extremities of the distribution system?
- Are high HAA5 SSS monitoring sites located in the extremities where there are no indications of biological activity or low disinfectant residual?
- Are high TTHM and HAA5 SSS monitoring sites generally downstream of storage facilities and booster disinfection stations?

- Are there any other areas where you suspect water age is high that are not represented with a high TTHM (and possibly high HAA5) SSS monitoring site?

Step 2. Consider geographic coverage and other factors to finalize site selection

The following issues should be considered in making final choices for SSS monitoring sites:

- **Look for geographic representation**. Select sites that are geographically diverse from the other SSS monitoring sites and existing Stage 1 compliance monitoring locations. EPA recommends that you locate at least one of the high TTHM SSS monitoring sites in a remote area of the distribution system.   If your distribution system contains hydraulically isolated portions, you should represent as many of these as possible with at least one SSS site. If you are only required to select one high TTHM site, it is strongly recommended that you locate this site far away from the treatment plant, near the last group of customers (but prior to the last fire hydrant).

- **Look for hydraulic representation**. Select SSS monitoring sites in hydraulically different areas. Even if sites are geographically near each other, they may represent different pressure zones. You should also select sites that represent mixing zones if multiple sources with different water quality characteristics are used.

- **Use sites that "multi-task"**. Prioritize sites that meet the multiple siting criteria and those identified based on more than one data source. For example, a candidate high TTHM SSS monitoring site based on water age model results that has low disinfectant residual historically, is near the edge of the distribution system and is downstream of a tank would be an excellent SSS monitoring site.

- **Select sites that are projected to have high water age** during the time of the day when sampling is normally done.

- **Consider site access**. Try to select SSS monitoring sites for which access will not be an issue. Each site should remain accessible over the long term in case the site is selected for Stage 2 DBPR compliance monitoring.

- **Select the best site in an area with several choices**. If you have more than enough sites in a given area of the distribution system and no other data favors one over the other, use historical TTHM or HAA5 data (if available) to prioritize sites.   For example, if disinfectant residual data are the same for three sites over the same periods, then the DBP data can be used to select a high TTHM/HAA5 SSS monitoring site. Remember that you *cannot* use Stage 1 DBPR compliance monitoring sites as SSS monitoring sites.

6.5.2 Special Case: Using DBP Formation Modeling to Select Sites

DBP modeling results using chemical constituent reactions can also be used to assist in selection of the SSS sampling locations. Systems should note that any DBP modeling would be used in addition to completing the modeling SSS requirements for analysis and submittal of water age results.

Most modeling software packages provide an option to model decay/formation of chemical constituents including DBPs with user-specified kinetic coefficients. To calibrate a model for a chemical constituent, field and laboratory tests are necessary to identify the kinetic coefficients (e.g. THM formation rate coefficient and limiting concentration) and to verify the results at different locations in the distribution system.

For a DBP formation simulation, the necessary input data includes:

- the DBP concentration leaving the source
- a first-order rate constant based on laboratory tests
- an ultimate formation potential (maximum concentration) of the DBP

As with the water age analysis, DBP modeling will begin each simulation with a zero concentration at every node unless the user specifies an initial concentration. Historical data could be used to determine initial concentrations throughout the distribution system. A long simulation, similar to one required for water age, could also be used to ensure that the results are not impacted by the initial concentration.

TTHM and HAA5 are usually modeled separately in distribution systems because they often have different formation rate constants and initial concentrations. HAAs may biodegrade in the distribution system but there is currently no mechanism in the modeling software to simulate both the formation and degradation simultaneously. In that case, HAA modeling may be better suited to general predictions of maximum possible concentration in the absence of degradation and may not calibrate well to actual field data.

6.5.3 Conducting Monitoring

This section presents sampling requirements and tips for sample collection for conducting monitoring for your SSS model.

REMINDER: you must continue to collect samples and comply with the Stage 1 DBPR during the IDSE. Results from SSS monitoring should **not** be used for making Stage 1 compliance determinations.

You must collect a **dual sample set** (i.e., two samples) at each location during the peak month for TTHM formation. One sample must be analyzed for TTHM and the other must be analyzed for HAA5. Two samples are required because the analytical methods used for the two groups of contaminants require different sample preservation methods. You must use EPA-approved methods for analysis of your TTHM and HAA5 samples. More information on EPA-approved methods can be found in Appendix C.

As you conduct SSS monitoring, you should keep in mind the following tips for sample collection:

- **Use appropriate sample bottles.** You should use sample bottles that already contain the appropriate dechlorinating agent and preservative for sample collection. You should contact your lab for a recommended sampling and preservation protocol. A typical sampling protocol can be found in Appendix C.

- **Flush your sample tap.** If you collect samples from a tap, you should open the cold water tap and allow the line to flush until the water temperature has stabilized (usually about 3-5 minutes). If you collect a sample at a hydrant or blow-off, the flushing time only needs to be long enough to purge the connecting line to the main. The purpose of this step is to ensure the sample does not represent stagnant water that has been sitting for a long time in the water line between the street and the faucet. The sample should represent the water flowing through the distribution system at the chosen sampling point.

- **Collect cold water samples.** If you collect indoor samples you should collect them from a cold water line.

- **Collect additional water quality data.** You may wish to collect additional water quality data, such as disinfectant residual and temperature data, at the time of DBP sample collection. This information can be helpful as you interpret monitoring results (e.g., unusually low residual at a location could mean unusually high residence time).

- **Re-sample if a sample is lost or broken.** If a sample bottle is lost or broken after sample collection, you should re-sample as soon as possible after the loss occurs. Only the lost sample needs to be recollected, not the entire sample set that was collected together. Make sure to note the loss of sample and resample date as a deviation in your IDSE report.

6.6 Selecting Stage 2 DBPR Compliance Monitoring Sites and Schedule

The purpose of the IDSE is to select Stage 2 DBPR compliance monitoring locations that reflect sites with representative high TTHM and HAA5 concentrations in the distribution system. After completion of the modeling analysis, selection of SSS monitoring locations and sampling during one monitoring period, the Stage 2 DBPR compliance monitoring sites must be selected for use in future compliance monitoring.

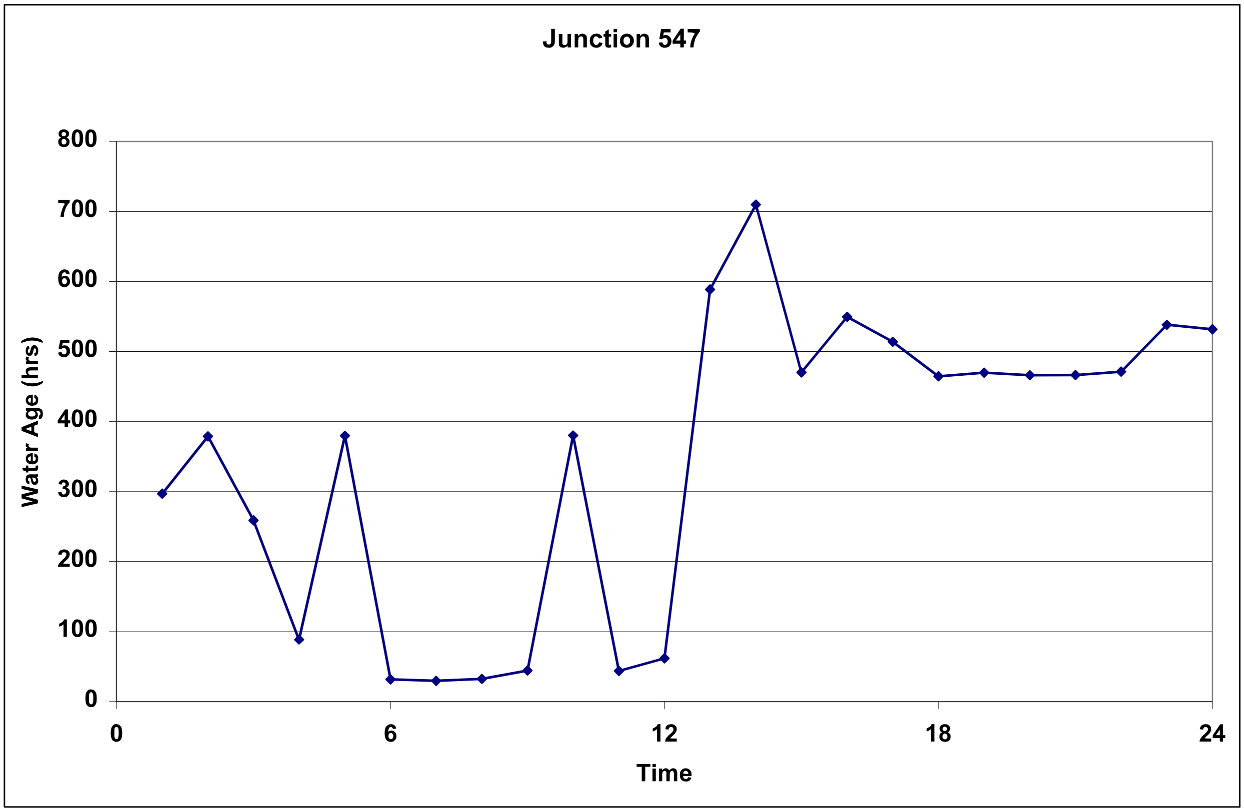
This section provides technical guidance for selecting Stage 2 Compliance Monitoring Sites. Justification for each site is required to be submitted in the IDSE report for a modeling SSS (See Section 6.7).

6.6.1 Analyzing Model Results at Monitoring Locations

To assist in the final selection of Stage 2 DBPR sampling locations, model results should be examined for each SSS monitoring location and each Stage 2 DBPR compliance monitoring location . It is recommended that you plot water age versus time for a minimum period of 24 hours at a time in the simulation when results have stabilized and are repeatable (e.g. last 24 hours of the simulation period) for each monitoring location. Note that you are required to submit a graph of water age for each monitoring location that is selected as a Stage 2 DBPR compliance monitoring site as part of the IDSE Report. As with all model analyses in the SSS, the typical operations in the peak month for TTHM formation must be represented. An example of an acceptable graph is given in Exhibit 6.12.

IMPORTANT NOTE: For security reasons, the graphs of water age for each selected Stage 2 compliance monitoring site should not be identified by site location number. A blind numbering system should be used on each graph that you can discuss with EPA or your state if they contact you with questions about your IDSE report.

Exhibit 6.12 Example of Typical Water Age Variation over Time



6.6.2 Analyzing SSS Monitoring Results

You must calculate the locational running annual average (LRAA) for each SSS monitoring site and Stage 1 DBPR compliance monitoring site in order to select Stage 2 DBPR compliance monitoring sites. The LRAA for each SSS monitoring site is equivalent to the single sample result taken during the peak month for TTHM formation (unless you conducted additional sampling). The LRAA for each Stage 1 DBPR compliance monitoring site should be the LRAA for the year in which you were required to complete SSS monitoring. It will be based on either one or four data points depending on your Stage 1 compliance monitoring frequency. You should consider using a spreadsheet to store your data and calculate your LRAAs.

6.6.3 Comparison of Modeling and Sampling Results

As part of the site selection process, you should compare modeling results to sampling results. Because of the dynamic nature of distribution systems, it is not expected that every sample will exactly match the model results. However, the sample data should generally demonstrate that the SSS monitoring locations correspond to the areas of the distribution system they were chosen to represent. Sampling results that do not fit with the predicted water age or DBP modeling results should be noted. This check is intended to look for trends that indicate the selected sites may not be appropriate and determine whether additional model analysis should be completed. For example, if many of the average residence time sites have TTHM concentrations that are significantly greater than at the high TTHM sites, this may indicate a problem with the model predictions. In this case it would be appropriate to revisit the model analysis to make sure the completed sampling represents high TTHM and HAA5 concentrations in the distribution system.

Systems should explain any discrepancies between the modeling and sampling results and describe any follow-up actions taken to investigate. In this case, systems should consider the following scenarios when analyzing their modeling and sampling results:

- The time of sample collection should be noted and compared to the water age graph to determine if the sample time coincided with the time of maximum water age. DBP concentrations can vary over time and while the average simulated concentration might be considered high, the concentration at certain times of the day may be relatively low.
- Operational events such as main breaks and flushing can change the typical flow patterns in a system and thereby affect the DBP concentrations.
- Additional field data collected during the sampling period (e.g. chlorine residual, heterotrophic plate count) may help to explain discrepancies between modeling and sampling results.
- Systems may choose to resample at the site(s).
- Verify that the model represents the current configuration of the distribution system. Unexpected sampling results may indicate inconsistencies in the model.

6.6.4 Select Final Compliance Monitoring Sites

You must first use the **site selection protocol in Exhibit 6.13** to identify Stage 2 compliance monitoring locations based on your LRAAs. The number of required Stage 2 compliance monitoring sites for your system can be found on page 2 of the **System Specific Study Requirements - Attachment** sheet in Chapter 2. If you complete all steps in the protocol and need additional compliance monitoring sites for the Stage 2 DBPR, repeat the protocol until the required number of sites has been selected. If you arrive at Step 3 or Step 7 and have no more Stage 1 DBPR sites from which to select, continue to the next step. You can also use **Worksheet 6.1** to help you organize your data.

You should compare Stage 2 sites selected using the protocol to model results for water age. In general, TTHM and HAA5 results and modeled water age are the most important factors in site selection. You should consider both predicted average water age and the 24-hour variation in water age. If you are choosing between two sites where one has large variations in water age throughout the day and the other is relatively consistent, you should select the site with consistent water age. Sites with discrepancies between model results and SSS monitoring results can be selected as Stage 2 DBPR compliance monitoring sites if justification is provided in the IDSE report.

The Stage 2 DBPR allows you to consider additional factors when selecting Stage 2 compliance monitoring locations. As you work through the site selection protocol, you should consider other factors that may lead you to select a site with a similar or slightly lower water age and/or LRAA. For example:

- The site provides more complete geographic coverage of the entire distribution system
- The site allows you to maintain a historical record
- Sampling at that site provides the opportunity to collect other water quality or operational data (e.g., chloramine systems may want to collect nitrate or nitrite data at that site)

Your IDSE report **must** include the basis (analytical results and modeling) and justification you used to select these Stage 2 DBPR compliance monitoring sites. This is particularly important for sites where there was a discrepancy between the model and the monitoring results. You should first explain why you selected the site for SSS monitoring, and then why you selected the site for Stage 2 compliance monitoring using modeling results and sample data. An example of how you might justify a site is given below.

> *This site has the highest water age of all nodes and had the highest TTHM levels of all samples collected during our SSS monitoring. Therefore, it was selected as our first high TTHM site.*

It is possible that EPA or your state may not concur with your justification and may require you to select different Stage 2 compliance monitoring sites.

Worksheet 6.1 Stage 2 DBPR Site Selection Worksheet for a Modeling SSS

Page 1 of 1

Instructions:

1) Enter the number of required Stage 2 DBPR compliance monitoring sites based on your ***System Specific Study Requirements - Attachment*** summary sheet from Chapter 2.

2) Enter the Site ID and LRAA for each SSS monitoring and Stage 1 compliance monitoring location. You may want to sort your entries in order by TTHM LRAA or HAA5 LRAA values.

3) As you work through the site selection protocol in Exhibit 6.13, fill in the "Stage 2 Site Type" column each time you select a site to indicate whether the site is a high TTHM, high HAA5, Existing Stage 1 DBPR Compliance Monitoring Site, or selected using criteria other than the protocol.

No. of Stage 2 DBPR Compliance Monitoring Sites Required

_____Highest TTHM _____Highest HAA5 ____Existing Stage 1 _______TOTAL

Site ID	LRAA		Stage 2 DBPR Site Type*
	TTHM (mg/L)	HAA5 (mg/L)	
Example	*0.075*	*0.045*	*Highest TTHM*

* Enter Highest TTHM, Highest HAA5, or existing Stage 1 DBPR

Exhibit 6.13 Protocol for Selecting Stage 2 DBPR (Subpart V) Compliance Monitoring Sites

	Steps[1] [required by rule]	Stage 2 Compliance Monitoring Sites Selected [2]
1	Select the location with the highest TTHM LRAA	1st highest TTHM site
2	Select the remaining location with the highest HAA5 LRAA	1st highest HAA5 site
3	For subpart H systems: Select the remaining existing Stage 1 DBPR average residence time compliance monitoring location with the highest HAA5 LRAA For ground water systems: Select the remaining existing Stage 1 DBPR maximum residence time compliance monitoring location with the highest HAA5 LRAA *Skip this step if you have no more Stage 1 DBPR sites*	1st Stage 1 DBPR site
4	Select the remaining location with the next highest TTHM LRAA.	2nd highest TTHM site
5	Select the remaining location with the next highest TTHM LRAA	3rd highest TTHM site
6	Select the remaining location with the next highest HAA5 LRAA	2nd highest HAA5 site
7	For subpart H systems: Select the remaining existing Stage 1 DBPR average residence time compliance monitoring location with the highest TTHM LRAA For ground water systems: Select the remaining existing Stage 1 DBPR maximum residence time compliance monitoring location with the highest TTHM LRAA *Skip this step if you have no more Stage 1 DBPR*	2nd Stage 1 DBPR site
8	Select the remaining location with the next highest HAA5 LRAA	3rd highest HAA5 site
If you need more Stage 2 DBPR compliance monitoring locations, Go back to ***Step 1*** *of this protocol and repeat the steps until you have selected the required number of total sites.*		

1. All steps are based on your calculated LRAAs for your SSS monitoring sites and Stage 1 DBPR compliance monitoring sites. This means that your existing Stage 1 DBPR sites can be selected in steps *other than* 3 or 7. Stop when you reach your required number of Stage 2 DBPR compliance monitoring sites.
2. You cannot select the same site as a highest TTHM and a highest HAA5 compliance monitoring site.

6.6.5 Determining Your Stage 2 DBPR Compliance Monitoring Schedule

The first step in determining your Stage 2 DBPR compliance monitoring schedule is to select your peak historical month. You should use the peak month for TTHM formation selected in your SSS modeling plan unless new data suggest another month. Refer to Section 6.3 for more information on determining peak historical month.

You **must** conduct Stage 2 DBPR compliance monitoring during the peak historical month. If you are a ground water system that serves more than 9,999 people or you are a surface water system that serves more than 499 people, you must also conduct Stage 2 compliance sampling at 90 day intervals before and/or after the peak historical month.

The intent of the required time interval is to ensure that samples are representative of the quality of water over an extended period and do not over-emphasize either high or low concentrations of TTHM or HAA5 that might occur seasonally. For example, a system on quarterly monitoring could sample in the **third full week of every third month**. It is not necessary to sample all sites on the same day.

6.7 Preparing the IDSE Report

Every system that conducts a modeling SSS **must** prepare and submit an IDSE Report. If you will have completed all requirements of the IDSE by your plan submittal deadline, you may submit completed forms or documentation for both the Modeling SSS Plan and IDSE Report for a Modeling SSS at the same time. You should submit the report to the Information Processing and Management Center (IPMC) for review by EPA or your state. See Section 1.4 of this guidance manual for information on how to submit your report to the IPMC.

EPA has developed an **IDSE Report for a Modeling SSS Form (Form 5)**, presented in this section and available electronically as part of the **IDSE Tool.** You are not required to use this form; however, if you choose not to use it, refer to Exhibit 6.14 for a list of the minimum elements you must include in your IDSE report. If any information has changed since submittal of your modeling study plan, revised information must be submitted with the report. A major component of the modeling study plan is to report on the final calibration of the hydraulic model and its suitability for use in the required modeling analysis. If you use Form 5 in this section, your IDSE report will contain all required information about your model.

The IDSE Tool creates a custom form for your system and provides links to technical guidance from this manual. The tool is available on EPA's website at http://www.epa.gov/safewater/disinfection/stage2.

IDSE Tool

Exhibit 6.14 Minimum Requirements for IDSE Report for a Modeling SSS

If you do not choose to use the IDSE Report for a Modeling SSS Form (Form 5), the following information must be provided in your IDSE Report:

- Analytical results from Stage 1 DBPR compliance monitoring and SSS monitoring in a tabular or spreadsheet format.
- An updated system schematic, if changed from your modeling study plan (Required if you did not indicate SSS monitoring locations in your study plan).
- Final information on model requirements, calibration, and modeling analysis, if changed or new since submittal of your study plan, including tables and graphs.
- A 24-hour time series graph of residence time for each Stage 2 DBPR compliance monitoring location selected.
- Selected Stage 2 DBPR compliance monitoring locations and timing, including the basis (analytical results and modeling) and justification for selection of those locations.
- Population served and system type (subpart H or ground water) if changed from your modeling study plan.
- An explanation of any deviations from your approved study plan.

Before you begin Stage 2 DBPR compliance monitoring, you will also be required to prepare a Stage 2 DBPR compliance monitoring plan. In addition, if you are a subpart H system serving >3,300 people, you must submit a copy of your Stage 2 compliance monitoring plan to the state. If you include **compliance calculation procedures** in your IDSE report, the report can meet the requirement of the plan, and you do not have to prepare or submit a separate plan. As a guide for specifying your compliance calculation procedures, refer to the Stage 1 DBPR, 141.133(b), and your Stage 1 compliance monitoring plan. Check with your state, as they may have different requirements under the Stage 2 DBPR. If you are a consecutive or wholesale system, your state may choose to use its special primacy authority to modify your Stage 2 compliance monitoring requirements. In this case, you should check with the state to see if they are going to use this authority. You should develop your IDSE report for the total number of required Stage 2 compliance locations for your system.

The IDSE Report for a Modeling SSS Form (Form 5) includes the following sections:

I. General Information
II. SSS and Stage 2 DBPR Requirements
III. Modeling Information
IV. SSS Monitoring Location Selection
V. SSS and Stage 1 DBPR Compliance Monitoring Results
VI. Selection of Stage 2 DBPR Compliance Monitoring Locations
VII. Justification of Stage 2 DBPR Compliance Monitoring Sites
VIII. Peak Historical Month
IX. Proposed Stage 2 DBPR Compliance Monitoring Dates
X. Distribution System Schematic
XI. Attachments

If you are submitting an SSS plan and IDSE report at the same time, you must submit the portions listed in bold above. Sections of the form with an asterisk (*) are required by the Stage 2 DBPR. An example of a complete IDSE report for a modeling SSS using this form is in Appendix F.

I. General Information

I.A. PWS Information* - If nothing has changed since you completed your modeling study plan, copy information from your plan into this section. If your system characteristics have changed, see Section 6.4 of this chapter for guidance on completing this section.

I.B. Date Submitted* - Enter either the date that you are submitting the form electronically, putting it in the mailbox, or dropping it off with an express delivery service. Be sure to submit your IDSE report before the deadline found on your requirements summary sheet.

I.C. PWS Operations - This section asks questions about your system to help inform EPA and state personnel during the plan review process. If nothing has changed since you completed your modeling study, copy information from your plan into this section. If your system characteristics have changed, see Section 6.4 of this chapter for guidance on completing this section.

I.D. Contact Person* - Enter the contact information of the person who is submitting the report. This should be the person who will be available to answer questions from EPA and/or state reviewers.

II. SSS and Stage 2 DBPR Requirements*

II.A. Number of Required Stage 2 DBPR Compliance Monitoring Sites - Refer to the ***System Specific Study Requirements - Attachment*** in Chapter 2. Copy the numbers from the table that correspond to your source type and the population served by your system.

II.B. IDSE Schedule - This should be the same schedule you entered for your modeling study plan. See Section 6.3 of this chapter for guidance.

II.C. Stage 2 DBPR Compliance Monitoring Frequency **-** Refer to the ***System Specific Study Requirements - Attachment*** in Chapter 2. From the "Stage 2 Compliance Monitoring Requirements" table, locate the monitoring frequency that corresponds to your source type and the population served by your system. Put a check mark in the box corresponding to that monitoring frequency.

II.D. Number of Required SSS Samples - Enter the number of samples you were required to collect during the peak month for TTHM formation.

III. Modeling Information

Systems with an approved model calibration as part of their modeling study plan do not need to complete this section. If any of your information submitted as part of the modeling study plan has changed, provide updated information in this section.

III.A. How was demand data assigned to the model? For each question, provide a brief description of the data and methods used to assign customer demands to the model.

III.B. Describe all calibration activities undertaken.* For each question, provide a brief description of the data and methods used to calibrate your model.

If you did not complete calibration prior to your study plan submittal or if your calibration has changed, submit a graph that documents your model calibration by showing simulated tank levels versus observed levels for the storage facility with the highest water age in each pressure zone of your system (see Exhibit 6.5 for an example)*.

Systems with an approved model calibration as part of their modeling study plan do not need to complete this section.

III.C. How was the SSS modeling performed?*

Systems with an approved model analysis as part of their modeling study plan do not need to complete this section unless their information has changed.

Systems who conducted their water age modeling analysis after submitting their modeling study plan should answer all questions.

- **Submit model output showing final average water age results over a 24-hour period***. The 24-hour period used for the average water age results table should represent a simulation time after the model has achieved a stable, repeating water age pattern (e.g. the last 24 hours of the simulation). EPA recommends that you submit this in tabular format to not pose a security risk to your system.

- **Submit a graph of water age versus time for the entire simulation duration for the tank with the highest overall water age in the system*.**

IV. SSS Monitoring Location Selection - Provide an explanation of the approach used to analyze water age results to select SSS monitoring locations. Describe how sites were ranked for water age (e.g. percentile, highest to lowest, etc.). Include any additional data that was used to assist in the analysis, such as residual disinfectant concentration. Describe practical considerations such as accessibility, coverage of geographic areas, or coverage of hydraulic zones that factored into the decision.

V. SSS and Stage 1 DBPR Compliance Monitoring Results*

V.A. <u>TTHM Results</u> - Enter the TTHM results for each monitoring site for each monitoring period in which you collected data. For each sample result, enter the date on which sampling was conducted. You should enter all SSS monitoring results as well as all Stage 1 DBPR compliance monitoring results collected during the IDSE period. If you collected samples during a single monitoring period, your LRAAs for those sites will be the same as the monitoring results. For each site ID, identify the location type (High TTHM, High HAA5, Average, Entry Point).

V.B. <u>HAA5 Results</u> - Enter the HAA5 results for each monitoring site for each monitoring period in which you collected data. For each sample result, enter the date on which sampling was conducted. You should enter all SSS monitoring results as well as all Stage 1 DBPR compliance monitoring results collected during the IDSE period. If you collected samples during a single monitoring period, your LRAAs for those sites will be the same as the monitoring results. For each site ID, identify the location type (High TTHM, High HAA5, Average, Entry Point).

V.C. <u>Where were your TTHM and HAA5 samples analyzed?</u> - Put a check mark in the appropriate box to identify whether your system analyzed TTHM and HAA5 samples in an in-house laboratory or sent the samples to a certified laboratory for analysis.

If you analyzed your TTHM and HAA5 samples in an in-house laboratory, check the appropriate box to identify whether your laboratory is certified. If you sent your TTHM and HAA5 samples to a certified laboratory, enter the name of the laboratory in the blank. If you used more than one laboratory (e.g., if you used different laboratories for SSS samples and Stage 1 DBPR compliance samples), list both laboratories, or check "in-house" and list the name of the laboratory if applicable.

V.D. What method(s) was used to analyze your TTHM and HAA5 samples? Put a check mark in the appropriate box to indicate the analytical method used to measure the TTHM and HAA5 concentrations of your SSS and Stage 1 DBPR compliance samples. If more than one method was used (e.g., if you used different laboratories for SSS samples and Stage 1 DBPR compliance samples), check more than one method. If you do not know what method was used, contact your laboratory.

VI. Selection of Stage 2 DBPR Compliance Monitoring Locations - Describe the comparison of sampling and modeling results. Provide a description of the comparison between sampling and modeling results, including any follow-up investigations done to resolve discrepancies. See Section 6.3.3 for more information.

- **You must submit a graph of water age versus time for each site selected***. You should show the selected sites on the distribution system schematic and assign each site a unique site ID (see Section XI). For security reasons, the graphs of water age for each selected Stage 2 compliance monitoring site should not be identified by site location number. A blind numbering system should be used on each graph, which you can discuss with EPA or your state if they contact you with questions about your IDSE report.

VII. Justification of Stage 2 DBPR Compliance Monitoring Sites* - Enter the site ID from the distribution schematic and the site category (highest TTHM, highest HAA5, or Stage 1 DBPR). You must provide a justification for each site including the modeling and sampling results that led you to select it. See Section 6.4.4 of this manual for guidance. For example, a justification for a highest HAA5 site might be:

High average water age, high HAA5 results during monitoring, measurable residual in historical TCR data, located in East Pressure Zone

Note that there is only space for 8 monitoring sites on this sheet. If you need more space, attach additional sheets.

VIII. Peak Historical Month

VIII.A Peak Historical Month for TTHM and HAA5* - Enter the month that you determined to be your peak historical month for TTHM and HAA5.

VIII.B Is Your Peak Historical Month the Same as Your Peak Month for TTHM Formation in Your Modeling Study Plan? - Put a check mark in the appropriate box to identify whether your system is using the same peak. If your SSS monitoring results or other factors prompted you to select a different peak month. explain how you selected a new peak month. Note that the modeling SSS was based on using the peak month for TTHM formation for the modeling analysis. However, compliance with Stage 2 DBPR is based on the peak historical month for TTHM and HAA5. You should use the same peak historical month that you used for your SSS monitoring unless you have convincing data to do otherwise.

IX. Proposed Stage 2 DBPR Compliance Monitoring Schedule* - Enter the ID for each Stage 2 DBPR compliance monitoring site in the table (these should match the ID's you enter in Section VII and on your schematic). Enter your proposed sampling schedule for the number of monitoring periods identified in Section II.C. The entry can be a specific date or week and can be in a number of different formats. For example:

- 7/9/07
- 2nd week in Nov '07
- Week of 7/9/07

Remember that at least one monitoring period must be during the peak historical month identified in Section VIII.A. Note that there is only space for 8 monitoring sites on this sheet. If you are a subpart H system serving more than 249,999 people you are required to monitor at more than 8 sites. Therefore, you will need to attach additional sheets.

X. Distribution System Schematic* A distribution system schematic is required *only if it has changed from your approved modeling study plan.* If it has changed, you must attach a distribution system schematic. **If you did not show your SSS monitoring locations on the distribution system schematic you submitted with your model study plan, you must submit a revised distribution system schematic**. See Section 6.4 of this manual for guidance.

XI. Attachments - Put a check mark in each of the boxes corresponding to any attachments that you have included in your report.

Note that there is only space for 8 monitoring sites in Section V and Section VII. If you need additional space you can attach additional sheets.

Note that some of the attachments are required by the rule.

If you deviated from your approved study plan, you must attach an explanation of all deviations.

If you submit your IDSE report electronically, you also have the option to submit attachments in hard copy. Include a note in your electronic IDSE report explaining that attachments are being submitted in hard copy, and mail the hard copy to the IPMC mailing address in your Requirements Summary Sheet. The IPMC will match the hard copy submission with your electronic submission when it is received.

If you are a subpart H system serving >3,300 people, you must submit a copy of your Stage 2 compliance monitoring plan to the state. If you include **compliance calculation procedures** in your IDSE report, the report can meet the requirement of the plan, and you do not have to prepare or submit a separate plan. As a guide for specifying your compliance calculation procedures, refer to the Stage 1 DBPR, 141.133(b), and your Stage 1 compliance monitoring plan. Check with your state, as they may have different requirements under the Stage 2 DBPR.

Enter the total number of pages in your IDSE report (including attachments) in the blank at the bottom of this section. This will allow EPA or your state to ensure that all pages were received.

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Form 5: IDSE Report for a Modeling SSS

I. GENERAL INFORMATION

(Skip this section if you are submitting the plan and report at the same time)

A. PWS Information*

PWSID: ____________________

PWS Name: ____________________

PWS Address: ____________________

City: ____________________ State: _____ Zip: __________

Population Served: ____________________

B. Date Submitted*

____

System Type:	Source Water Type:	Buying / Selling Relationships:
☐ CWS	☐ Subpart H	☐ Consecutive System
☐ NTNCWS	☐ Ground	☐ Wholesale System
		☐ Neither

C. PWS Operations

Residual Disinfectant Type: ☐ Chlorine ☐ Chloramines ☐ Other:__________

Number of Disinfected Sources: ___ Surface ___GWUDI ___Ground ___Purchased

D. Contact Person*

Name: ____________________

Title: ____________________

Phone Number: ____________________ Fax: ____________________

E-mail: ____________________

II. SSS AND STAGE 2 DBPR REQUIREMENTS*

A. Number of Required Stage 2 DBPR Compliance Monitoring Sites _____ TOTAL

Highest TTHM:_______ Stage 1 DBPR:_______

Highest HAA5:_______

B. IDSE Schedule

☐ Schedule 1

☐ Schedule 2

☐ Schedule 3

☐ Schedule 4

C. Stage 2 DBPR Compliance Monitoring Frequency

☐ Once during peak historical month

☐ Every 90 days (4 monitoring periods)

D. Number of Required SSS Samples

______ TOTAL

Form 5: IDSE Report for a Modeling SSS

III. MODELING INFORMATION
(Skip this section if you submitted a modeling study plan with an approved model calibration and your information has not changed, or if you are submitting your plan and report at the same time)

A. How was demand data assigned to the model? (*attach additional sheets if needed*)

1.	What method was used to assign demands throughout the system?	
2.	How did you estimate diurnal demand variation? How did you determine total system demand?	
3.	How many demand categories did you use?	
4.	How did you address large water users?	

B. Describe all calibration activities undertaken* (*attach additional sheets if needed*)

1.	When was the model last calibrated?	
2.	What types of data were used in the calibration?	
3.	When was the calibration data collected?	
4.	What field tests have been performed to collect calibration data?	

Form 5: IDSE Report for a Modeling SSS

III. MODELING INFORMATION (Continued)

5.	How did you determine friction factors (C-factors)?	
6.	Was the calibration completed for the peak month for TTHM formation? If not, was the model performance verified for the peak month for TTHM formation?	
7.	How well do actual tank levels correlate with predicted tank levels during the peak month for TTHM formation? **Submit a graph of predicted tank levels vs. measured tank levels for the storage facility with the highest water age in each pressure zone.***	
8.	If you are using a water quality model, what parameters are modeled? How was the model calibrated?	

Form 5: IDSE Report for a Modeling SSS

III. MODELING INFORMATION (Continued)

C. How was the SSS modeling performed?* (*attach additional sheets as needed*)

1.	Was modeling done for the operating conditions during the peak month for TTHM formation*?	
2.	How were operational controls represented in the model?	
3.	How was water age simulated during the peak month for TTHM formation (time steps, length of simulation, etc.)?	
4.	What are the average water age results for your distribution system? **Submit final model output showing 24-hour average residence time throughout the distribution system*.** **Submit graph of water age at the longest residence time storage facility in the distribution system showing the predictions for the entire EPS simulation period*.**	

Form 5: IDSE Report for a Modeling SSS

IV. SSS MONITORING LOCATION SELECTION

How were the SSS monitoring locations selected? ***(attach additional sheets as needed)***

1.	What model results were used as the basis for selection?	
2.	What criteria were used in selecting average residence time, high TTHM, and high HAA5 sites?	
3.	What additional data was used in the analysis, and how was it used?	
4.	How did you look at practical considerations like accessibility of sampling locations?	
5.	How did you verify that your selected sampling locations corresponded to the selected node in your model?	

Form 5: IDSE Report for a Modeling SSS

V. SSS AND STAGE 1 DBPR COMPLIANCE MONITORING RESULTS*

A. TTHM Results

Site ID & Category	Data Type	TTHM (mg/L)				LRAA
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					

Attach additional sheets as needed for SSS and Stage 1 DBPR results.

Form 5: IDSE Report for a Modeling SSS

V. SSS AND STAGE 1 DBPR COMPLIANCE MONITORING RESULTS* (Continued)

B. HAA5 Results

Site ID & Category	Data Type	HAA5 (mg/L)				LRAA
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					
	Sample Date					
	Sample Result					

Attach additional sheets as needed for SSS and Stage 1 DBPR results.

Form 5: IDSE Report for a Modeling SSS

V. SSS AND STAGE 1 DBPR COMPLIANCE MONITORING RESULTS* (Continued)

C. Where were your TTHM and HAA5 samples analyzed?

☐ In-House

Is your in-house laboratory certified? ☐ Yes ☐ No

☐ Certified Laboratory

Name of certified laboratory: ____________________

D. What method(s) was used to analyze your TTHM and HAA5 samples?

TTHM	HAA5	
☐ EPA 502.2	☐ EPA 552.1	☐ EPA 552.2
☐ EPA 524.2	☐ EPA 552.3	☐ SM 6251 B
☐ EPA 551.1		

VI. SELECTION OF STAGE 2 DBPR COMPLIANCE MONITORING LOCATIONS

Describe the comparison of sampling and modeling results (*attach additional sheets as needed*):

1.	How well did the sampling results correspond to the modeling results?	
2.	For samples that did not match well with model results, what follow-up investigations were performed?	
3.	Were additional samples collected? (Include data on table in Section IV)	
4.	**Submit a graph of water age versus time for each selected sampling location*.**	

Form 5: IDSE Report for a Modeling SSS

VII. JUSTIFICATION OF STAGE 2 DBPR COMPLIANCE MONITORING SITES*

Stage 2 Compliance Monitoring Site ID	Site Type	Justification
	☐ Highest TTHM ☐ Highest HAA5 ☐ Stage 1 DBPR	
	☐ Highest TTHM ☐ Highest HAA5 ☐ Stage 1 DBPR	
	☐ Highest TTHM ☐ Highest HAA5 ☐ Stage 1 DBPR	
	☐ Highest TTHM ☐ Highest HAA5 ☐ Stage 1 DBPR	
	☐ Highest TTHM ☐ Highest HAA5 ☐ Stage 1 DBPR	
	☐ Highest TTHM ☐ Highest HAA5 ☐ Stage 1 DBPR	
	☐ Highest TTHM ☐ Highest HAA5 ☐ Stage 1 DBPR	
	☐ Highest TTHM ☐ Highest HAA5 ☐ Stage 1 DBPR	

Attach additional copies of this sheet if you need more room.

Form 5: IDSE Report for a Modeling SSS

VIII. PEAK HISTORICAL MONTH

A. Peak Historical Month* ______________

B. Is Your Peak Historical Month the Same as your Peak Month in Your Modeling Study Plan?

☐ Yes ☐ No

If no, explain how you selected your new peak historical month *(attach additional sheets if needed)*:

____

____

____

____

____

____

IX. PROPOSED STAGE 2 COMPLIANCE MONITORING SCHEDULE*

Stage 2 Compliance Monitoring Site ID	Projected Sampling Date (date or week)[1]			
	period 1	period 2	period 3	period 4

[1] period = monitoring period. Complete for the number of monitoring periods from Section II.C.

Attach additional copies of this sheet if you need more room.

Form 5: IDSE Report for a Modeling SSS

X. DISTRIBUTION SYSTEM SCHEMATIC*

(Skip this section if you submitted a modeling study plan and your distribution system schematic ***was complete*** *and has not changed from your approved modeling study plan, or if you are submitting the plan and report at the same time)*

ATTACH a schematic of your distribution system. If your schematic has changed or if you did not show your SSS monitoring locations on the distribution system schematic you submitted with your model study plan (Form 4), you must submit a revised distribution system schematic.

XI. ATTACHMENTS

- ☐ Tabular or spreadsheet documentation that your model meets minimum calibration requirements if updated since approved modeling study plan* (Section III).
- ☐ Additional sheets for explaining model information/results, including required graphs if not submitted as part of an approved modeling study plan* (Section III).
- ☐ Additional sheets for sampling results, if needed (Section V).
- ☐ Additional sheets for selection of Stage 2 DBPR compliance monitoring sites (Section VI).
- ☐ Graph of water age versus time for all Stage 2 DBPR sites selected* (Section VI).
- ☐ Additional sheets for justification of Stage 2 DBPR Compliance Monitoring Sites, if needed (Section VII). **REQUIRED if you are a subpart H system serving more than 249,999 people**.
- ☐ Additional sheets for explaining how you selected the peak historical month (Section VIII).
- ☐ Additional sheets for proposed compliance monitoring schedule (Section IX). **REQUIRED if you are a subpart H system serving more than 249,999 people**.
- ☐ Explanation of deviations from approved study plan.
- ☐ Distribution system schematic* (Section X). **REQUIRED if it has changed from your approved model study plan or if monitoring locations were not shown**.
- ☐ Compliance calculation procedures (for Stage 2 Compliance Monitoring Plan).

Total Number of Pages in Your Report: ______

Note: All items marked with an asterisk (*) are required by the rule.

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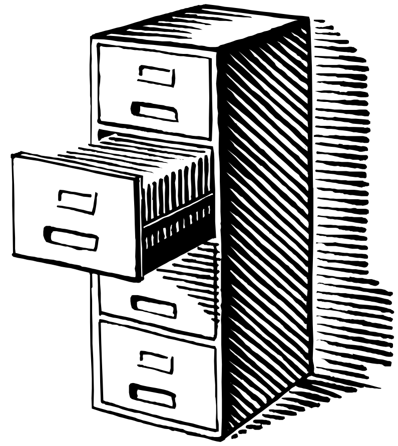
6.8 Recordkeeping



The IDSE report for a modeling SSS must be kept on file for **10 years** after the date it is submitted. If EPA or your state modifies the recommendations made in your report or approves alternative Stage 2 DBPR compliance monitoring locations, you must also keep a copy of EPA or your state's notification on file for 10 years after the date of the notification. You must make your IDSE report and any notification available for review by your state or the public.

The modeling study plan, including any modifications by EPA or your state, must also be kept on file for as long as you are required to retain your IDSE report for a modeling SSS. You must make the plan and any modifications available for review by your state or the public.

6.9 Next Steps: Preparing the Stage 2 DBPR Compliance Monitoring Plan

As the final step before you can begin compliance monitoring for the Stage 2 DBPR, you must develop and implement a **Stage 2 DBPR monitoring plan** by the deadline provided in your requirements summary sheet. The plan will be similar to your Stage 1 DBPR monitoring plan in that it will identify how you intend to sample for compliance with Stage 2. You must keep your plan on file for state and public review. If you are a subpart H system serving > 3,300 people, you **must** submit your plan to EPA or your state prior to when you are required to start monitoring.

Exhibit 6.15 contains the minimum requirements for what must be included in your Stage 2 DBPR compliance monitoring plan. Because compliance monitoring plans are not addressed as part of the IDSE provisions of the Stage 2 DBPR, ***EPA has not included detailed guidance for developing Stage 2 compliance monitoring plans in this guidance manual***. EPA plans to develop other manuals and training that address the compliance monitoring provisions of the Stage 2 DBPR.

See EPA's website http://www.epa.gov/safewater/disinfection/stage2 for a up-to-date inventory of Stage 2 DBPR guidance manuals and training materials, or call the Safe Drinking Water Hotline at 1-800-426-4791.

Exhibit 6.15 Required Contents of Stage 2 DBPR Compliance Monitoring Plans

All Systems	Additional Requirements for Consecutive and Wholesale Systems [1]
• Monitoring locations • Monitoring dates • Compliance calculation procedures	• If your state has used its special primacy authority to modify your monitoring requirements, you must include monitoring plans for other systems in your combined distribution system

1. See Appendix D of this manual for guidance specifically for consecutive and wholesale systems

References

References R.M. Clark and W.M. Grayman. 1998. "Modeling Water Quality in Drinking Water Systems", AWWA, Denver, CO

T.M. Walski, D.V. Chase, D.A. Savic, W. Grayman, S. Beckwith, E. Koelle. 2003. "Advanced Water Distribution Modeling and Management", Haestad Methods, Waterbury CT: Haestad Press.