BROWN AND CALDWELL

Technical Memorandum

6500 SW Macadam Avenue, Suite 200
Portland, OR 97239
Tel: 503-244-7005
Fax: 503-244-9095

Prepared for: City of Bend

Project Title: Bend WQ Monitoring for Compliance with Stage 2 DBP Rule

Project No: 133813

Technical Memorandum – Hydraulic Model Calibration

Date: May 2, 2008

To: Tom Hickman and Roger Prowell; City of Bend Water Division

From: Shem Liechty, Bob Willis, Ed Olson, Josh Brown; Brown and Caldwell

1. INTRODUCTION

To comply with the Stage 2 Disinfection Byproduct Rule (Stage 2 DBPR) the City of Bend (City) intends to complete the Initial Distribution System Evaluation (IDSE) using the modeling option of the System Specific Study (SSS) approach. Previously, the City has used a steady-state computer model of its water system; however, EPA guidelines for Stage 2 DBPR require the use of a dynamic model that is calibrated to operations during the peak month for total trihalomethanes (TTHM) formation. This technical memorandum (TM) describes the methods and data that were used to develop the dynamic model and calibrate it to the peak TTHM formation month, which was June 2005 for the City's water system. It includes a discussion of the modeling software that was used for the project, created model scenarios, demand allocation, hydraulic model modifications and the calibration results.

2. MODELING SOFTWARE

The City maintains and operates its hydraulic model in MWH Soft's H2ONET modeling software. For this study the model was converted to InfoWater for all hydraulic modification and calibration efforts. Upon completion of the project the water system model will be converted back to H2ONET. The City currently owns 3 licenses of the H2ONET software.

3. HYDRAULIC MODEL MODIFICATIONS

Prior to this project the City's steady-state model included most of the water system facilities; however, a number of model modifications were necessary to meet EPA's minimum model requirements. A dynamic model, or a model capable of performing an Extended Period Simulation (EPS), is required to perform the water age analysis to evaluate the system's Disinfection Byproducts (DBP) levels. EPS is a way of modeling a distribution system's changing demands and operational conditions over a specific time period. The general modifications made to convert the steady-state model to execute an EPS representative of Peak TTHM month formation include:

1. Add all Major Water Distribution System Facilities
2. Add all Operational Controls
3. Develop Diurnal Curve (representative of Peak TTHM or HAA5 Month)
4. Reallocate Demands (representative of Peak TTHM or HAA5 Month)

The specific modifications made during the calibration process are described in Section 6 of this TM.

4. MODEL SCENARIOS

Several different demand and operational conditions, or scenarios, were simulated in the model. Each scenario represents a different combination of demand conditions and operational settings for the water system. The scenarios created include:

1. Hydrant Test Calibration Scenarios
2. Dynamic Calibration Scenario
3. Peak Month TTHM Contamination Water Age Scenario

The Hydrant Test Calibration scenarios are steady-state simulations, which provide an instantaneous simulation of demands and operational settings at the time each test was performed in the field. The remaining scenarios are 24-hour dynamic or extended period simulations (EPS).

5. MODEL DEMANDS

Accuracy of a model is highly dependent on the accuracy of the distribution of demands in the model. Several demand sets for both the calibration and water age scenarios were developed and allocated in the model. The different methods used for the calculation of the demands are described below. The diurnal patterns that were used with the demand sets are also described below.

5.1 Water Age System Demand Allocation

Demand allocation consists of calculating the total system demand and then distributing that demand appropriately throughout the system. Total system demand for a given day is equal to the water supplied to the system minus the water stored in the tanks. The total system demand was broken down into a demand per customer using the City's water billing data from the month of peak TTHM formation, June 2005. Demands per customer were then assigned to the closest pipe and subsequent node in the model. **Figure 5-1** and the following steps describe the demand allocation process that was used for this project.

1. Obtained billing data including addresses for each customer and calculate the June 2005 demand for each customer.
2. Geocoded (locate geographically) each of the customers by street address or by matching the customer to a parcel.
3. Flagged each model junction in the model as a demand junction or non-demand junction. Non-demand junctions will not have a demand, such as on a transmission pipeline or at a pump station.
4. Calculated the total demand at each demand junction as the sum of the demand for the customers closest to each pipe and subsequent demand junction.

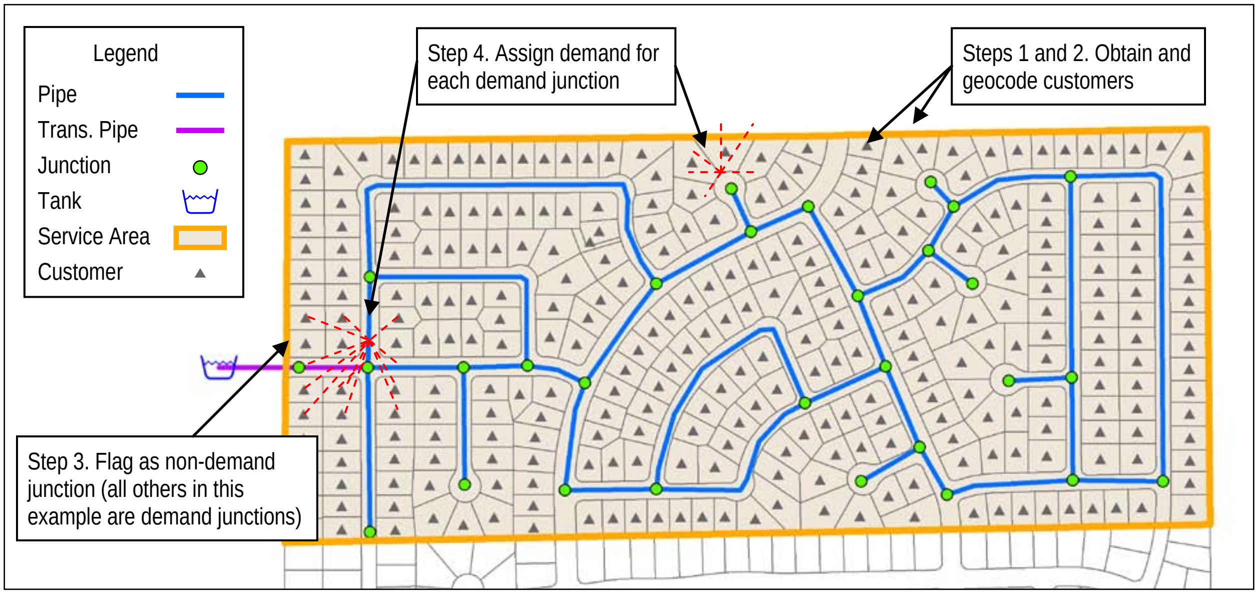

Figure 5-1. Demand Allocation from Billing Data

5.2 Diurnal Pattern

A diurnal pattern is necessary for an EPS to accurately portray the changes in water demand throughout a typical day. The daily water use pattern, or diurnal pattern, was calculated from Supervisory Control and Data Acquisition system (SCADA) records of tanks levels and flow rates from the wells and surface water. Separate diurnal patterns were calculated for the day of dynamic calibration (June 2nd, 2005) and for peak month TTHM formation. **Figure 5-2** shows the two diurnal patterns.

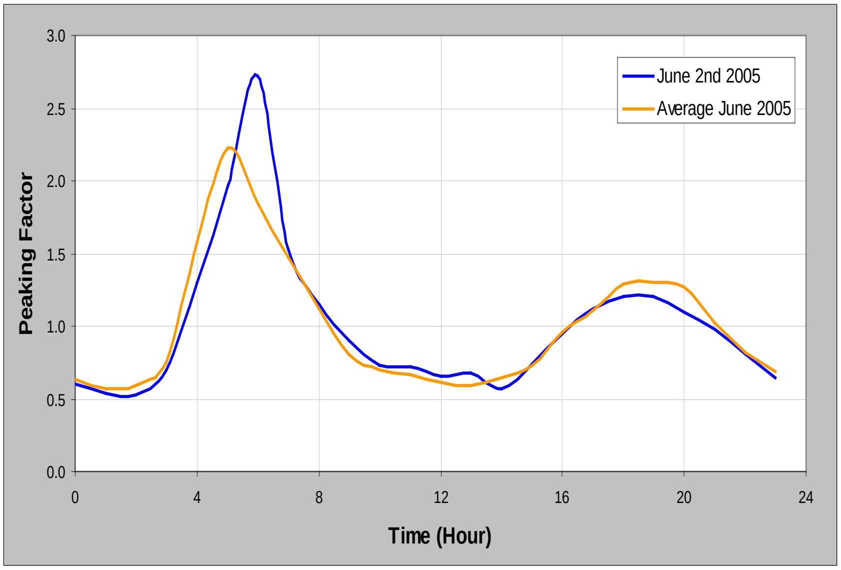

Figure 5-2. Diurnal Patterns

6. MODEL CALIBRATION

The model was calibrated to ensure that model results are representative of actual system operations. Model calibration involves adjusting model parameters until model results match field test data. Brown and Caldwell created a calibration testing plan for collecting field data (see Appendix A). Representatives from Brown and Caldwell and the City then performed the field testing. A steady-state and a dynamic calibration of the City water system were performed. Each is described in the following sections.

6.1 Steady-State Calibration

The purpose of steady-state calibration is to verify the pipe connectivity, pipe roughness factors and the elevation of facilities (i.e. tanks, pumps, and valves) in the model. Field data from the 8 hydrant test performed on the system were used for the steady-state calibration. The steady-state calibration scenarios in the model were set up to represent the system on the day of testing. Demands for each scenario were scaled to match system demands at the time of test. Tank levels, wells, and pump stations were set to match SCADA records at the time of each test.

Adjustments were made to the model until pressures in the model matched the recorded field data from before and during the hydrant test. Some connectivity issues were corrected to maintain the division of pressure zones and re-align pipes to match recent water system changes made between the City and the Outback Site. Some of the roughness factors were also increased slightly to better match field results.

The model calibrated well. Pressures in the model matched within 5 psi of pressures recorded during the field tests for 6 of the 8 tests. Hydrant tests 6 and 7 matched within 10 psi of the field data, both tests where located in Pressure Zone 6. Pressure Zone 6 is supplied from various pressure zones though a total of 14 pressure reducing valves (PRVs). The set hydraulic grade for the 14 PRVs ranges from 3660 ft. to 3735 ft. This appears to have caused discrepancies between the model and the field tests related to PRVs opening or closing based on their settings. Steady-State Calibration field test data and results are located in Appendix B.

6.2 Dynamic Calibration

The purpose of dynamic calibration is to verify the operational control settings in the model (i.e. valve settings and pump on/off controls). The City's SCADA records provided the information needed for the dynamic calibration. Data for June 2nd, 2005 were extracted from the SCADA records for comparison to model EPS results. June 2nd, 2005 was selected as the dynamic calibration day because it fell within the system's peak TTHM formation month.

The dynamic calibration scenario in the model was set up to represent the system on June 2nd, 2005. Demands in the model were scaled to match total system demand for the day of calibration. Initial tank levels and well flows were set to match SCADA records. Graphs of dynamic calibration results are attached in Appendix C. The model tank levels, pump flows and well flows match well. The graphs only show the results for water faculties that had complete SCADA records. Overall, the model is operationally well calibrated.

6.3 Summary

This TM documents the work completed to modify the model to meet EPA minimum requirements for an SSS approach and model calibration for the City of Bend. City Staff was contacted throughout the steps outlined in this TM to ensure the accuracy of the model input parameters. The model calibrated well hydraulically and operationally. The model is ready for use in evaluation of water age to comply with Stage 2 DBPR.