APPENDIX J

Contiguous Water System Hydraulic Model, and GIS
Management and Model Updating Protocols
Technical Memorandum, West Yost Associates
November 13, 2014

WEST YOST ASSOCIATES
Consulting Engineers

TECHNICAL MEMORANDUM

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SUBJECT: City of Modesto, Contiguous Water System Hydraulic Model, and GIS Management and Model Updating Protocols

INTRODUCTION

It is important that the City of Modesto's (City) contiguous water system hydraulic model (hydraulic model) be updated regularly to reflect newly installed/modified water system pipelines and facility conditions, so the model can be used confidently to evaluate the City's water system. The City also desires, as it continues to refine its Geographic Information System (GIS), to establish a unique link between the hydraulic model and the GIS, so that information can be transferred from one to the other more easily. The purpose of this Technical Memorandum (TM) is the following:

- To develop a method for assigning unique pipeline identifiers to the GIS that can also be used to identify pipeline facilities in the model that have been created from the GIS; and
- To develop protocols for updating the City's hydraulic model, so that these model updates can be performed efficiently and on a regular updating schedule, and for updating the City's GIS.

This TM describes recommended hydraulic model management and documentation protocols and GIS and hydraulic model linkages for review and discussion with the City, prior to the City adopting this practice.

The last major update and calibration of the City's contiguous water system hydraulic model was completed in 2003[1] by West Yost Associates (West Yost), and additional updates of the City's existing hydraulic model were completed in 2007, as part of the Engineer's Report (West Yost, 2009).[2] In 2010, the model was converted from the Innovyze's H_2OMap® software to the InfoWater® software and provided to the City. Since 2010, City staff has been updating the hydraulic model on an "as-needed" basis, typically as part of specific hydraulic modeling investigations by the City. As part of the 2014 Water Master Plan (WMP) project, a comprehensive hydraulic model update will be undertaken to incorporate new or changed pipeline alignments/facilities constructed since about 2006. The model is currently not an all-pipe model; however, these updates during the 2014 WMP will improve the model and have a significant hydraulic effect by adding new distribution or transmission pipelines, or new looping pipelines. Additionally, the updates will also significantly improve the hydraulic capacity of the existing system.

As part of the update, West Yost is also recommending model and GIS protocols that will allow the City, as it moves forward, (at some future time) to develop an all-pipe model that has a one-to-one relationship to the City's water system GIS pipeline data.

The following sections first present the development of globally unique identifiers which facilitate establishing a one-to-one relationship between the water system hydraulic model and the GIS, the procedures for updating the hydraulic model including a summary of key work tasks that will be completed for the 2014 WMP, and then follows with the recommended hydraulic model management and documentation protocols that should be adopted by the City staff for all subsequent hydraulic model updates.

DEVELOPMENT OF GLOBALLY UNIQUE IDENTIFIERS (GUID)

To provide a streamlined transfer process between the hydraulic model and the GIS database, a globally unique identifier will be required for each pipeline. Although the GIS uses object ID's to assign unique identifiers to pipelines and other facilities, when the GIS is updated, the object ID's are automatically re-assigned by the GIS engine, and therefore do not necessarily remain attached (are not unique) to a particular pipeline or GIS facility. In contrast, a globally unique identifier is one that is associated with a particular pipeline and remains attached to the pipeline until that pipeline is removed from the GIS database. For example, if the GIS system represents a pipeline with two segments that intersect with and connect to another pipeline at an intersection, a GUID would be assigned to each segment. If the pipelines are subsequently found to not be interconnected to the other pipeline, the pipelines would be removed from the GIS and replaced with a new pipeline with the correct configuration. A new GUID would be assigned to the new pipeline. Similarly, if a pipeline is replaced in the field with a new pipeline, the old pipeline would be deleted, and the new pipeline would be entered into the GIS and assigned a new GUID. Figure 1 illustrates the GUID assignment process when an existing pipeline configuration is changed in the GIS database.

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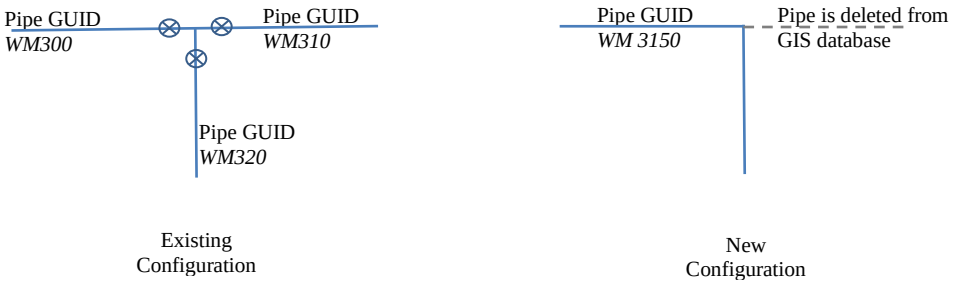
[1] *City of Modesto Hydraulic Model Development, Calibration and Verification Technical Memorandum*, West Yost Associates, August 26, 2003.

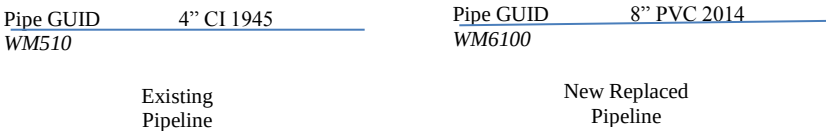
[2] *City of Modesto Engineer's Report, Appendix A,* West Yost Associates, October 5, 2009. Modeled facilities included in the Engineer's Report were based on model updates that were current through 2006.

Figure 1. GUID Assignment in GIS Database

Sample 1: Change of configuration for three connected pipelines to a single pipeline



Sample 2: Pipeline Replacement



There are different options for generating pipeline GUID's for the City's GIS system. One option is to use a GUID that is a 16-bit number, represented as a 32-character hexadecimal string (e.g., {166A1613-A9CD-4981-83F1-9007E4D707D2}). The GUID's can be generated by the computer which makes them unique and impossible to create duplicates, even across different computers. Therefore, a GUID created for a geographic feature can never be accidentally duplicated for another geographic feature. However, this GUID generated by the computer does not have any meaningful correlation to any feature in the City's GIS database.

There are other options in developing a GUID. The second option is to develop a pipeline GUID by using valve identification (valve ID) information in the GIS valve database for valves that are connected to the pipeline. Each pipe segment in the water system is connected to water valves at each end of the pipe segment. Each valve has a unique ID. By assigning these two valve IDs as the GUID to the pipe, all pipe IDs will be unique and have no duplicates, as long as the valve IDs in the GIS database are unique. For example, if the valve IDs for a pipe segment are V456 and V458, the GUID for the pipeline that is connected to these two valves would be V456*V458. The advantage to this method is that the pipeline GUID would provide a correlation to the valve information that is connected to the pipeline, so that the GUID can be correlated to a physical system location, based on the location of the valves.

A third option to develop a GUID is to create a unique numerical identifier (facility ID) for each pipeline in the GIS database, and assign this facility ID in the attribute field in the GIS database. Any new pipeline added to the GIS database would be assigned a new facility ID to keep the database unique. For example, there are 19,514 pipeline segments in the GIS database that West Yost received from the City,[3] the facility ID assigned to these pipelines could be labeled as

[3] *GIS database (file: Water_MainLine.shp) received from the City on October 23, 2014.*

1 to 19514. The facility ID could also be enhanced by adding a label with an abbreviation denoting a water main, followed by a numerical number (i.e. WM1 to WM19514). If a new pipeline is added to the GIS database, the new facility ID would be WM19515.

City staff should determine which GUID methodology to use, and assign the GUID to the GIS database. West Yost recommends utilizing the valve ID to develop the pipeline GUID. This recommended methodology will provide correlation to the valve information that is connected to the pipeline.

Once the GUID is developed, it can also be assigned to any hydraulic model pipeline that is created from the GIS. In addition to development of a GUID field in the GIS system, two additional fields (e.g. GIS UPDATE and MODEL) are recommended to be added to the GIS pipeline database. The GIS UPDATE field can be used to track when any new changes on the pipeline attribute data have been updated or added in GIS system. The second field, e.g. MODEL, can be used to track if the new attribute data has been delivered to the City's hydraulic model staff for hydraulic model update. When the City decides to update the hydraulic model either on a semi-annual or annual basis, these fields can be useful to track which pipelines in the GIS database have or have not been sent to the hydraulic modeler since the last model update.

Table 1 provides an illustrative example of the proposed new fields to the City's existing GIS pipeline database that includes the GUID, configuration changes and hydraulic model exchange information.

Table. 1. Sample of Changes Applied to the City's GIS Database to Include Model Transfer Protocol

Existing Data Fields from City's GIS [(a)]																New Data Fields Added to City's GIS		
Enabled	MATERIAL	PIPE_SIZE	YR_INSTL	SOURCE	OWNER	MAINTENANC	SPCL_ATTRI	NOTE	REPLACED	WORK_ORDER	TYPE	EASEMENT	EASEMENT_W	EASEMENT_A	STATUS	Shape_len	GUID	GIS_UPDATE	MODEL
1	PVC	8.00000000	0		MODESTO	MODESTO	DEW				MAIN LINE		0		ACTIVE	501.38649023600	V8747*V8677		
1	PVC	10.00000000	0		MODESTO	MODESTO	DEW				MAIN LINE		0		ACTIVE	1.62477533000	V8700*V8650	Replace	Sent; 11/12/2014
1	PVC	8.00000000	0		MODESTO	MODESTO	DEW				MAIN LINE		0		ACTIVE	317.60061847500	V7647*V6667	New	Sent; 11/12/2014
1	PVC	8.00000000	0		MODESTO	MODESTO	DEW				MAIN LINE		0		ACTIVE	2112.83707717000	V1700*V2600	Replace	Sent; 10/12/2013
1	PVC	8.00000000	0		MODESTO	MODESTO	DEW				MAIN LINE		0		ACTIVE	5.01263871728	V47*V66	New	Sent; 10/12/2013

[(a)] Data fields source: *Water_mainLin.dbf*. Received from the City on October 23, 2014

EXISTING PROCEDURES FOR HYDRAULIC MODEL UPDATES

The City does not currently have a regular schedule for updating its water system hydraulic models. As discussed above, localized updates to the City's contiguous water system hydraulic model have been performed by the City staff on an "as-needed basis". These updates include facility (*e.g.*, pipelines, wells, storage reservoirs, and pressure regulators) and/or operational data (*e.g.*, pressure control settings, *etc.*). The key work tasks to update the existing hydraulic model for the 2014 WMP include four steps.

1. Review as-built plans, the City's GIS database, and Operations staff field notes information that are dated from 2006 to October 2014[4] to identify pipelines that are not included in the existing hydraulic model;
2. Update the water system hydraulic model based on information obtained during Step 1;
3. Generate maps for City Staff review and comment; and
4. Revise the hydraulic model to incorporate the City's comments from Step 3.

Figure 2 presents the process that West Yost will undertake to update the existing hydraulic model.

When updating the hydraulic model, some information from the City's GIS database will be included in the pipeline attribute data in the hydraulic model. Additional data fields will be added in the updated hydraulic model to help maintain the one-to-one relationship with the City's water system GIS pipeline data, and to provide additional documentation on the model updates. Table 2 summarizes the pipeline attribute data fields that will be incorporated into the hydraulic model.

[4] Data received from the City on October 2014.

Table 2. Summary of Pipeline Attribute Data to be Added to the Hydraulic Model

Attribute Data Field in GIS	Corresponding Data Field in Hydraulic Model	Description
Data Fields from City's GIS Database		
GUID or FAC_ID[a]	GISGUID or GISFAC_ID	Unique pipeline ID field used to maintain a one-to-one relationship with the City's GIS pipeline database
PIPE_SIZE	GIS_SIZE	Pipeline diameter in inches
YR_INSTL	GISYR_INST	Installation year
MATERIAL	GIS_MAT	Pipeline material type (e.g., ACP, PVC, STL, UNK, etc.)
OWNER	GISOWNER	Identifies if pipeline is owned by the City or private
Data Fields that will be added by West Yost		
---[b]	GIS_DUP	Indicates pipeline is split by West Yost and has a duplicate GUID or FAC_ID[c]
---[b]	MOD_WYA	Indicates whether pipeline is modified by West Yost , and is different from the City's GIS database
---[b]	WYA_UPDATE	Provides date when pipeline is last updated in the hydraulic model
---[b]	WYA_SOURCE	Provides source file that is used to update the pipeline in the hydraulic model

[a] Field is not available in the recent GIS database provided to West Yost. However, this field would be created in the City GIS when City staff completes the development of the GUID as discussed in this TM.

[b] Not applicable to the City's GIS database.

[c] Indicates that a unique GUID or FAC_ID is duplicated when the pipe is split to accommodate a connection to another intersecting pipe. This operation would be performed only when necessary as it will cause a loss in the one-to-one relationship with the City's GIS database.

Additional tasks will also be performed to update the City's hydraulic model, which are summarized in Table 3.

Table 3. Summary of Hydraulic Model Update Performed for the Water Master Plan Update

Task	Description of Task
Assign Pipeline C-factors	Representative roughness factors (C-factors) will be assigned based on hydrant test results which are developed to confirm C-factor based on pipeline age and material type
Assign Facility Controls	Facility setting and controls will be updated based on recent operation data received from the City
Allocate Water Demands	Geocoded metered water demands will be used to allocate water demands to the closest pipeline/junction[(a)]

[(a)] Geocoded metered water demands procedure and results will be discussed in Chapter 3 of the Water Master Plan.

The completion of the above tasks will provide the City with an updated hydraulic model that more accurately represents the City's water system as it exists as of 2014, and also incorporates updated facility controls. The following section presents the recommended hydraulic model management and documentation protocols for all future updates of the City's hydraulic model.

RECOMMENDED HYDRAULIC MODEL MANAGEMENT AND DOCUMENTATION PROTOCOLS

Effective and successful hydraulic model management requires:

1. Updates that are scheduled to be performed regularly;
2. Clear communication between City staff from different departments/divisions; and
3. Efficient data management.

The following sections present the recommended protocols for management of the City's hydraulic model.

Update Schedule

The City's hydraulic model should be updated regularly so that it will not become outdated when compared to the City's GIS pipeline data and current operational controls. A realistic, routine update schedule should be selected, so that these updates do not create undue burden on City staff, but still support the hydraulic model's applications. It is recommended that the hydraulic model will be updated on either a semi-annual or annual basis. This recommended schedule depends on the number of capital improvement projects that the City has completed on an annual basis, and can be adjusted in the future to better meet the City's needs and staffing.

Internal Communication and Data Management

Changes to the City's water system facilities and operational controls should be documented regularly and documentation should be accessible to both Public Works and Utilities Department staff. Clear communication is required between the Public Works and Utilities Departments and within different divisions for each Department in order to effectively and efficiently transfer the data necessary for updating the City's water system hydraulic model. Figure 3 presents the recommended internal communication and data management protocols for the City's routine hydraulic model updates.

Summary of Recommended Hydraulic Model Management and Documentation Protocols

Performing regular updates of pipelines and other system facilities including operational controls in the hydraulic model will help keep this tool up-to-date and representative of the City's current water system conditions. This is a critical component in maintaining the hydraulic model and providing accurate and reliable hydraulic evaluation results for the City's water system. Figure 3 illustrates the recommended hydraulic model management and documentation protocols for regular updates to the City's hydraulic model. The protocols are set-up so that the City can assign a staff member as a Task Leader for each task to clearly identify staff responsibilities. This will provide a single point of contact/responsibility if questions arise, and will also help provide more efficient and successful hydraulic model updates.

Figure 2. Hydraulic Model Update Process

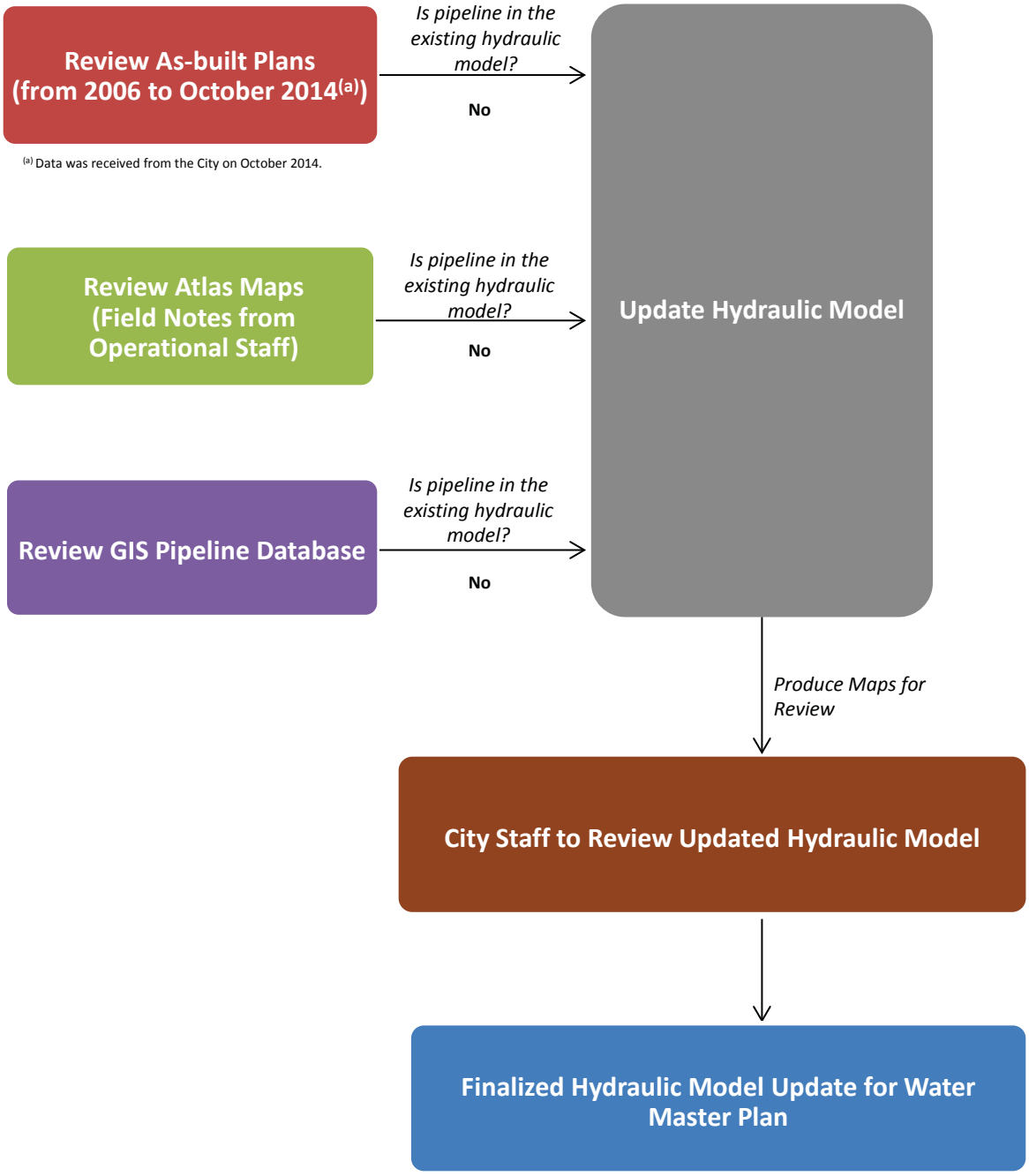


Figure 3. Recommended Hydraulic Model Management and Documentation Protocols

Task 1
Update GIS Pipeline Data

Data Type: Pipelines
Relevant Data: Diameter, Material Type and Installation Date

WATER IMPROVEMENT PLANS
Task Leader:
To be determined by City
Department:
Utilities – Planning and Project for Water Design
Task:
Provide as-built drawings of new and replacement pipelines to Information Technology – GIS staff

FIELD MAPS AND GPS POINTS
Task Leader:
To be determined by City
Department:
Utilities – System Operations & Maintenance
Task:
Provide any pipeline discrepancies found during field work and field GPS points to Information Technology – GIS staff

OTHER IMPROVEMENT PLANS
Task Leader:
To be determined by City
Department:
Other Departments – Community and Economic Development, Park and Recreation
Task:
Provide as-built drawings of new and replacement pipelines to Information Technology – GIS staff

GIS PIPELINE DATABASE
Task Leader:
To be determined by City
Department:
Information Technology – GIS staff
Task:
Update pipeline changes in GIS; track edits in separate MODEL field and utilize unique GUID

Task 2
Update Asset Management and SCADA Systems

Data Type: Other Water System Facilities (e.g. well pump, pressure reducing station, storage tank) , Operational Controls
Relevant Data: Elevation, Diameter, Pump Curve, Reservoir Overflow Level, Pressure Setting, or Reservoir Level Setting

Task Leader:
To be determined by City
Department:
Utilities – System Operations & Maintenance
Task:
Input changes to facility operational controls in SCADA System and notify Utilities – Engineering Services for Water Division

Semi-Annual to Annual

Task Leader:
To be determined by City
Department:
Utilities – Engineering Services for Water Division
Task:
Input changes to facilities in the City's Asset Management System

Semi-Annual to Annual

Semi-Annual to Annual

Task 3
Provide Up-to-Date Water System Data to Hydraulic Modeler

Task Leader:
To be determined by City
Department:
Utilities – Engineering Services for Water Division
Task:
Provide the following data prior to scheduled hydraulic model update:

- GIS pipeline shapefile with unique GUID
- Water system facility data from the Asset Management System in Excel Spreadsheet format
- Operational control data from SCADA System in Excel Spreadsheet format

Semi-Annual to Annual

Task 4
Perform Hydraulic Model Update

Task Leader:
To be determined by City
Department:
Utilities – Engineering Services for Water Division
Task:
Perform hydraulic model update from City's GIS pipeline mapping , facility or control data

Notes:
Schedule for update is assumed to be at quarterly basis, and can be adjusted in the future to meet the City's need and staffing.