ROCHESTER HILLS, MICHIGAN

AMENDMENT TO WATER DISTRIBUTION SYSTEM STUDY

January 2005

ARCADIS FPS

Infrastructure, buildings, environment, communications

ARCADIS FPS

Amendment to Water Distribution System Study

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Executive Summary

The City of Rochester Hills provides drinking water to nearly 70,000 customers through approximately 22,000 connections to the publicly owned and operated water distribution system. The City purchases water on a wholesale basis from the Detroit Water and Sewerage Department (DWSD). Water is supplied through four metered connections to the DWSD water transmission system. Due to a number of factors including low and uneven pressures in the system, high peak rates required from DWSD and overall system reliability concerns after national events on September 11, 2001 and the blackout in the summer of 2003 the City commissioned a study to evaluate methods to improve the system in these areas.

The basis for the study was a hydraulic computer model of the distribution system developed using Haested Methods WaterCAD. The model simulated demands and pressures throughout the system for average day, maximum day, peak hour and fire flow conditions. The model was calibrated using hydrant flow tests under known system conditions. The model was then validated using differing sets of conditions. Results of the model follow actual system response closely.

A number of options for improving known system deficiencies were simulated including increasing flows from the existing DWSD connections, adding new pumping and storage facilities and combinations of the two. Personnel from DWSD were briefed on the approach and independently validated the model for accuracy. Recommendations for system improvements from the modeling included building two ground storage tanks and associated pumping facilities – one in the northwest of the city and one in the east central part of the City. Additionally, operational improvements were recommended to improve the efficiency of the four DWSD connections within stated DWSD requirements.

An economic analysis related to the capital costs of the recommended improvements was completed. Project costs in 2004 dollars are estimated to be approximately $7.7 million. Reduced charges from DWSD as a result of the improvements average approximately $1.4 million per year resulting in an estimated project payback period of about 10 years.

The results of the study strongly support building storage and pumping facilities within the City of Rochester Hills water distribution system. The alternative of maintaining the status quo is clearly not in the best interest of the long term operational, economic or reliability perspective of the system.

Introduction

In September 2002 ARCADIS FPS, Inc. (ARCADIS) completed a water system analysis of the Rochester Hills water distribution system. The purpose of the analysis was to:

- Identify potential pressure and flow problems/deficiencies in the existing distribution system
- Identify improvements and components required to increase water pressure to the northwest portion of the City and allow for future development and,
- Identify means and methods to level out peak demand periods on the system.

The recommendations from the study included adding two finished storage water facilities – one in the northwest and one in the east central location of the City. It was also determined that an additional potential benefit of system storage would be to reduce peak flows from the Detroit Water and Sewerage Department (DWSD) connections resulting in reduced water charges. Details of the study are documented in the *Water Distribution System Modeling and Evaluation*, dated September 2002.

In October 2003 Rochester Hills contracted with ARCADIS to complete a more detailed modeling and financial analysis to confirm the results and recommendations of the original study. Management and engineering personnel from DWSD were also briefed on the project. Detailed tasks included:

1. Confirm storage tank(s) locations, size and operation.
2. Confirm project cost.
3. Meet with DWSD Engineering to gain agreement on the acceptability of water storage and the impact of storage on average day, maximum day and peak hour demands.
4. Verify DWSD contract commitments regarding adjustments to the City's current water rates as a result of reducing peak hour demands.

5. Obtain written documentation to the greatest extent possible from DWSD detailing the financial implications the reduced peaking factors will have on water rates.

6. Develop cost effective analysis and pay-back estimates.

This report should be considered an addendum and intergral to the original report.

Peaking Factors

Peaking factors are used throughout the report and refer to the relationship between average day, maximum day and peak hour demands. These factors are calculated by dividing the maximum day and peak hour demand by the annual average day demand. Peaking factors are used to size facilities during the design process but are also used by DWSD to set contract community rates. While they refer to that same theoretical calculations they are used in different ways.

Peaking factors are used during the modeling analysis as design criteria to size facilities such as pump stations. For this analysis DWSD required peaking factors of 3 for maximum day and 5 for peak hour, respectively. These hypothetical peaking factors are higher than actual historical recorded peaking factors resulting in a conservative design of facilities.

The other use of peaking factors is in the estimate of DWSD annual charges to the City. These peaking factors are determined from actual annual water demands registered by the master meters at the four connection points with the DWSD system. Average day demand is calculated by dividing the sum of all four meters over the entire year by 365. The maximum day demand is determined by the actual 24-hour maximum demand during the year. The peak hour is determined in the same way based on the actual highest recorded single hour throughout the year. The peaking factors are determined by dividing the maximum day and peak hour usage by the annual average day demand to arrive at the maximum day peak and peak hour factors, respectively. These factors vary from year to year.

Modeling Analysis Results

Additional modeling analysis was performed to determine if demands from the four DWSD supply points could be equalized and also to determine the most beneficial location, capacity, and control strategy for the proposed water tanks and booster pumping stations.

During the course of this additional modeling, ARCADIS met with Ali Ghanavi from DWSD on several occasions to discuss specific aspects of the model and the project input to ensure their acceptance in the concept of water storage for Rochester Hills.

DWSD required an increase in the theoretical peaking factors to determine the maximum day demand and peak hour demand from what was used during the original study. The increase in the peaking factor and subsequent demands are shown in Table 1.

Table 1				
	Previous Peak Factor (2002/2003 Rates)	Previous Demand (MGD)	Current Peak Factor	Current Demand (MGD)
Max Day	2.4	19.1	3	25
Peak Hour	3.4	27.1	5	40

The demand information DWSD provided for Rochester Hills also changed the supply point distribution. The redistribution of the flow percentages from each DWSD connection is shown in Table 2. Approximately 40% of the demand is located in the north and 60% is located in the south.

Table 2		
	Supply Point Distribution	
	Previous	Current
RC-1	19%	36%
RC-2	62%	41%
RC-3	15%	21%
RC-4	4%	2%

Modeling results indicate that due to the higher maximum day demand the tank located in the east central part of the City should be increased to 3.0 million gallons (MG) from 2.0 MG that was previously proposed. The proposed location for the east central tank is north of Avon Road and east of Rochester Road.

The original recommendation of a 2.0 MG storage tank in the north is still adequate. The proposed location for the tank and associated booster pumping station in the north is on Tienken Road west of Adams Road.

The preliminary capacity of the booster pumps was determined using the model. They were sized to restrict flow from the DWSD supply points to the maximum daily demand. The preliminary pump capacity in the north is approximately 6000 gpm at 150 feet TDH. The preliminary pump capacity in the south is approximately 7000 gpm at 145 feet TDH. Final pump capacities will be determined during detailed design.

DWSD evaluated the possible impact of the proposed new Rochester Hills storage facilities on their system. Specifically, they were concerned about the impact of the proposed tank in the north because of its close proximity to RC-2. The minimum hydraulic grade line (HG) for DWSD's system at RC-2 is 1120 feet. The booster station in the north maintains the hydraulic grade at RC-2 at 1137 feet.

To maintain demands on the DWSD supply points at the maximum day demand under worst case conditions flow control valves are required at each feed point. These valves can be remotely monitored through the City's SCADA system.

Extended period model simulations (24-hours) were run to ensure the new storage tanks would drain and fill adequately with DWSD demands limited to the maximum daily demand. The control logic for the booster pumps was discussed with DWSD. For each booster pumping station a control node was chosen to determine the pump status. Each tank had a fill line and a drain line that acted as the suction for the pumping station. The fill line had a valve that was set to close any time the pump was on.

The control junction in the north was located at node J-630 on the suction side of the booster pumping station. Pump control strategy included turning the pumps on if the HGL at the control node fell below 1000 feet and the tank level was over 34 feet. Once the tank level dropped below 11.5 feet the pump turned off.

The control junction in the south was located adjacent to supply feed RC-1. If the HGL at the control node was below 1000 feet (meaning the system was trying to draw more water and the demand was higher) and the tank level was over 34 feet, the pump turned on. Once the tank level dropped below 11.5 feet the pump turned off.

In order for the booster pump station to "back feed" areas in the north several existing flow control valves (FCV) need to be deactivated. FCV 6 located on Rosebriar south of Rain Tree, FCV 8 located on Brewster, and FCV 21 located on Medinah all need to be deactivated. When FCV 21 was deactivated the water was recirculating to feed the booster pumping station. Therefore, check valves were added in the model on Palm Aire.

Cost Estimates

Project cost estimates were updated based on the new recommendations noted above. Total project costs are detailed in Table 3. Because of the early stage of planning probable construction cost estimates include a 20 percent construction contingency and 20 percent engineering allowance for design, construction engineering and administration. Estimate of probable project costs is $7.7 million.

Table 3
Estimate of Probable Costs

Items	Quantities	Amount
Prestressed Concrete Ground Level Tank		
3.0 MG	Lump Sum	$1,300,000.00
2.0 MG	Lump Sum	$1,060,000.00
Flow Control Valves, Meters and Chambers		
RC-1, 16"	Lump Sum	$50,000.00
RC-2, 30"	Lump Sum	$90,000.00
RC-3, 54"	Lump Sum	$160,000.00
RC-4, 30"	Lump Sum	$90,000.00
North Tank, 2 pumps (6000 gpm @150')	Lump Sum	$1,300,000.00
South Tank, 2 pumps (7000 gpm @145')	Lump Sum	$1,300,000.00
	Subtotal	$5,350,000.00
	Contingencies	$1,050,000.00
	Total Construction Cost	$6,400,000.00
	Engineering	$1,300,000.00
	Total Project Cost	$7,700,000.00

DWSD Coordination

ARCADIS personnel met numerous times to discuss the project with DWSD personnel from both a technical and management viewpoint. DWSD performed independent model analysis using the hydraulic model previously developed by ARCADIS. The new tanks were included in the model. DWSD was satisfied that the impact on the existing DWSD transmission system is acceptable. A letter signed by the Assistant Director of Engineering Services conceptually agreeing to the new storage facilities was received on July 26, 2004, and is attached.

ARCADIS also met with management personnel to determine the current process to determine new rates. DWSD agreed that after the new facilities are constructed and in operation new peaking factors will be determined. A letter signed by the Director of DWSD and received on May 27, 2004, details the procedure and is attached.

DWSD Rate Analysis

The DWSD customer community rate determination is based on a complex equation that takes into account the annual average day demand, maximum day demand, peak hour demand, distance from DWSD facilities and elevation. The only variable that can be manipulated through system design and operation is the peak hour demand. System storage can be used during peak demand periods to subsidize required flows from DWSD, effectively limiting the flow requirements from DWSD to maximum day demand. This in turn reduces one of the five factors – peak hour peaking factor- to the maximum day peak factor reducing the overall rate charged to Rochester Hills by DWSD.

It is estimated using the 2004/2005 rate calculation for Rochester Hills supplied by DWSD that the recommended improvements will reduce the overall rate for wholesale water from DWSD from $15.60/McF to $12.75/McF. This calculation is shown in the tables labeled DWSD Rate Calculation – 2005 and DWSD Rate Calculation – 2005 Modified in the Appendix. The only difference in the calculation is the reduction of the Peak Hour Peaking Factor from 3.2 to 2.5. Based on current maximum day demand in Rochester Hills this results in an estimated annual savings of $1,187,281. This savings will vary from year to year based on total consumption and maximum day flows but will always be less than the cost without the new storage facilities based on the existing DWSD rate structure.

Cost Effective Analysis

A cost effective analysis was conducted to determine the most cost effective approach for the two options – continuing the current operation of the Rochester Hills water system or adding storage that will reduce peak flows to maximum day flows. The analyses calculated Average Equivalent Annual Cost (AEAC) for both systems. The AEAC is an industry standard for comparing options and results in an annual cost to fund each option. Calculations are attached in the Appendix.

The analysis takes into account the cost of purchasing water from DWSD and the cost to pay back bonds for any associated capital improvements. Year 2005 was used as the baseline year for the capital improvements with 20 years to pay back the bonds at an annual interest rate of 5%. Results of the analysis show that the storage option is the most cost effective. AEAC for the storage option is $5,969,688 and $6,485,098 for the status quo option.

Note that the AEAC for status quo option equals the estimated charges from DWSD for the year 2005. This is because there is no capital costs associated with this option leaving only water charges to pay off.

Pay Back Analysis

Payback analysis was completed by dividing total project costs by the net annual profit. The estimated total project costs are detailed above and are equal to $7,700,000. The net annual profit is determined by the estimated amount of rate reduction as a result of the improvements minus estimated operation and maintenance cost and financing costs of the new facilities.

The DWSD rate reduction was estimated by evaluating system demands and associated costs for the years 2001 through 2004. The highest annual savings was $1.7 million in 2001, the lowest of $1.2 million was in 2004. The average cost savings with the addition of storage was approximately $1.4 million per year.

Operation and maintenance costs were estimated using professional experience and data from similar systems for salaries and administrative costs, electricity, chemicals and repair and maintenance. It is noted that these types of facilities are highly automated and require nominal personal attention during normal operation. For this analysis it was estimated approximately 14 person hours per week are required over the life of the facility. This conservative estimate could easily be handled by existing personnel. Average annual O&M costs were estimated to be approximately $124,000.

Annual costs associated with financing the capital costs were estimated using 4.5% interest rate amortized over 20 years. The estimated annual payment is slightly over $550,000. This assumes a portion of the project development costs will be funded through existing reserves.

Using these figures the pay-back period is estimated to be approximately 10 years.

Alternative Analysis

The following table provides a side by side comparison of the two potential choices of building new storage and pumping facilities or continuing to operate the system in the current configuration.

	Pros	Con
Storage	▪ Improved reliability ▪ Improved system pressures ▪ Improved fire fighting capability ▪ Economically advantageous ▪ Good system design	▪ DWSD uncertainty ▪ DWSD customer uncertainty ▪ Upfront investment
No Storage	▪ Known system response ▪ Known rate impacts ▪ Easy ▪ No capital investment required	▪ System issues not addressed ▪ Not economically beneficial ▪ Potential adverse financial impacts due to other customers building storage

Conclusions

A detailed technical and economic evaluation was conducted on the validity of adding system storage to the Rochester Hills water system. The following conclusions have been reached:

- The addition of storage to the Rochester Hills water system is both technically and economically desirable.

- With the current information on DWSD rate structure and opinions of probable project costs the pay-back period is approximately 10 years after the improvements are in operation.

- § The required storage should be ground storage with booster pump stations. A 2.0 MG tank is required in the northwest and a 3.0 MG tank is required in the east central.

- § The addition of storage will allow peak water demands required from DWSD to be reduced to maximum day demands resulting in lower future fees from DWSD.

- § The addition of storage will solve the concerns detailed in the original study – to improve pressures in the northwest portion of the system, level out peak demands from DWSD and improve flow and pressure problems throughout the system.

- § Overall, the improvements will increase reliability and flexibility of the existing system.