Report as of FY2007 for 2006GU75B: "Development of an optimum Operational Management for the Saipan Water Distribution System"

Publications

Project 2006GU75B has resulted in no reported publications as of FY2007.

Report Follows

PROJECT SYNOPSIS REPORT

Project Title: Development of an Optimum Operational Management Scheme for the Saipan Water Distribution System

Problem and Research Objectives

The goal of the Commonwealth of the Northern Marianas Islands (CNMI) Government is to provide 24-hour water service to all residents served by the Commonwealth Utility Corporation (CUC) water system. A special task force, which has been created by the CNMI government, has been carrying out various projects to accomplish the goal of providing 24-hours water service to all CUC customers. Large sums of Federal funds have been expended on system metering, drilling new wells, and adding new water storage capabilities. In spite of these attempts, CUC has not been able to completely accomplish the 24-hours water goal. The basic reason for this problem is that the Saipan water system is a very complicated system and the CUC operators find it difficult to understand the complex system hydraulics which controls how water flows through the system. In addition, inadequate inflow to the system, system leakage, and lack of ways to examine various system operation scenarios have made the goal of 24-hours water service difficult to obtain.

The Saipan water distribution system, as shown in Figure 1, is operated as 14 interconnected sub-regions. Each sub-region, a sample of which is shown in Figure 1, is expected to operate somewhat independently. WERI researchers have initiated the development of a skeletonized computer model of each of the fourteen sub-regions of the CUC water system using the Haestad WaterCAD water distribution system modeling program. These skeletonized models do not include all pipes in the system, but are limited to all pipes greater than 4 inch in diameter, and all the major water sources, tanks and transmission components of each sub-region. The skeleton models represent the major components that control the hydraulic movement of water through the system.

The goals of this project were: 1) to complete the skeleton model of the Saipan water distribution system that will includes all major pipes, wells, reservoirs, and springs and, 2) develop sub-region based demands to apply to the water system model, and 3) operate the entire system as a whole to assist in developing optimum ways to transfer water through the system.

The benefits expected from the project include a better understanding of the adequacy of the existing pumps and well systems, the adequacy of the existing storage facilities to provide for daily fluctuating demands, the ability of the well and storage system to provide sufficient flows, and a more in depth understanding of the most efficient means to move water from water supply rich regions to those that have supply shortages. The overall goal is to provide delivery of water on a 24 hour basis to all areas served by the system.

Methodology

The first major component of the project was the completion of the 14 sub-regional skeleton models. The skeleton model that was developed includes all the pipes greater that 4 inch diameter. Several trips were made to Saipan to field verify various aspects of each of the sub-region models and to discuss the complex connections in the system with CUC water division and field staff. We gathered available data on the physical and hydraulic description of all of the pumps, wells and spring sources including the hydraulic characteristics of all well and booster pumps used to move water through the system. This was necessary to be absolutely sure the model was a valid representation of the existing field condition in the water system.

In order to accurately predict the pressure at the junction nodes, it was necessary to assign the proper elevation for each pipe junction. This was done by exporting the junction nodes for each sub-region from the Haestad water system model to the ArcGIS shape file format (Figure 2). The exported shape file contained an empty field for the junction elevation variable. This point shape file of junction location was next added to the ArcGIS map. Next a digital elevation model raster file was added to the map. Elevations were assigned to each junction using the “Extract Values To Points” ArcGIS tool. This function extracts the elevation value for the junction from the grid cell in which the junction node resides and assigns that value to the junction node. The junction node shape files with updated elevations were then imported back to the Haestad format. The model was then ready to run with updated elevations resulting in proper pressure computations at each junction node.

A second very important modeling consideration for a water distribution system model is the customer water demands in the system. Demands are input to the water system model at junction nodes. A detailed analysis was carried out in order to assign realistic junction node demands. First a listing of customers in each sub-regional area was obtained from Saipan water master plan of 1996. Figure 3 shows the location of each of the sub-regions. Table 1 shows the listing of number of customers for each of the sub-regions that was obtained from CUC. CUC personnel also provided information on the estimated number of people being served at each customer location. They felt that 6 people per customer location was a good estimate to use for our study’s purposes. The next step was to multiply the number of customers per region by 6 people per customer to get the total number of people being served in each sub-region. The number of people in each region was multiplied by varying values of typical US national usage rates of 80, 100, and 150 (gallons/person/day) to get the total volume of water required in each region per day. These numbers were then adjusted to the gallons per minute (gpm) flow rates that the water system model requires. The total gpm for each region was divided by the total number of junctions in the region to obtain a flow demand for each junction. The junction demands were then assigned to the junctions using the global editing option of the Haestad model. For our first model runs we used the 100 gallons/per capita/per day values for our initial model runs. Values for other use rates could be easily entered for the junctions.

Each sub-model was run and meticulously checked in steady state mode to be sure all computed flow and pressure values were reasonable and agreed with measured system values provided by CUC.

Principal Findings and Significance

The main product of this project was the development of a skeleton model that contains updated descriptions of the main transmission and distribution lines, the sources, storage tanks and pumps in Saipan's water distribution system. The model has been verified by the CUC water division staff and the water demand rates used are those that represent the best estimates based on Saipan's water master plan of 1996. Each sub-region model is operational and ready for use for making improvements in water system operation. These improvements should help CUC to meet the Government's goal of providing 24-hours water to all customers.

Future studies should be made to update the estimates of water system demands that were used in this study. New census data has been made available since the last master plan effort was made. If these new census values are applied using GIS techniques more realistic demands for each junction location can be found. Also major demand customers should also be identified. These include commercial laundries, laundromats, and barracks areas for guest workers. These locations induce large demands at point locations in the system and need to be adequately accounted for if the model is to be a true representation of the real system.

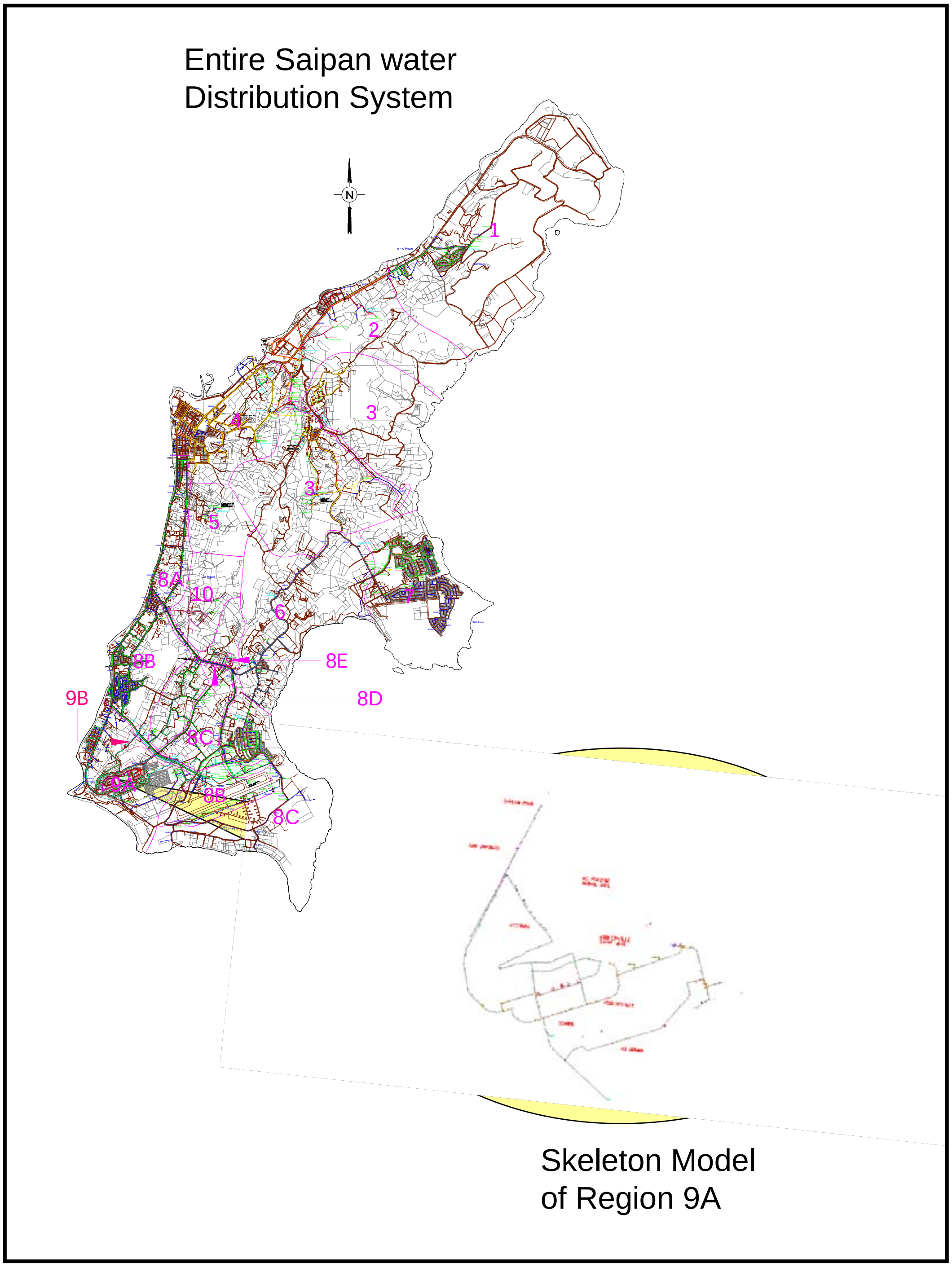

Figure 1. Saipan water distribution system and skeleton model of sub-region 9a.

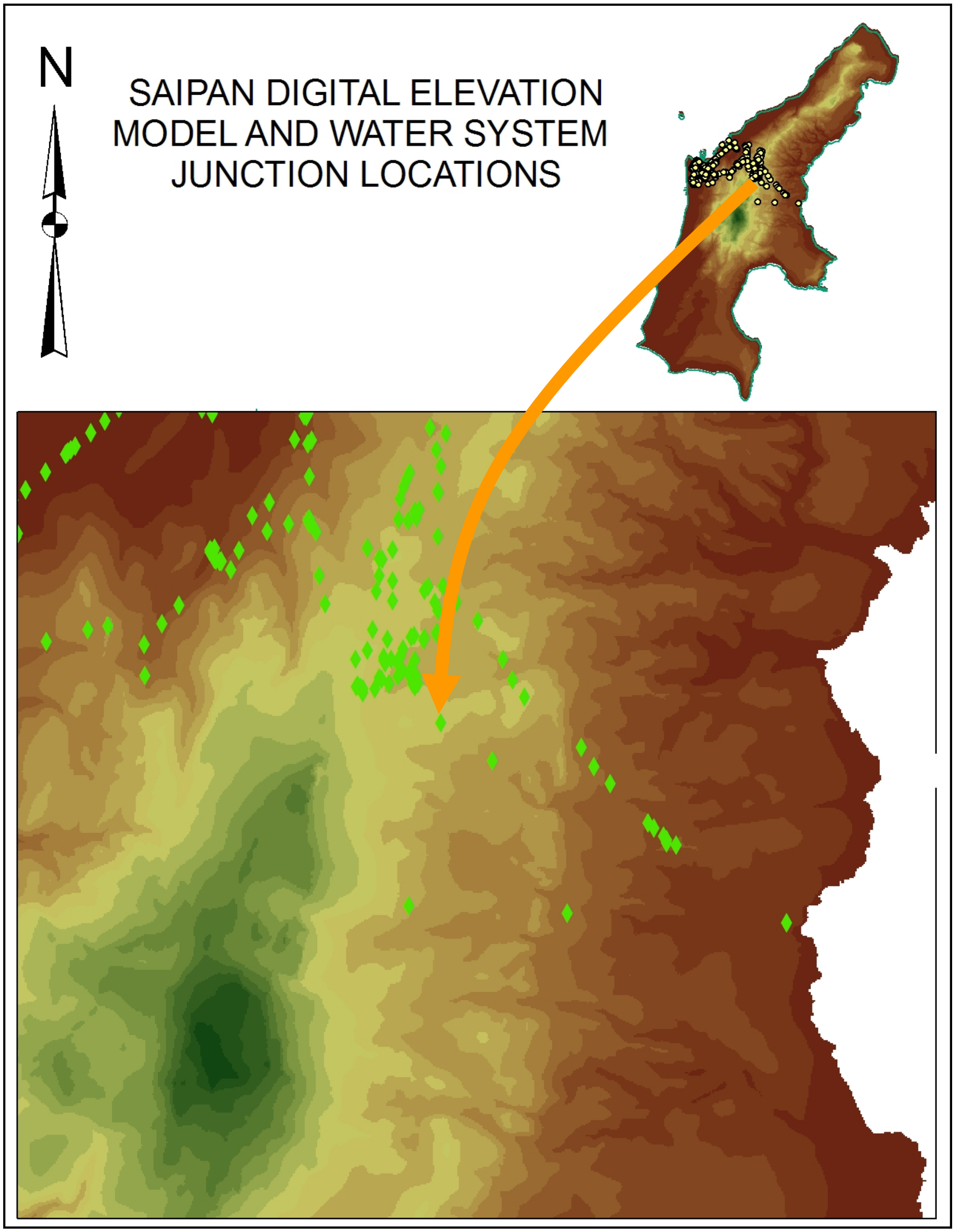

Figure 2. Saipan digital elevation model (DEM) with water system junction nodes used for assigning junction node elevations.

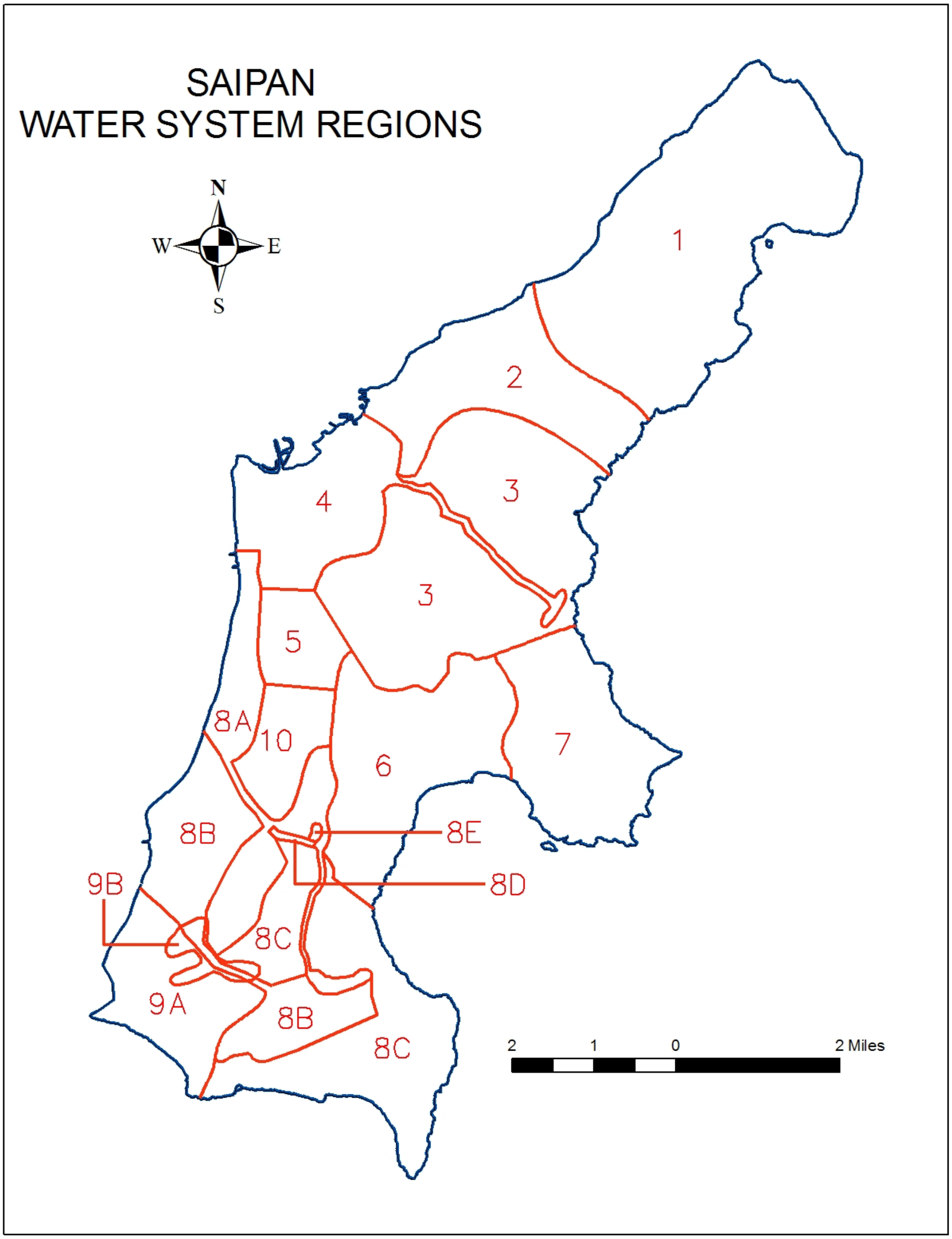

Figure 3 Saipan water system sub-regions

WATER USE DEMAND CALCULATION
FOR
SAIPAN WATER DISTRIBUTION SYSTEM
Using CUC Routing System

Region	# Customers	# People	Water Use GPD/P	Water Use GPD/P	Water Use GPD/P	Water Use (gpm)	Water Use (gpm)	Water Use (gpm)
		6/customer	80	100	150	80	100	150
1	443	2658	212640	265800	398700	148	185	277
2	582	3492	279360	349200	523800	194	243	364
3	908	5448	435840	544800	817200	303	378	568
4	3163	18978	1518240	1897800	2846700	1054	1318	1977
5	249	1494	119520	149400	224100	83	104	156
6	1180	7080	566400	708000	1062000	393	492	738
7	1113	6678	534240	667800	1001700	371	464	696
8A	2078	12468	997440	1246800	1870200	693	866	1299
8B	1361	8166	653280	816600	1224900	454	567	851
8C	1211	7266	581280	726600	1089900	404	505	757
8D	180	1080	86400	108000	162000	60	75	113
8E	50	300	24000	30000	45000	17	21	31
9A	1545	9270	741600	927000	1390500	515	644	966
9B	164	984	78720	98400	147600	55	68	103
10	384	2304	184320	230400	345600	128	160	240
TOTAL	**14,611**	**87,666**	**7,013,280**	**8,766,600**	**13,149,900**	**4,870**	**6,088**	**9,132**

Table 1 Water system customers and demands by sub-region