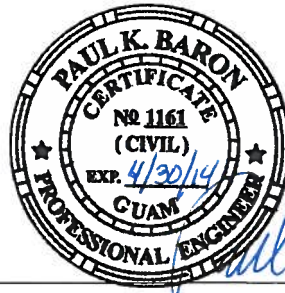




April 17, 2013

Memorandum



Paul K. Baron 4-17-13

To: Chris Lund PE – Receiver Project Manager

Cc: Doug Lee PE, Jeff Pintenich PE, Aaron Sutton PE

Prepared by: Paul Baron PE Tel: 671-472-6792

Subject: Evaluation of GWA Sanitary Sewer System Capacity to Accept Ordot Leachate Job no.: 04385-11-001

General:

This memorandum summarizes our evaluation of the capacity of the existing sewer collection system from the Ordot Dump receiving manhole near Aqueda Johnston Middle School to the Hagatna (Agana) Wastewater Treatment Plant (HWWTP). The purpose of our evaluation is to confirm if the system has adequate capacity to convey leachate from Ordot Dump to the HWWTP for treatment; and confirm if a request from Guam Waterworks Authority (GWA) to retain 12 hours of the peak estimated leachate generation volume can be accommodated in the closure design. This 12-hour hold volume equates to approximately 24,000 gallons at the projected peak daily flow of leachate.

The sewer system was evaluated based on information provided in discussions with GWA and information from GWA's Geographic information system (GIS) database that included pipe sizes, lengths, and manhole inverts for the sewer collection system. The GIS information was used to calculate the full flow capacity of the pipes using the Hazen-Williams equation.

It is important to note that a detailed analysis of GWA's sewer system was beyond the scope of this memorandum, and while the full flow capacities for individual pipe elements were checked for contributing leachate flow from Ordot Dump, no consideration was given to sewer manhole entrance losses or other factors that may contribute to headlosses in the wastewater collection system. However, these headlosses are relatively small for individual gravity sewer segments and the estimates of capacity provided herein are reasonable. In addition, related rainfall information from the United States Geological Survey (USGS) was used to develop a correlation between the rainfall events and inflow and infiltration (I&I) into the sewer system that GWA indicated is a problem.

Dero Road to Route 4:

The existing sewer main on Dero Road is 8 inches in diameter at the terminal manhole (MH) ID 834 (see Figure 1 next page, and Sheet 1 of Appendix 1, Ordot Dump to HWWTP Sewer Collection System Plan). The sewer main increases in size to 10 inches in diameter at the intersection of Dero Road and Judge Sablan Street, where an additional 8-inch-diameter sewer contributes domestic flow from a housing area to the south (see Sheet 2 of Appendix 1). The 10-inch-diameter sewer increases to a 12-inch sewer main along Route 4 at GWA MH 830 (see Sheet 3 of Appendix 1).

The section of sewer on Dero Road with the lowest available capacity after projected residential development in the adjacent areas and leachate contribution from Ordot Dump is a 10-inch pipe downstream of the manhole at the intersection with Judge Sablan Street (from MH 837 to MH

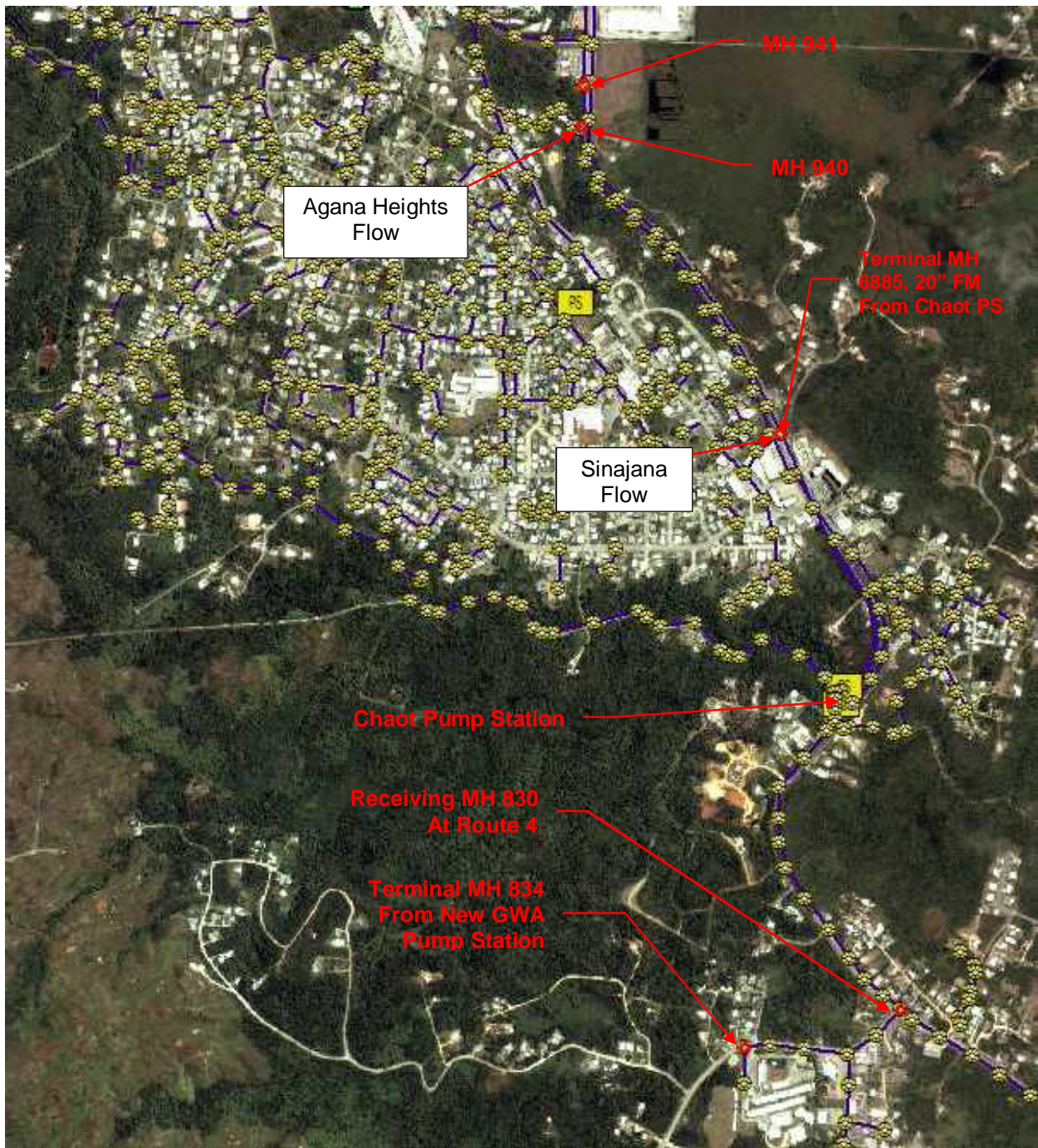


Figure 1. Overall View of Existing GWA Wastewater Collection System.



829). see Sheets 2 and 3 in Appendix 1. This section of sewer has a slope of 0.28 percent and a capacity of about 525 gallons per minute as shown in Table 1.

Per the Dero Road Conceptual Design Report prepared by GHD, dated September 13, 2012, the estimated peak wastewater flow from ultimate build-out of the potential service areas along Dero Road is approximately 78 gallons per minute (gpm). The expected maximum instantaneous flow from the leachate pumps from the Ordot Dump property is 80 gpm which results in an estimated peak flow of 158 gpm between MH 834 and 837. This is only approximately 43 percent of the available capacity of the pipe (estimated at 366 gpm, see Table 1 and discussion in following paragraphs). Additionally, an analysis of the service area off Judge Sablan Street shows approximately 115 residences, one small school, and about 7 offices. Based on a peak flow factor of 4.0, (the GWA standard), the estimated peak flow from that service area is 108 gpm. Therefore, the total estimated peak flow in the 10-inch sewer main from MH 837 to MH 830 is 266 gpm (78 + 80 + 108). This is only approximately 50 percent of the available capacity of the pipe (estimated at 525 gpm, see Table 1). Even with development beyond what is expected, the capacity of the existing gravity sewer collection system along Dero Road is more than adequate to receive the leachate flows.

Route 4 to Hagatna WWTP:

The sewer from MH 830 at the Dero Road/Route 4 intersection conveys wastewater to the Chaot Pump Station located further north along Route 4 via gravity through a series of 10-, 12-, 14- and 15-inch pipes. There are no reported I&I SSO's along this length of the sewer system according to the information provided for our evaluation. There are no other major contributory areas until the Chaot Pump Station where the flows from Sinajana are also collected. Wastewater is then pumped through a 20-inch force main to MH 6885 near a high point on Route 4 by the Summer Holiday Tower Condominiums in Sinajana (See Figure 1 and Appendix A, Sheet 8). Wastewater flow is then conveyed via gravity downhill and north along Route 4 via a series of 15-inch gravity sewers to between MH 6896 or MH 6897 where it is diverted across Route 4 to MH 940 which discharges into MH 941 (see Appendix A, Sheets 11 and 12).

As noted above, flow is discharged into MH 940 from Chaot Pump Station and Agana Heights. In addition, MH 842 is immediately downstream of MH 941, and appears to also receive a significant amount of flow from Agana Heights. This location, specifically MH 941, has been a source of overflows in the past based on our design coordination meeting held with GWA on November 11, 2012, and confirmed with data in the GWA SSO summary report for October 2011 to September 2012. In that meeting, GWA advised that the sewer collection system along Route 4 to the WWTP is adequate to handle the projected leachate flows. GWA also stated the sewer line at the bottom of the hill near the McDonald's Restaurant occasionally experiences overflows during large storm events due to I&I of stormwater and a flattening of the slope of the gravity line that they believe is creating a hydraulic jump near this location. GHD analyzed the GIS sewer data at this location and noted that there is reduction in the slope from 7 percent to 1 percent in the sewers between MH 6895 to MH 842 that could be contributing to the overflow problem.

Table 1 shows the MH ID, pipe size, pipe length, manhole inverts and pipe slopes for the sewer collection system from leachate terminal, MH 834, to MH 184 which is near the receiving manhole for the HWWTP. GHD identified the upstream (US) and downstream (DS) manholes, and pipe segment with the least amount of capacity (highlighted in yellow) based on full flow conditions. In addition, the table shows the percent of flow the leachate would represent in the pipes with the least capacity for each pipe segment, and shows the estimated peak flows for the system along Dero Road, inclusive of leachate. Note, the level of analysis that was done for



estimating the system capacity along Route 4, although not comprehensive, is a reasonable check that can support the conclusions on whether or not the sewer system has adequate capacity to receive the leachate flows.

Table 1 also shows that the portion of flow from the leachate represents less than 2 percent of the overall capacity of the pipe in the area around MH 941 where the existing overflows occur. Based on discussions with GWA Operation's Staff, they believe that I&I flows from Agana Heights into MH 842 may be the most likely cause of the overflows based on their observations. Also, since the flow from MH 941 (immediately upstream of MH 842) is essentially all from the Chaot Pump Station, which pumps at a fairly constant rate, regardless of whether there is wet or dry weather; we do not believe the overflows at MH 842 are specifically related to the flows coming from this portion of the system.

GHD also reviewed GWA's Statewide Sanitary Sewer Overflow (SSO) Annual Compliance Report which contains the records of sanitary sewer overflows from October 2011 to September 2012. The records show that six overflows occurred along the entire 13,500 feet of sewer main from Ordot-Chalan Pago to the Hagatna WWTP during this period, and all of them were at just two locations located approximately 3,000 feet from the end of the system. Of these SSO's, three occurred at MH 941, a fourth was a combined incident at MH 940 and MH 941, and a fifth one was a combination incident at MH 941 and MH 6897 all due to I&I. The sixth overflow occurred at MH 10103 near the Hagatna main pump station due to clogging from FOG (fats, oil, and grease).

Table 2 summarizes the related information from the Annual Compliance Report for the overflows noted above as well as the action taken for each incident. As the Table shows, approximately 5,000 gallons of sewage spilled total during the 5 I&I related events. During this same period from October 2011 to September 2012, there was a total of 136 sewage overflows Island-wide with a total spillage of over 32,400 gallons.

Table 3 summarizes the rainfall data for the 5 I&I-related overflows based on rainfall data from the USGS website for the Mount Chachao Station near Piti (this is the closest rain gauge station, see http://waterdata.usgs.gov/ku/nwis/current/?type=precip&group_key=county_cd). As the data shows, the 5 overflow events all occurred after significant rainfall events. In all cases there was a lag between the beginning of the rainfall period and the overflow event of between 2 and 5 hours, which is expected due to the length of time it takes the I&I to enter the system, and the difference in geographic location between the Mount Chachao Station rain gauge and the collection system receiving the I&I. It is also important to note that the 5/26/12 and 8/7-8/12 overflows occurred during what appear to be two of the highest intensity rainfall periods of the year (see Figure 2).



TABLE 1. SUMMARY OF GRAVITY SEWER SYSTEM FROM DERO ROAD TO MH 184

GWA US MH ID #	GWA DS MH ID #	PIPE SIZE OUT (IN)	PIPE LENGTH OUT (FT)	SLOPE	MIN CAPACITY (GPM)	LEACHATE % OF FLOW	COMMENTS
834	835	8	215	-0.0049	363	22.0%	Est. System peak flow 158 gpm
835	836	8	283	-0.0089			Est. System peak flow 158 gpm
836	837	8	350	-0.0305			Est. System peak flow 158 gpm
837	829	10	284	-0.0028	525	15.2%	Estimated System Peak Flow 266 gpm
829	830	10	274	-0.0051			Estimated System Peak Flow 266 gpm
830	831	12	181	-0.0022	928	8.6%	Estimated System Peak Flow 266 gpm
831	832	12	210	-0.0022			
832	833	12	202	-0.0051			No System Flow Estimate Available
833	2707	12	270	-0.0053			
2707	4102	12	320	0.0023			
4102	4103	12	300	-0.0055			
4103	4104	10	220	-0.0363			
4104	4105	10	200	-0.0487			
4105	825	10	225	-0.0827			
825	826	10	300	-0.0841			
826	827	10	290	-0.0379			
827	828	10	100	-0.0310	1,346	5.9%	
828	6881	14	96	-0.0035	1,757	4.6%	
6881	959	14	70	-0.0109			
959	6878	14	75	-0.0139			
6878	6885	14	25	-0.0188			To Chaot PS (assumed invert)
6885	6886	15	245	-0.0351			Flow from Chaot FM
6886	6887	15	300	-0.0370			
6887	6888	15	300	-0.0630			
6888	6889	15	300	-0.0613			
6889	6890	15	300	-0.0350			
6890	6891	15	300	-0.0350			
6891	6892	15	165	-0.0450			
6892	6893	15	245	-0.0468			
6893	6894	15	190	-0.0527			
6894	6895	15	240	-0.0538			
6895	6896	15	234	-0.0500			
6896	940	15	182	-0.0705			End of new inactive line
940	941	15	350	-0.0119	4,162	1.9%	Location of Overflows
941	842	15	350	-0.0120			Location of Overflows
842	942	15	350	-0.0132			
942	939	18	350	-0.0036	3,510	2.3%	
939	494	18	350	-0.0051			
494	937	24	288	-0.0011			
937	938	24	251	-0.0011	3,943	2.0%	
938	394	24	269	-0.0011			
394	935	24	285	-0.0011			
935	936	24	287	-0.0011			
936	6908	24	328	-0.0025			
6908	180	30	127	-0.0011	7,090	1.1%	
180	181	36	227	-0.0026			
181	182	36	302	-0.0012	12,004	0.7%	
182	183	36	25	-0.0012			
183	184	36	301	-0.0012			
184	36	246	-3.7	0.0150			To HWWTP



Table 2. Summary of GWA's Statewide SSO Annual Compliance Report for Mainline

Incident	Start Date & Time	End Date & Time	Location	Sub Facility	Root Cause	Net Spill (gal)	Description of Incident	Action Taken
1	5/26/12 2:40 PM	5/26/12 3:05 PM	Chalan Canton Tasi	Manhole	Heavy Rain I&I	50	Found MH ID # 941 overflowing.	Manually regulate pump cycles at CD-7 New Chaot P/S due to heavy rain in the area. Continued until flow was normal.
2	8/7/12 8:00 PM	8/7/12 11:20 PM	Chalan Canton Tasi	Manhole	Heavy Rain I&I	200	Received call from base, investigated and found manhole spilling	Set up traffic control to prevent vehicles from falling into offset manhole # 941. Once the sewer surge subsided, secured manhole and removed traffic cones.
3	8/8/12 6:15 PM	8/8/12 7:45 PM	Rt4 Chalan Canton Tasi	Manhole	Heavy Rain I&I	900	Inspection found Manhole ID #941	Set up traffic control to prevent motorist from hitting manhole and causing damage. SSO calculated at approximately 10 gpm through manhole cover.
4	8/15/12 9:30 PM	8/15/12 11:00 PM	Rte 4 Chalan Canton Tasi	Gov't. Clean Out	Heavy Rain I&I	1,800	Received call from base report of overflow, found MH # 941 and MH 940 offset.	Set up traffic control in front of MH # 940 and 941, it was needed to prevent motorist from driving into manhole and causing damages or injuries, approximately 10 gallons per minute was spilling from each manhole. Secured upon completion
5	8/22/12 7:05 PM	8/22/12 8:45 PM	Chalan Canton Tasi Rt. 4	Manhole	Bad Weather	2,000	Made inspection to area found MH's OID #6897 and OID #941 overflowing.	Set up traffic cones to deter motorist from running over manholes. Stood-by to monitor until the overflow ceased.
6	3/15/12 9:00 AM	3/15/12 11:00 AM	Marine Corp drive	Manhole	FOG	30	Inspection found MH ID #10303 overflowing.	Inserted jetter into Manhole ID # 10303. Hit obstruction at 20 feet, flow started to deplete, jetted total 80 feet toward Jbox. Grease identified as reason for overflow, removed debris and disinfected. Normal flow restored, reported to base control.

Table 3. Related Rainfall Data for Sewage Overflows

Incident	Start Date/Time	End Date/Time	Rain Patterns
1	5/26/12 2:40 PM	5/26/12 3:05 PM	A total of 3.55 inches of rain fell over approximately 2 hours from 12 noon to 2 PM with a peak of 3.43 inches from 12:30 to 1:15 PM.
2	8/7/12 8:00 PM	8/7/12 11:20 PM	A total of 2.89 inches of rain fell over approximately 3 hours and 45 minutes from 6 PM to 10:45 PM with a peak of 2.30 inches from 7 to 8 PM
3	8/8/12 6:15 PM	8/8/12 7:45 PM	A total of 5.95 inches of rain fell over approximately 5 hours and 30 minutes from 1:30 PM to 7 PM with a peak of 5.32 inches from 1:30 to 2:45 PM
4	8/15/12 9:30 PM	8/15/12 11:00 PM	A total of 2.2 inches of rain fell over approximately 6 hours and 30 minutes from 3:30 PM to 10 PM with a peak of 0.72 inches from 3:30 to 4 PM and another burst of 1.26 inches from 8 to 8:45 PM.
5	8/22/12 7:05 PM	8/22/12 8:45 PM	A total of 2.93 inches of rain fell over approximately 6 hours and 30 minutes (same as previous day) from 3:30 PM to 10 PM with a peak of 1.95 inches from 4:15 to 6 PM.

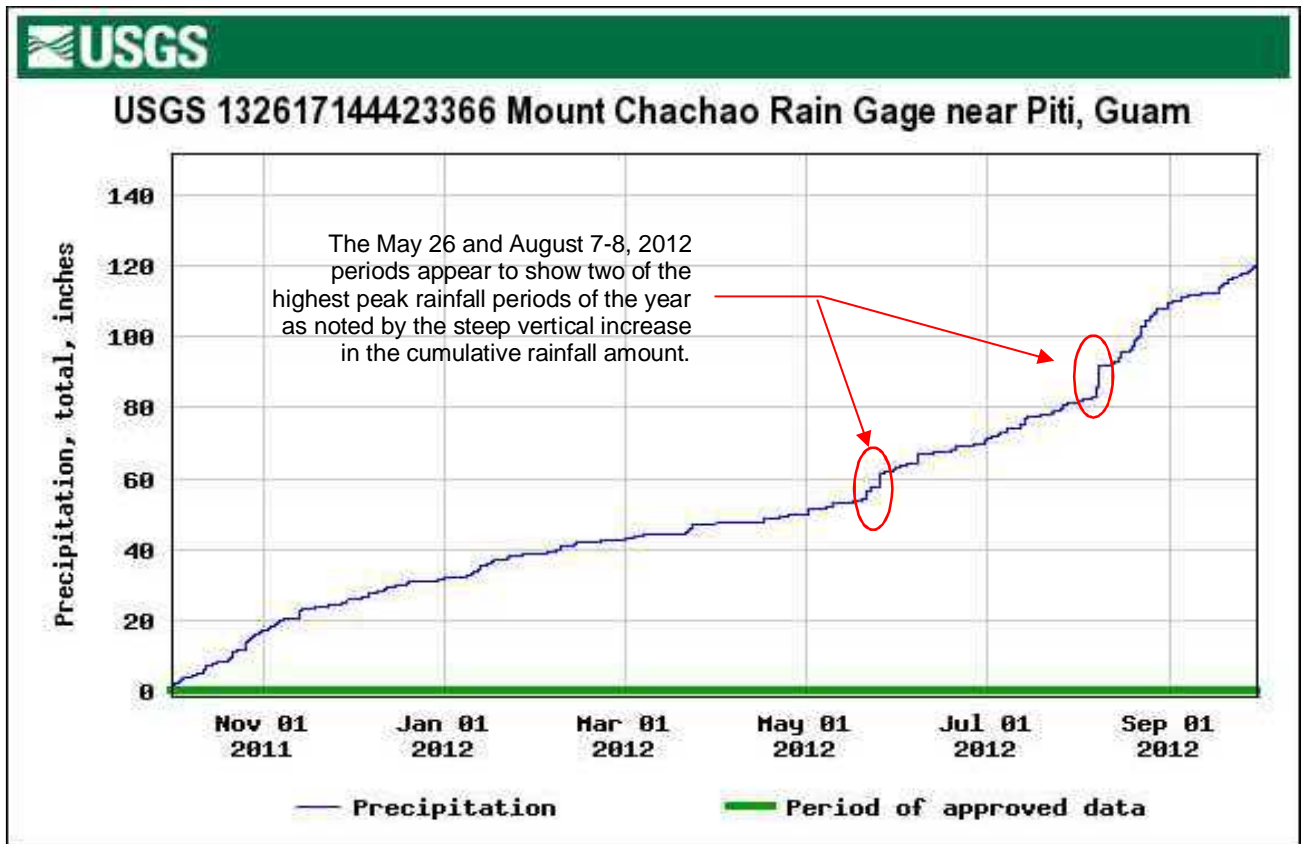


Figure 2. Annual Rainfall Cumulative Curve

Conclusions & Recommendations:

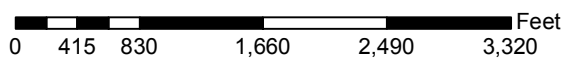
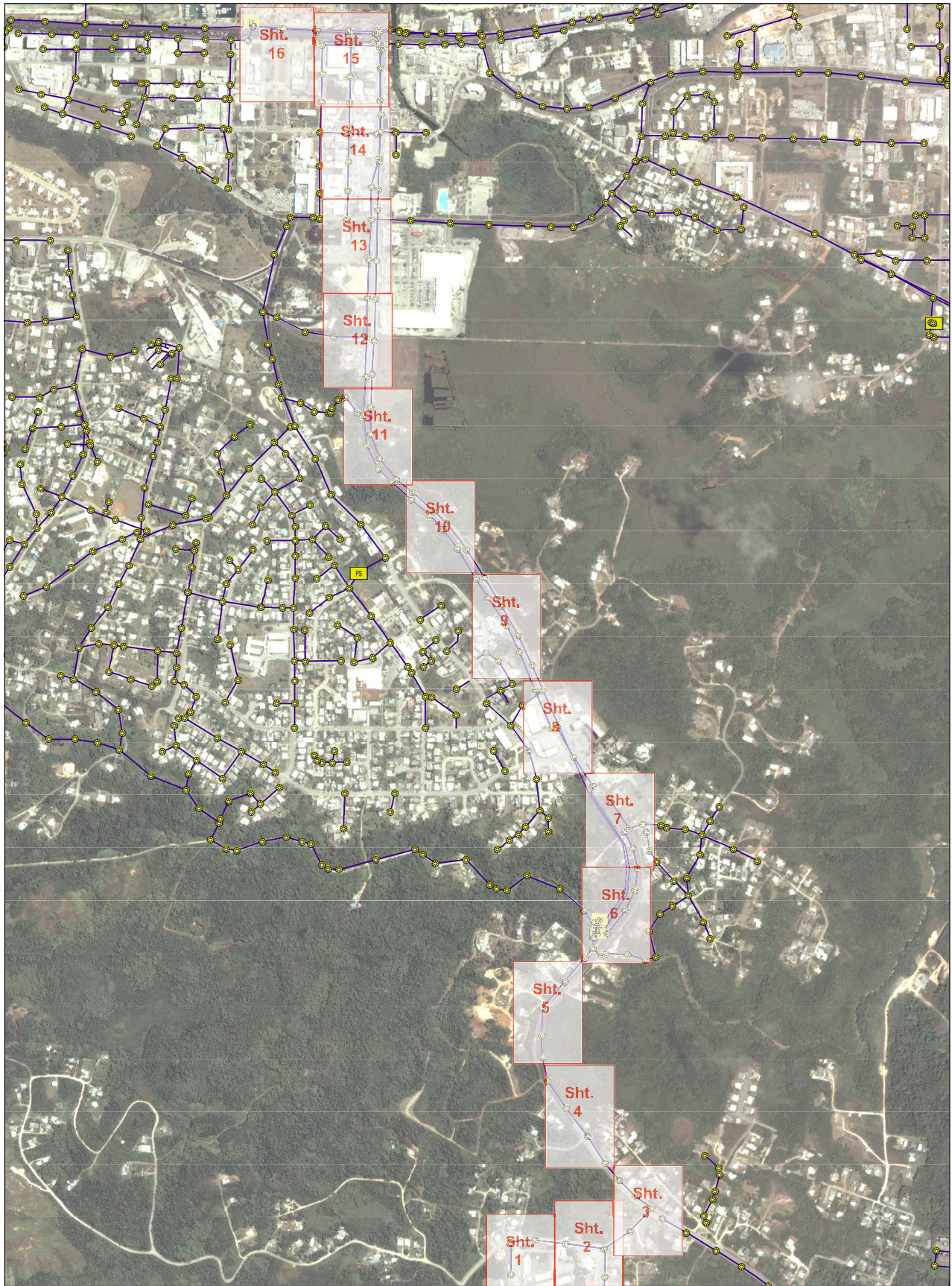
The capacity of the existing GWA sewer collection systems along Dero Road is more than adequate to handle the projected leachate flows from Ordot Dump after its closure as well as future development in the area. The sewer system along Route 4 to the Hagatna WWTP also has adequate capacity and following extreme rainfall events, the system occasionally experiences SSOs resulting from I&I at or near MH 941.

It is clear that the capacity of the sewers is not an issue in dry weather, and that overflows occur as a result of I&I only after extreme rainfall events. This is substantiated by GWA. In addition, and as expected, there is a lag between the rainfall and the overflow events; and all the overflow events were stopped within 25 minutes to 3 hours and 20 minutes. In closure design discussions with GWA, it was agreed that in order to help alleviate the potential to exacerbate SSO events due to I&I, the leachate management system at Ordot Dump will have the capacity to temporarily hold leachate after large rainfall events. GWA requested that the leachate be held for up to 12 hours after wet weather to let the inflow surge from the I&I subside.




As requested by GWA, the Ordot Dump Closure Plans provide at least 12 hours of leachate storage, when needed, to avoid pumping during heavy rain events or during peak flow times within GWA's system. The storage is provided in three 16,000-gallon tanks located at the low end of the project site. The planned 48,000-gallon storage capacity provides retention for nearly 24 hours at the projected peak flow and over 13 days at the projected long-term annual average flow of 3,600 gallons per day (gpd) of leachate.



APPENDIX 1: Ordot to HWWTP Sewer Collection System Plan



Legend

-  Manhole
-  PumpStation
-  SewerMain

Key Map



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-  Manhole
-  SewerMain



MH 837 AT JUDGE SABLAN STREET INTERSECTION



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-  Manhole
-  SewerMain



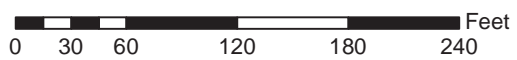
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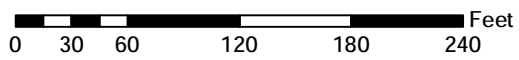
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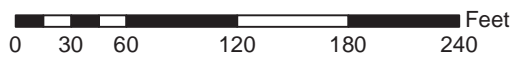
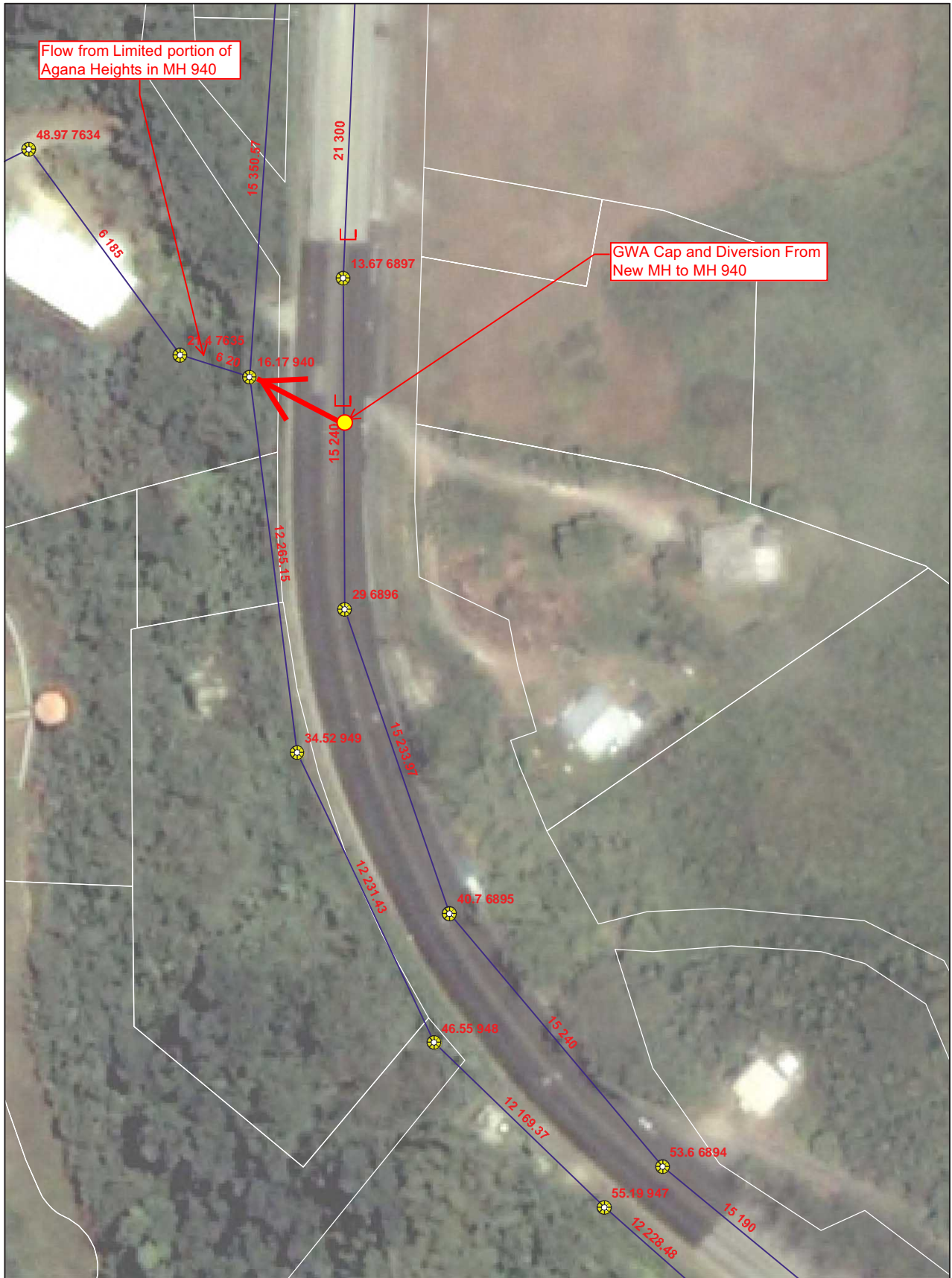
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