increase storage in the system. This weir should be raised to prevent the fast moving influent flow from splashing over the weir under peak flow conditions.

The model indicates that these improvements to the Broad Street CSO regulator will eliminate overflows for both the 3-month and 1-year storms.

Tampa Street (CSO 007). The model showed that the NRI has the capacity to receive more flow from this regulator. Increasing the diameter of the dry weather connection from 10-inches to 18-inches will eliminate overflows for the 3-month and 1-year storms. A "duckbill" type valve or flap gate is also recommended at this location to keep the Nashua River from flowing over the regulator and into the sewers when the River is at high stage.

Lock Street (CSO 009). The model showed a considerable amount of headloss across the dry weather connection, indicating that the pipe was undersized. Removing the plate (as noted in Chapter 3) and increasing the diameter of the dry weather connection from 10-inches to 18-inches would eliminate overflows for the 3-month and 1-year design storms.

Nashua River (CSO 006). This structure is on the banks of the Nashua River, where the NRI and NMRI connect. It is one of the primary relief points for the interceptor system. Simulations of the 3-month and 1-year design storms, under NFBC, produced 0.32 mgal and 1.26 mgal of overflow, respectively. Although the interceptor upstream and downstream of the structure is extremely large (108-inch diameter), flow is limited by a 54-inch by 54-inch opening, designed to protect the downstream interceptor from surcharging and to limit flow to the NWTF. Here, the recommended improvement is raising the weir by 2.5 feet, rather than increasing the diameter of the connecting pipe. This will allow the hydraulic grade in the pipe to rise higher before overflowing, yet is not predicted to cause flooding upstream. This improvement will eliminate overflow for the 3-month and 1-year design storms.

East Hollis Street (CSO 005). The weir at the East Hollis Street CSO is the lowest in the system. As previously discussed, downstream hydraulic restrictions at the NWTF can cause flow in the interceptor to rise above the weir, causing overflows. Raising the weir by 3.0 feet would prevent flow in the interceptor from discharging out the East Hollis Street structure. It would also reduce overflows from the combined sewage entering the East Hollis Street structure. The model predicts that implementing this SOM would reduce the 3-month storm overflow volume by 0.21 mgal, and would reduce overflow from the 1-year storm by 0.31 mgal.

Burke Street (CSO 004). The model indicates that during peak flows, flow will overtop the weir. Increasing the diameter of the dry weather connection from 10-inches to 15-inches, coupled with increasing the height of the weir by 3 inches, is predicted to eliminate overflows during the 3-month and 1-year design storms.

Salmon Brook (CSO 002). The model predicted no overflows at this CSO during either the 3-month or 1-year design storms. As a result, no system optimization measures were developed for the Salmon Brook CSO.

Farmington Road (CSO 003). Dry weather flow from the Farmington Road CSO regulator is diverted to the South Merrimack Interceptor (SMI). Providing hydraulic relief at the NWTF would significantly reduce the peak hydraulic grade in the SMI. That in turn would allow more flow to be diverted from the Farmington Road system. This could be accomplished by increasing the diameter of the dry weather connection from 10-inches to 20-inches. With this modification in place overflows are predicted to be eliminated at CSO 003 during the 3-month and 1-year design storms.

Summary of Proposed System Optimization Measures

System optimization measures can eliminate overflows that occur under NFBC during the 3-month and 1-year storms in six of the seven CSOs. The CSO discharges eliminated are at CSOs that are relatively remote from the NWTF, at locations where end-of-pipe storage or treatment facilities would be more difficult to construct and operate. The model predicts that if all recommended SOMs are implemented, as shown in Table 8-4, overflows would still occur during the 1-year storm at CSO 005.

TABLE 8-4. SUMMARY OF SYSTEM OPTIMIZATION MEASURES WITH NWTF WET WEATHER BYPASS

NPDES Discharge Number	Location		Overflow Volume for Design Storm Event (mgal)			Description of SOM
			3-Month	1-Year	2-Year[1]	
CSO 002	Salmon Brook	w/o SOM	0.00	0.00	0.00	None
		w/ SOM	0.00	0.00	0.00	
		Change	**0.00**	**0.00**	**0.00**	
CSO 003	Farmington Road	w/o SOM	0.12	0.32	0.46	Increase DWC to 20 inches
		w/ SOM	0.00	0.00	0.05	
		Change	**-0.12**	**-0.32**	**-0.41**	
CSO 004	Burke Street	w/o SOM	0.39	0.84	1.24	Raise weir elevation 0.25 feet Increase DWC to 15 inches
		w/ SOM	0	0	0.01	
		Change	**-0.39**	**-0.84**	**-1.23**	
CSO 005	E. Hollis Street	w/o SOM	0.33	0.86	1.39	Raise weir elevation 3.0 feet
		w/ SOM	0.12	0.55	0.93	
		Change	**-0.21**	**-0.31**	**-0.46**	
CSO 006	Nashua River	w/o SOM	0.32	1.26	2.59	Raise weir elevation 2.5 feet
		w/ SOM	0	0	1.09	
		Change	**-0.32**	**-1.26**	**-1.50**	
CSO 007	Tampa Street	w/o SOM	0	0.02	0.12	Increase DWC to 18 inches
		w/ SOM	0	0	0	
		Change	**0.00**	**-0.02**	**-0.12**	
CSO 008	Broad Street	w/o SOM	0.21	0.51	0.7	Raise weir elevation 0.5 feet Increase DWC to 20 inches
		w/ SOM	0	0	0.04	
		Change	**-0.21**	**-0.51**	**-0.66**	
CSO 009	Lock Street	w/o SOM	0.04	0.08	0.12	Increase DWC to 18 inches Remove diversion plate at DWC
		w/ SOM	0	0	0	
		Change	**-0.04**	**-0.08**	**-0.12**	
TOTAL		w/o SOM	1.41	3.89	6.62	
		w/ SOM	0.12	0.55	2.12	
		Net Change	**-1.29**	**-3.34**	**-4.50**	

Note: [1]. Based on the 2-year actual storm event.

SYSTEM OPTIMIZATION COST DERIVATION

This section presents cost estimates for the proposed system optimization measures.

Cost Estimating Approach

System optimization measure costs have been developed based on typical unit costs for simple modifications, and site-specific costs for more complex optimization measures. Certain types of system optimization measures (such as constructing masonry weirs) will have similar unit costs regardless of location. These unit costs were then adjusted as appropriate to account for site-specific factors. More complex system optimization measures, such as increasing the size of a connection between a regulator and interceptor, required site-specific cost estimates. A brief discussion of the basis for developing unit costs for the types of system optimization measures is presented below.

Unit Cost Derivation

Unit construction costs were developed based on the 20-city average ENR Construction Cost Index of 6512 (May, 2001), and represent a preliminary estimate of a contractor's bid price for the work, including costs for labor, materials, equipment, contractor overhead and profit, and contractor's contingencies. An additional allowance of 25 percent for other contingencies was added, along with a 20 percent allowance for legal, administrative, and engineering costs, to arrive at the total unit costs.

Costs for Weir Improvement SOMs

Masonry Weirs. The estimated cost is based on the following approach:

- Perform construction during dry weather, when there is no overflow, so that bypass pumping will not be required.
- Provide traffic cones and/or barrels, and a police detail for traffic control

- Utilize bricks, concrete masonry unit (CMU) blocks, and mortar as required to construct the weir.
- Utilize a four person crew, including one authorized confined space entrant, one laborer, and one foreman.
- Based on the costs incurred on other, similar projects, a typical cost of $3,700 per weir is anticipated for masonry weir construction work.

Cast-in-Place Concrete Weirs. The estimated cost is based on the following approach:

- Perform construction during dry weather, when there is no overflow, so that bypass pumping will not be required.
- Provide traffic cones and/or barrels, and a police detail for traffic control.
- Utilize reinforcing steel and/or wire fabric to reinforce and anchor the new work to the existing structure. Wooden forms will be installed, and concrete placed. After the concrete has cured, the forms will be stripped.
- Utilize a five person crew: a laborer and a carpenter (both qualified as confined space authorized entrants); a confined space attendant; a laborer to handle material at the ground surface; and a foreman.
- Allow two consecutive days to install reinforcing forms and place the concrete. A third day will be required to strip forms and finish the work.

Based on the costs incurred on other, similar projects, a typical cost of $13,750 per weir is anticipated for cast-in-place construction work.

At the Burke Street (004) and East Hollis Street (005) CSOs, it was assumed that the weir elevation could be raised with brick construction, and therefore would cost $3,700 at each site. In the Nashua River (006) CSO, the large weir and high flows warrant a stronger, formed concrete weir. Therefore the estimated cost is $13,750.

SOM Costs

Enlarging dry weather connections. Typical costs for replacing the dry weather connection pipes at the regulators with larger diameter pipes have been developed based on costs for similar work done recently in the greater Boston area. Those costs were adjusted to reflect the current construction cost index (ENR 6512). The following were included in the projected cost:

- Excavation and shoring
- Dewatering
- Bypass pumping during construction
- Manholes
- Paving/site work
- Traffic control/police details
- Mobilization

Based on costs incurred on other, similar projects, a typical cost of $60,000 per connection is anticipated.

At the Broad Street regulator, the section of dry weather connection pipe to be replaced is significantly longer than at other typical sites. Therefore, the cost for this work at CSO 008 was estimated separately, based on bids submitted for other, similar projects. Based on this, a cost of $720,000 was estimated for improvements at CSO 008.

SOM costs

Flap-gate at end of outfall. The $40,000 unit cost for the flap-gate to be installed at the end of the Tampa Street CSO outfall includes the cost of the gate, and installation costs. The cost was derived from manufacturer cost estimates.

Table 8-5 presents the recommended SOMs and the estimated cost for each improvement.

TABLE 8-5. SUMMARY OF SYSTEM OPTIMIZATION MEASURES WITH NWTF WET WEATHER BYPASS

NPDES Discharge Number	Location	Description of SOM	Cost
CSO 002	Salmon Brook	None	$0
CSO 003	Farmington Road	Increase DWC to 20 inches	$60,000
CSO 004	Burke Street	Raise weir elevation 0.25 feet Increase DWC to 15 inches	$63,700
CSO 005	E. Hollis Street	Raise weir elevation 3.0 feet	$3,700
CSO 006	Nashua River	Raise weir elevation 2.5 feet	$13,750
CSO 007	Tampa Street	Increase DWC to 18 inches Install Flap-gate on end of outfall	$100,000
CSO 008	Broad Street	Raise weir elevation 0.5 feet Increase DWC to 20 inches	$723,700
CSO 009	Lock Street	Increase DWC to 18 inches Remove diversion plate at DWC	$60,000
TOTAL			**$1,024,850**

Note: DWC = Dry weather connection

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CHAPTER 9

METHODOLOGY FOR DEVELOPING CSO CONTROL ALTERNATIVES

This chapter describes the methodologies used to develop, size, cost, and evaluate the alternatives identified for CSO control in Nashua.

First, the CSO control technologies considered in this study are presented. This is followed by discussions of the methodology for sizing alternatives, cost estimating, and the methodology used to evaluate performance. The end of this chapter identifies non-monetary issues that were factors in analyzing alternatives and developing the recommended plan.

CSO CONTROL TECHNOLOGIES

The first step in the evaluation process was to identify and screen general technologies suitable for CSO control. Three categories of CSO control technologies were examined:

- Collection system controls
- Storage technologies
- Treatment technologies

Technologies were screened by evaluating their general characteristics, effectiveness, and feasibility of implementation within the Nashua study area. Technologies were considered for localized use (at individual CSOs) and widespread use (at multiple CSOs) as applicable.

While sewer separation is not addressed as a CSO control technology in this chapter, sewer separation was evaluated and compared with other alternatives (see Chapter 10).

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Collection System Controls

Collection system controls include alternatives that target existing combined sewer collection system features. Some low-cost collection system controls such as street cleaning and proper maintenance of collection system structures, as presented in the Nine Minimum Controls Report (*Report on Nine Minimum Control Measures,* prepared by CDM, April 1996), have already been implemented in Nashua. Other collection system controls evaluated in this study include system optimization measures (SOMs) such as raising regulator weirs, and relieving hydraulic constraints in the system where they exist for short distances, by enlarging pipes or increasing slopes. Details of these collection system controls were presented in the previous chapter, and the recommended SOMs were incorporated into model simulations used for sizing CSO control alternatives.

Storage Technologies

Storage of wet weather flows in the collection system can be an effective means of CSO control, provided that the stored flow is later conveyed to the wastewater treatment plant, once capacity becomes available. Storage technologies can provide flow equalization in the collection system, reducing the hydraulic peak to the wastewater treatment plant.

Storage technologies that are available include in-system storage, off-line storage, and surface storage. Off-line storage, which involves using storage tanks or conduits in parallel with the sewer system, is of principal consideration for Nashua. Peak flows would be stored during the height of a storm, then would be pumped back into the collection system for subsequent treatment once capacity is available. *

Storage tanks offer significant advantages: they are simple to design and operate, and they can respond to rapid changes in flow. The main drawback to off-line storage is difficulty in acquiring appropriate sites large enough to accommodate these facilities.

Treatment Technologies

Treatment technologies target reducing the pollutant loads in CSO discharges. Specific technologies address specific pollutants, such as floatables, bacteria and viruses, suspended solids, and various biochemical constituents. Treatment technologies that were evaluated for Nashua include screening, detention/treatment, high-rate sedimentation, and disinfection. These processes are reliable and are commonly used in wastewater treatment, specifically in treating CSOs. In general, these processes are flexible, readily automated, and capable of operating over a wide range of flows.

Screening. This technology removes solids and floatables of various sizes, depending on the type of screen. Screens come in many different sizes and shapes: simple bar screens, coarse and fine screens, and microstrainers. Typically, coarse screens are used upstream of other control technologies, to protect the function of downstream facilities. Screening equipment can be installed either in-line or off-line, depending on the type. A major consideration with in-line facilities is avoiding large head losses, which could restrict flow and possibly cause flooding. Microstrainers and fine screens are more susceptible to operational problems such as clogging and high head loss. Coarse bar screens and fine screens that have been used effectively in CSO applications have been considered in this report for use in end-of-pipe treatment facilities, both adjacent to CSO regulators and at the NWTF bypass.

Detention/Treatment. The detention/treatment technology is based on conventional primary sedimentation, where suspended solids sink to the bottom of a large tank. This technology has been used historically to remove settleable solids in domestic sewage and has also been successfully used for CSO treatment. Detention basins offer the advantages of being able to store CSOs during small storm events and providing treatment during larger events. Detention basins also provide contact time necessary for chlorine disinfection. However, one of the disadvantages of this technology is that it requires a relatively large land area.

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High-Rate Sedimentation. While conventional sedimentation tanks were considered for primary treatment facilities adjacent to CSO regulators, enhanced settling methods such as coagulant addition/flocculation, lamella settlers, tube settlers, and high rate ballasted settling systems were considered for use at the NWTF. Although high rate sedimentation technologies are less common than conventional sedimentation for CSO control applications, they are a proven technology for removal of BOD and TSS, where can out-perform conventional sedimentation technologies, and have relatively small land requirements.

In common chemically enhanced, ballasted sedimentation processes, a chemical coagulant such as alum or ferric is added to screened wastewater to destabilize suspended solids and colloidal material. The wastewater stream then passes into an injection tank where a flocculant aid polymer and ballast (either recycled sludge or microsand) are added and rapidly mixed with the wastewater, forming floc. Wastewater then flows to a maturation tank where milder mixing helps to form ballasted floc particles containing polymer bridges between the ballast and destabilized suspended solids. Next, wastewater enters the settling tank, where the majority of floc particles settle to the bottom of the tank. Most of the remaining particles are removed in the plate-settling zone, and clarified water exits over a series of plate settler weirs. The ballasted floc is removed and if microsand is used as the ballast a grit cyclone separates the sludge for thickening or final disposal and recycles the microsand to the treatment process.

Disinfection. Disinfection destroys disease producing microorganisms such as bacteria and viruses. Disinfection efficiency depends on factors such as mixing, contact time, dosage control, and equipment reliability. Several disinfection technologies involve the use of chlorine-based compounds. These technologies require a subsequent dechlorination step, to reduce residual chlorine levels to prevent harm to aquatic life.

Sodium hypochlorite solution is essentially a concentrated form of liquid chlorine bleach. It is the most commonly used disinfectant for CSO treatment. Chemical metering pumps can automatically deliver sodium hypochlorite from storage tanks to CSO flow in response to storm events. This disinfection technology is recommended for use in conjunction with the treatment technologies presented above.

The most common form of dechlorination at CSO treatment facilities involves applying liquid sodium bisulfite. Like sodium hypochlorite, chemical metering pumps can automatically deliver sodium bisulfite from storage tanks to CSO flow in response to storm events. Sodium bisulfite dechlorination is recommended for use in conjunction with the treatment technologies presented above.

DEVELOPMENT OF ALTERNATIVES

The CSO control technologies described above were evaluated further for applicability in Nashua, based on the hydraulic characteristics of the Nashua combined sewer system and the land use characteristics of the area. A discussion of the process used to develop alternatives is presented below and includes a description of the sizing of facilities, cost estimating, and performance evaluation.

CSO Control Technology Sizing

The first step in developing site-specific CSO control technologies was to select the appropriate size of the facilities and equipment, based upon the intended level of control. Model simulations for near future baseline conditions (NFBC) with the recommended system optimization measures (SOMs) were run with the typical year rainfall file and for a series of design storms. The larger storm events in the typical year, along with design storm events with recurrence intervals greater than one year, were the basis for sizing the alternative.

CSO control technologies were sized to achieve a range of levels of performance (e.g., number of untreated overflows per year). For example, storage tanks were sized to achieve four, one, and zero overflows in a typical year. CSO control technologies were

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subsequently sized to achieve higher levels of performance (e.g., to achieve no untreated overflows in response to 2-year, 5-year, and larger storm events).

Storage tank sizes were selected based on containing the overflow volume from the design storms while treatment units were sized to handle the peak flow rate. After the unit sizes were computed, capital costs were developed for each alternative.

CSO Control Cost Estimating

Construction Cost Estimates. Most construction costs were derived from published sources or based on the cost of other projects in New England involving equipment and tanks similar to those being considered for Nashua. All costs presented below were developed based on an Engineering News Record (ENR) cost index of 6512, representing the National 20-city average, May 2002.

Storage. Storage facility costs were estimated using an equation (USEPA CSO Control Manual, September 1993) that accounts for materials, excavation, backfill, concrete work, and mechanical and electrical equipment. The calculation is based on the CSO volume to be stored, and assumes a 15-foot sidewater depth. Other costs that are added to the basic facility cost, computed with the equation, include piping, sheeting, disposal of excavate, and odor control costs. Piping costs were computed based on an equation that estimates the cost per unit length of pipe for a given pipe diameter, while sheeting, disposal of excavate and odor control costs were estimated from projects of similar scope and size.

what about land costs? O&M costs?

Screening and Disinfection. Construction costs for screening and disinfection facilities included costs for a chlorine contact tank, mechanically-cleaned fine screens and chemical feed (disinfection/dechlorination) equipment and associated building space, effluent pumps, odor control equipment, and piping to convey flow to and from the facility. The chlorine contact tank cost was developed using the construction cost curve

land costs? O&M costs?

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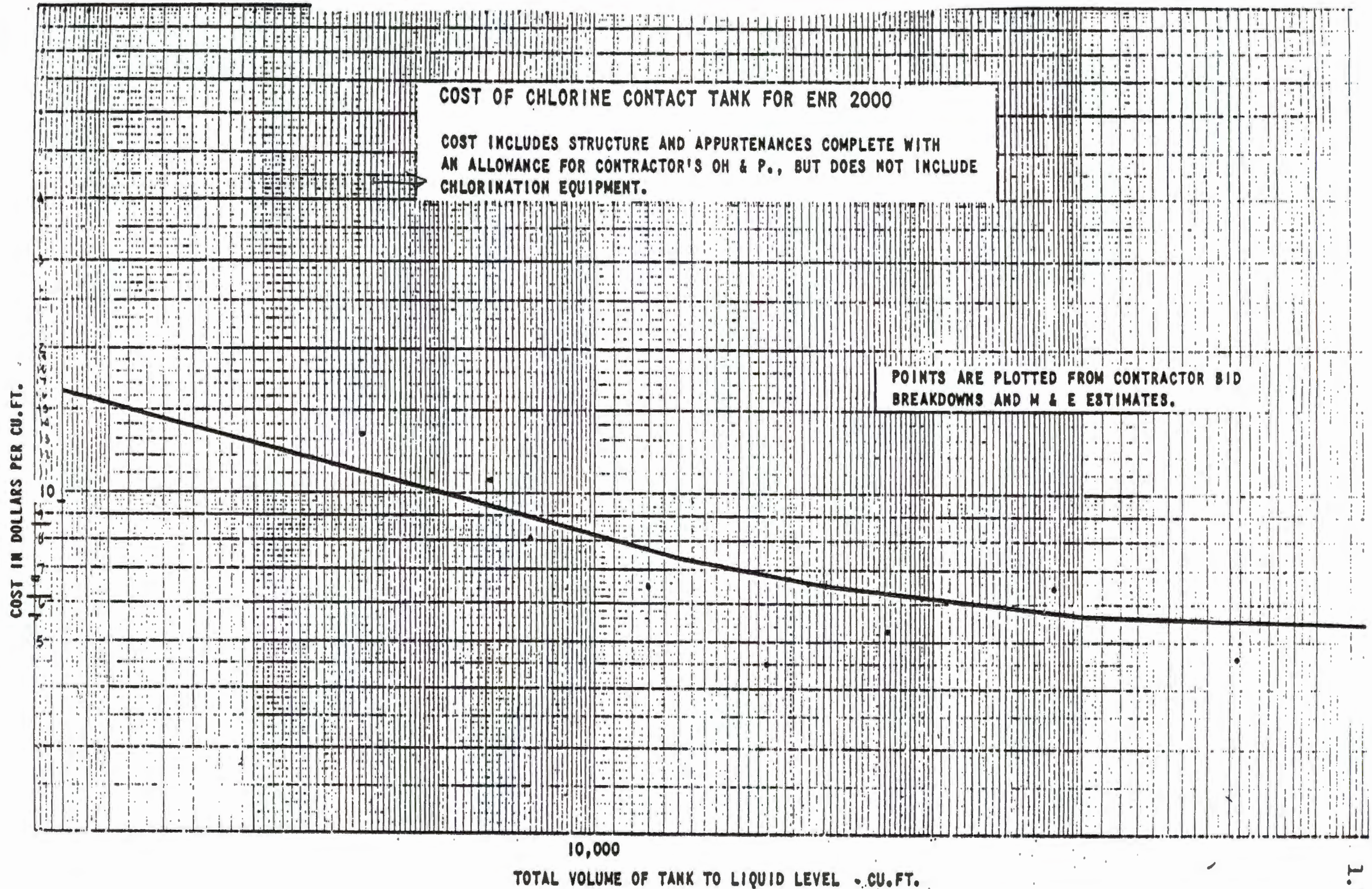
FIGURE 9-1. CHLORINE CONTACT TANK COST CURVE, ENR 2000



shown in Figure 9-1, which produces a unit cost per cubic foot of CSO to be treated. A chlorine contact tank must be large enough to provide 15 minutes of detention time at peak design flow. Costs for screening and chemical feed facilities were based on the construction cost curve shown in Figure 9-2, in which cost is a function of the peak CSO rate in mgd. For the purpose of developing costs, it was assumed that flow discharged from screening and disinfection facilities would require pumping. The cost for effluent pumps was calculated from Figure 9-3, in which the cost is determined by the expected peak flow to be pumped. Piping costs were computed as described for storage alternatives, above.

Detention/Treatment. The detention/treatment alternative involves primary sedimentation tanks, mechanically-cleaned fine screens and chemical feed (disinfection/chlorination) equipment, odor control equipment, and associated building space, effluent pumps, and piping to convey flow to and from the facility. The primary sedimentation tank costs were computed using the same equation used for the storage tanks. Tank size was based on providing an overflow rate of 4,500 gpd/ft^2 under peak flow conditions. Piping costs were computed as described for storage alternatives, above. Costs for screening and chemical feed facilities and effluent pumps were calculated from the construction cost curves described for the screening and disinfection facility alternatives, above.

High-Rate Sedimentation. Construction costs for high-rate sedimentation units were developed from cost data provided by manufacturers of the two units evaluated for use in Nashua, US Filter's Actiflo and ODI's Densadeg. Since the high-rate sedimentation process will be followed by disinfection and dechlorination, costs for chlorine contact tanks and chemical feed facilities were calculated from the construction cost curves described for the screening and disinfection facility alternatives, above.

Capital Costs. Capital costs include base construction costs, derived as described above, and allowances for contractor overhead and profit, engineering and construction

FIGURE 9-2. SCREENING BUILDING/CHEMICAL FEED COST CURVE, ENR 6512

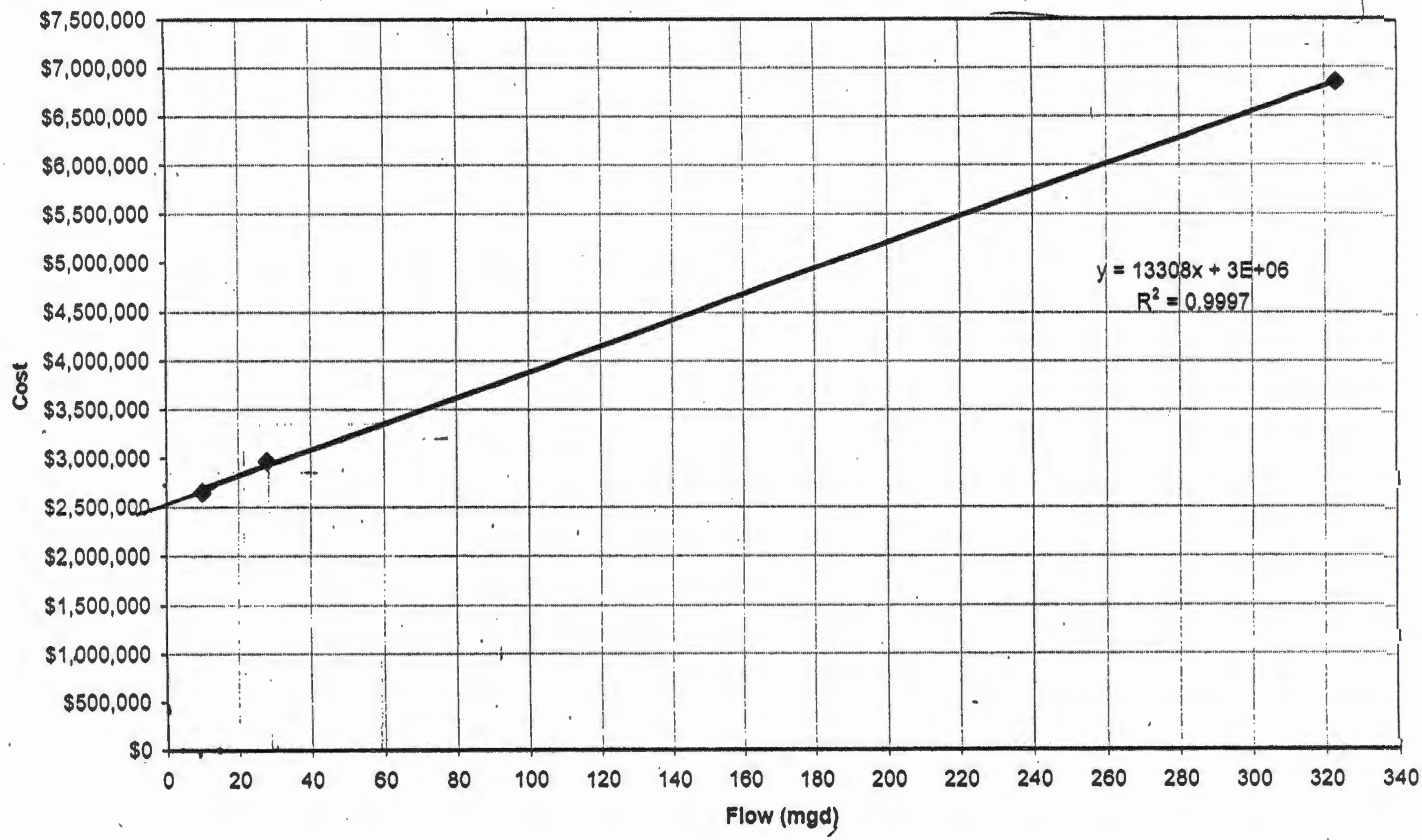
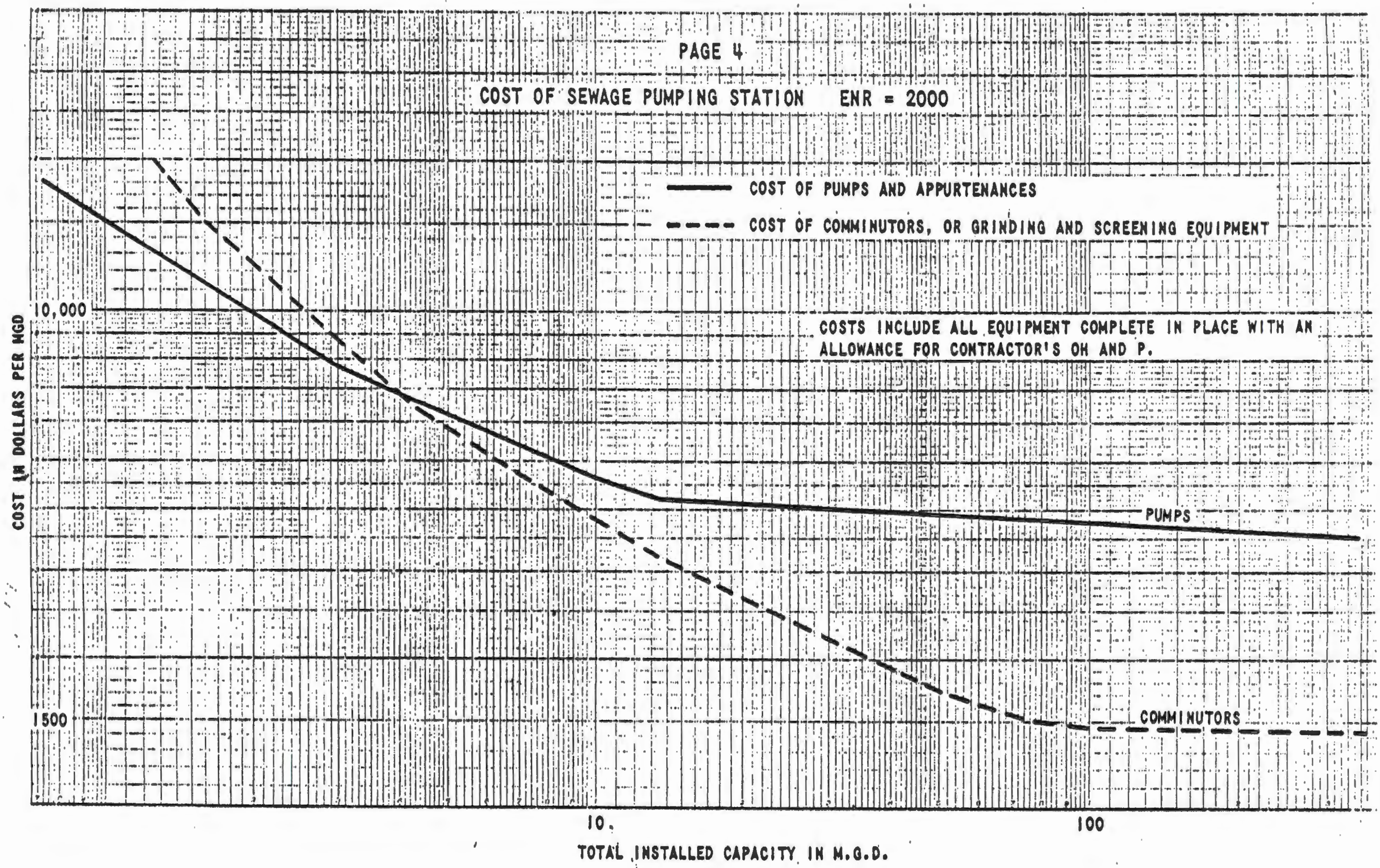


FIGURE 9-3. SEWAGE PUMPING STATION COST CURVE, ENR 2000



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management, and an appropriate contingency. Loaded construction costs were computed by applying a 17 percent allowance for contractor overhead and profit to the base construction costs. A 20 percent allowance for engineering and construction management was then applied to the loaded construction cost, and a 25 percent contingency was then added to the loaded construction cost plus allowance for engineering and construction services.

Sewer separation costs used for comparison to alternatives developed as part of this study were based on actual cost data developed from current sewer separation projects in Nashua. Those construction costs include piping, excavation, appurtenant structures, and backfill. Other costs included in the capital cost for sewer separation include reconstructing curbs and sidewalks, repaving streets, and realigning adjacent utilities disrupted by the work. why?

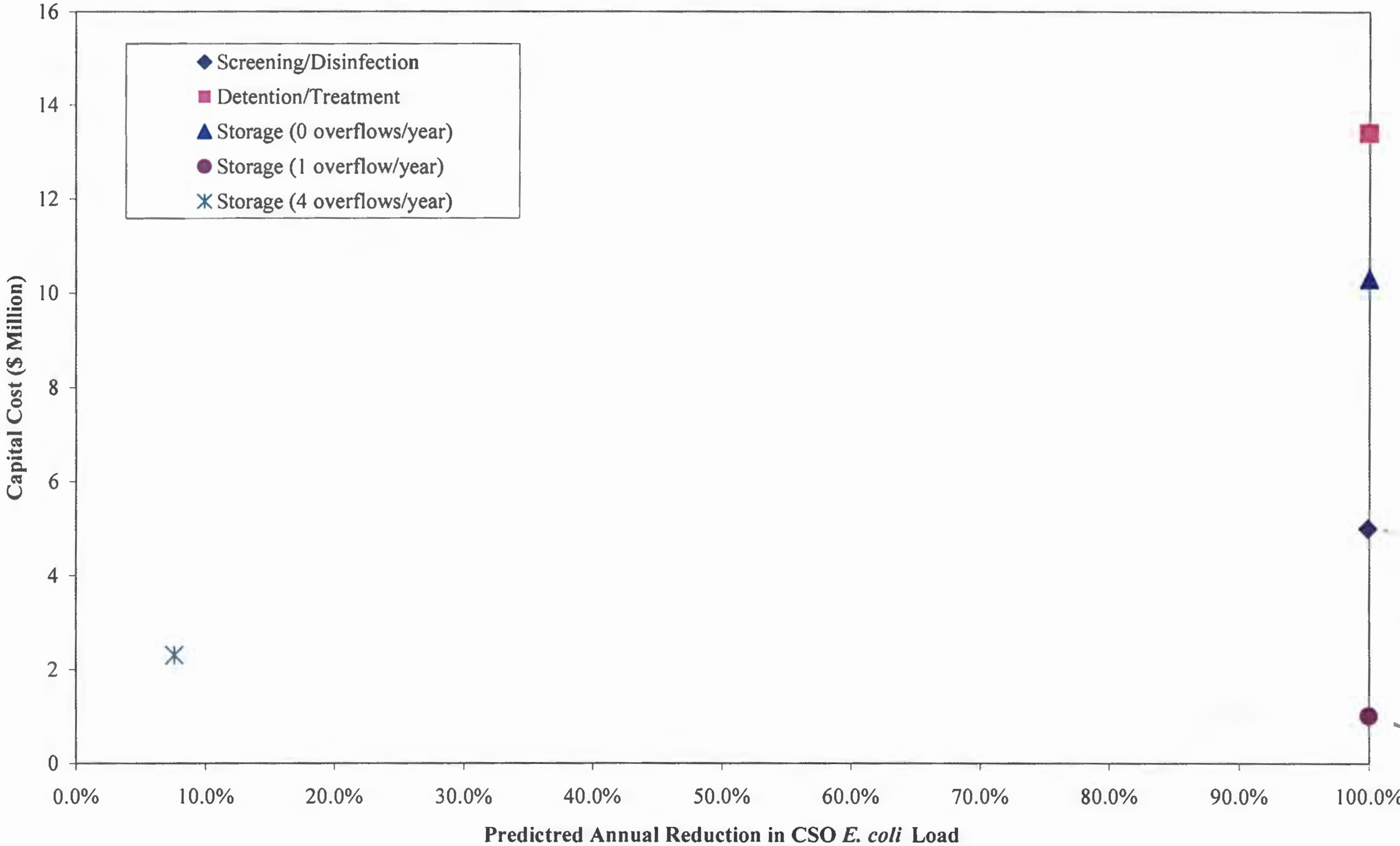
Evaluation of CSO control alternatives

After developing costs for the different CSO control alternatives, the alternatives were compared against one another in terms of cost-performance. Percent reduction of the annual *E. coli* loading was plotted against the facility costs. Alternatives with a relatively high cost and poor performance (top and left hand portion of the graph in Figure 9-4) were eliminated from further consideration. Conversely, alternatives with relatively high performance and low cost (at the "knee-of-the-curve") appeared most suitable in terms of cost-performance. Cost-performance curves were developed based on bacteria loading from CSOs only, as well as on bacteria loading from CSOs and stormwater.

Non-Monetary Factors

Non-monetary factors involve aspects of an alternative that cannot be fully quantified in terms of cost. These can reflect performance, uncertainty or risk associated with alternatives, and are often useful for comparing various alternatives.

FIGURE 9-4. EXAMPLE OF A COST-PERFORMANCE CURVE FOR ALTERNATIVES EVALUATED FOR THE EAST HOLLIS STREET CSO (005)



The following non-monetary factors were considered in comparing alternatives:

- Performance
- O&M considerations
- Proximity to NWTF
- Other considerations

These factors are discussed in the paragraphs that follow.

Performance. The performance of a CSO control alternative was measured in terms of the capability to achieve fecal coliform disinfection standards, to prevent discharge of disinfectant residuals, and to control floatables.

Operations & Maintenance (O&M) Considerations. This factor focused on the operational and maintenance complexity of each alternative, the suitability for unattended automatic start-up following prolonged down time, and prior CSO applications. Technologies that were simpler to operate and maintain, were suited to rapid, unattended start-up and shut-down, and had been used successfully at CSO treatment facilities were rated higher in terms of this factor.

Proximity to NWTF. Resources to operate and maintain remote treatment facilities are centered at the NWTF. For that reason, it is preferable to locate more complex alternatives, such as sedimentation basins and screening and disinfection units, close to the NWTF

Other Considerations. Considerations related to operator and public safety, such as the need to store bulk chemicals on site, were compared. For example, alternatives that did not require chemical storage were considered preferable.

CHAPTER 10

DEVELOPMENT AND EVALUATION OF CSO ALTERNATIVES

As discussed in Chapter 8, providing a wet weather treatment unit just upstream of the NWTF would significantly reduce overflows at upstream CSO regulators. Implementing recommended system optimization measures (SOMs) would reduce the activation frequency and discharge volumes even further. With the implementation of a wet weather treatment unit upstream of the NWTF and SOMs, all overflows would be eliminated during the 1-year design storm, except for at East Hollis Street (CSO 005).

The hydraulic model was also used to simulate performance over a typical year, after implementing the SOMs and the wet weather treatment unit upstream of the NWTF. That simulation showed favorable results: no overflows would occur at the Salmon Brook (002), Tampa Street (007), Broad Street (008) and Lock Street (009) CSOs; and only one activation annually each at the Farmington Road (002), Burke Street (004), and Nashua River (006) CSOs. The East Hollis CSO (005) and the proposed NWTF wet weather treatment unit would be the most active wet weather discharges, with the East Hollis CSO activating 7 times, and the NWTF wet weather treatment unit activating 10 times in the annual simulation. Discharge volumes and peak overflow flow rates for the 5 largest storms in the typical year are presented in Table 10-1.

INITIAL SIZING OF ALTERNATIVES

The two most active CSO discharges are the East Hollis Street CSO and the NWTF wet weather treatment unit, where the model predicted annual CSO discharge volumes of 1.71 and 16.56 mgal, respectively. Alternatives evaluated at these two sites included storage; screening followed by disinfection and dechlorination, and detention/treatment (conventional sedimentation) followed by disinfection and dechlorination. Additionally, high-rate, chemically enhanced sedimentation, followed by disinfection and dechlorination was evaluated for the NWTF treatment unit. These alternatives are discussed in detail below.

TABLE 10-1. CSO VOLUMES AND PEAK DISCHARGE RATES FOR THE 5 LARGEST STORMS IN THE TYPICAL YEAR (Near Future Baseline Conditions, with SOMs and Wet weather bypass at NWTF)

NPDES Discharge No.	Location	Overflows During the 5 Largest Storms in the Typical Year									
		5th Largest		4th Largest		3rd Largest		2nd Largest		Largest	
		Vol. (mgal)	Qpk (cfs)	Vol. (mgal)	Qpk (cfs)	Vol. (mgal)	Qpk (cfs)	Vol. (mgal)	Qpk (cfs)	Vol. (mgal)	Qpk (cfs)
002	Salmon Brook	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
003	Farmington Road	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	6.60
004	Burke Street	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1.10
005	E. Hollis St.	0.02	2.60	0.05	4.10	0.08	7.00	0.57	27.0	0.96	43.2
006	Nashua River OF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	33.2
007	Tampa Street	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
008	Broad Street	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
009	Lock Street	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.02		0.05		0.08		0.57		1.43	

005/006	Combination	0.02	2.60	0.05	4.10	0.08	7.00	0.57	27.0	1.38	76.4
NWTF	NWTF Bypass	1.52	40.4	1.86	44.3	2.14	42.2	3.32	66.0	3.85	92.1

East Hollis Street CSO Structure (005)

The hydraulic model predicted that the East Hollis Street CSO structure would activate 7 times in the typical year, discharging 1.71 mgal of combined sewage into the Merrimack River. The following alternatives were considered for this location:

- storage tank sized to allow four overflows in a typical year
- storage tank sized to allow one overflow in a typical year
- storage tank sized to allow no overflows in a typical year
- screening and disinfection facility
- detention/treatment facility

The estimated sizes and estimated costs for these facilities are presented in Table 10-2.

TABLE 10-2. ALTERNATIVES SIZED FOR THE EAST HOLLIS STREET CSO STRUCTURE (005)

Alternative	Capital Cost (millions)	Details of Design Level of Control
Storage, 4 overflows/year	$2.3	Storage volume: 0.02 mgal Untreated discharge in typical year: 1.58 mgal Basin size: 15 feet deep, 19 feet long, 9 feet wide
Storage, 1 overflow/year	$6.5	Storage volume: 0.57 mgal Untreated discharge in typical year: 0.39 mgal Basin size: 15 feet deep, 96 feet long, 48 feet wide
Storage, 0 overflows/year	$10.3	Storage volume: 0.96 mgal Untreated discharge in typical year: 0.00 mgal Basin size: 15 feet deep, 131 feet long, 65 feet wide
Screening/Disinfection	$5.0	Sized to treat Q_{pk}= 43.2 cfs 15 minutes of detention at Q_{pk}, Volume = 0.29 mgal Reduces *E. coli* concentration in discharge to 126 col/100mL Treated CSO discharged in typical year: 0.95 mgal
Detention/Treatment	$13.4	Sized to treat Q_{pk}= 43.2 cfs Overflow rate: 4,500 gpd/ft^2 29 minutes of detention at Q_{pk}, Volume = 0.56 mgal Reduces *E. coli* concentration in discharge to 126 col/100mL Treated CSO discharged in typical year: 0.41 mgal

The cost-effectiveness of each alternative considered at the East Hollis Street CSO is presented in Figure 10-1, where capital cost is plotted against percent *E. coli* reduction on an annual basis.

Figure 10-1 shows the relationship between capital cost and percent reduction in *E. coli* loading to the rivers for the Hollis Street CSO (005), for the five control alternatives under consideration. This figure illustrates that three of the approaches under consideration:

1. detention and treatment;
2. storage sized for no overflows in a typical year; and
3. screening with disinfection;

would each achieve virtually 100% reduction in *E. coli* discharges to the river from CSO 005. Of these three alternatives, the screening and disinfection approach would have the lowest capital cost.

Figures 10-2 and 10-3 present this information in a different format, showing that the alternative of screening and disinfection is one of the three approaches with the highest performance in terms of bacterial reduction. Furthermore, it is the most cost effective of all the approaches considered here, having the lowest capital cost per trillion colonies of *E. coli* removed from the CSO discharge.

Under the screening and disinfection alternative, screens with an opening of ½ inch or less between the bars would remove floatable materials and larger, objectionable solids. A facility of this type would remove approximately 99.97% of the bacterial load to the river, at an estimated capital cost of $4.98 million.

Although the storage tank sized for zero overflows in a typical year would eliminate bacteria loadings from this CSO on an annual basis, virtually the same reduction in bacterial loading to the river could be obtained at less than half the cost with the screening and disinfection alternative.

The detention/treatment alternative would also essentially eliminate the bacteria discharges to the river in the typical year (99.99% reduction) but was the most expensive alternative

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FIGURE 10-1. COMPARISON OF COST VS. PERFORMANCE FOR ALTERNATIVES AT EAST HOLLIS STREET CSO (005)

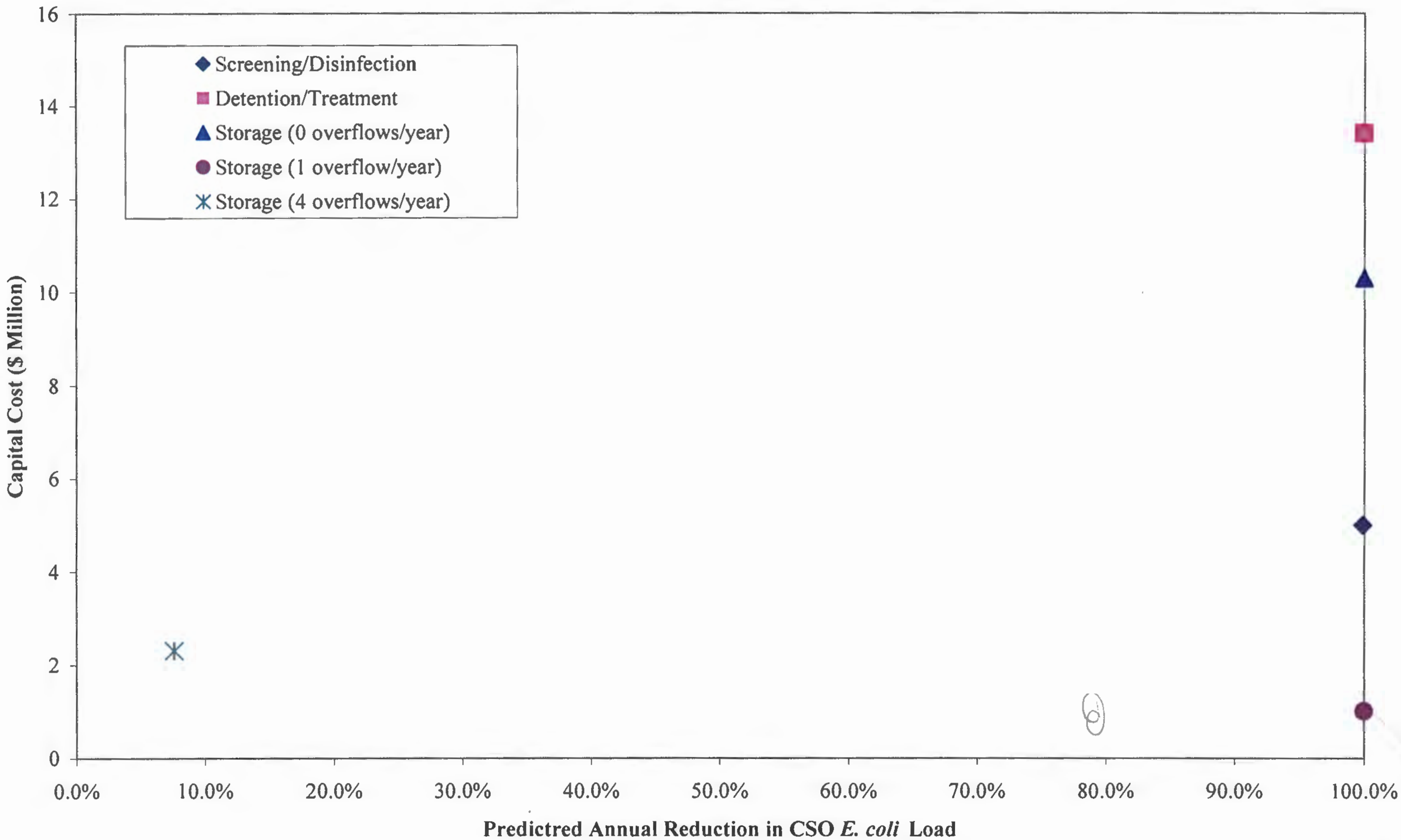


FIGURE 10-2. COMPARISON OF ALTERNATIVES IN TERMS OF PERFORMANCE, EAST HOLLIS STREET CSO (005)

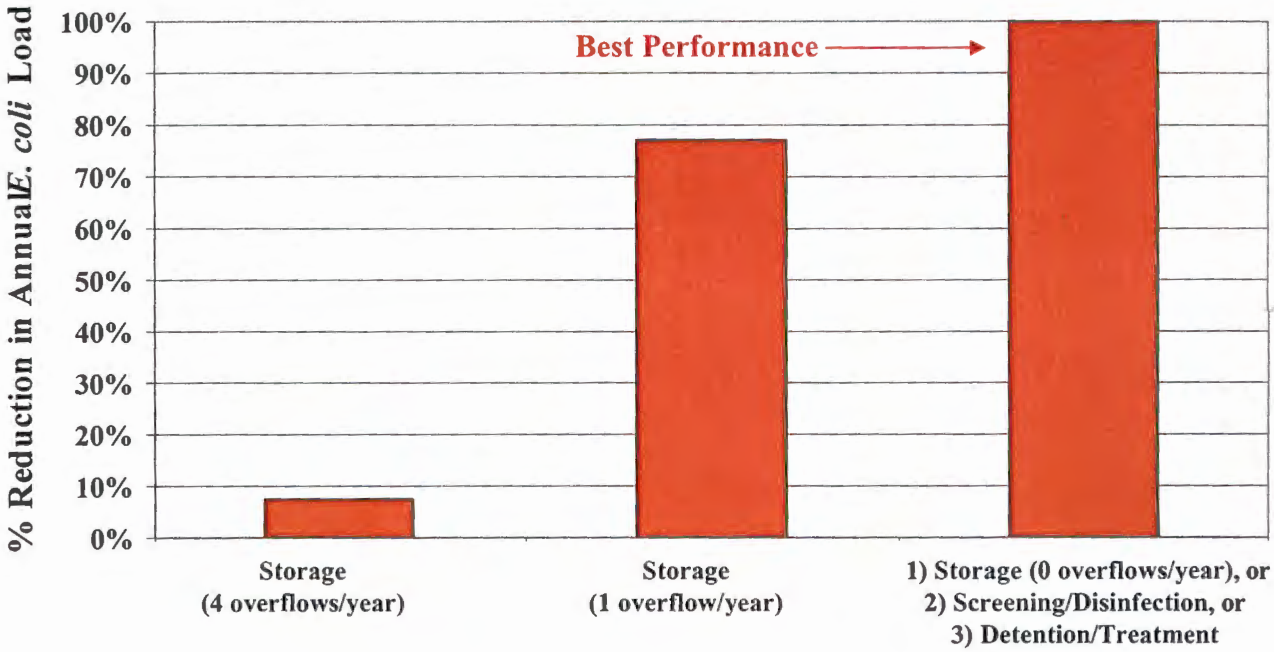
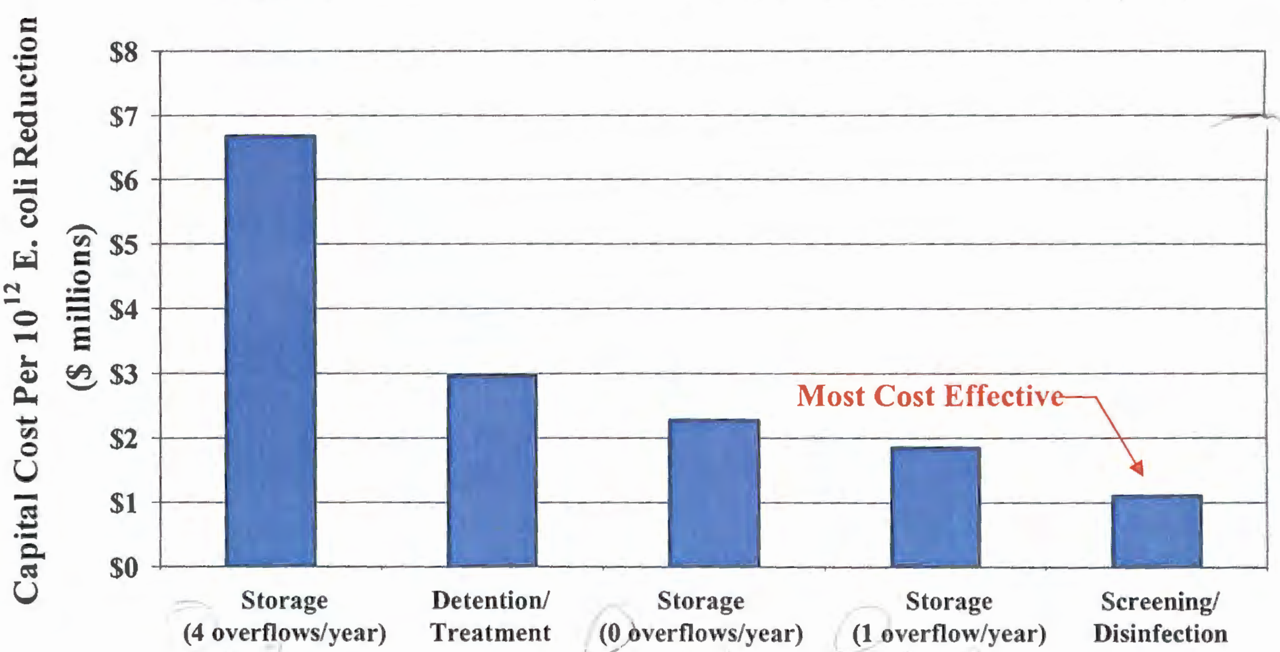


FIGURE 10-3. COMPARISON OF ALTERNATIVES IN TERMS OF COST-EFFECTIVNESS, EAST HOLLIS STREET CSO (005)



($13.4 million). Though the detention/treatment facility also would reduce settleable solids discharged, it is a more complex treatment alternative than a screening and disinfection facility.

Furthermore, the detention/treatment facility would discharge flow only once during a typical year. Such infrequent operation of the equipment can cause operational problems. Since the primary water quality parameter of concern is bacteria, and the screening and disinfection facility achieves essentially the same bacterial reduction at substantially less cost, the alternative was not considered further.

The 1997 LTCP included a detailed discussion of possible sites for locating a treatment unit near the East Hollis Street CSO structure. That study, which evaluated sites based on the basis of current land use, historical significance, presence of a buffer zone, site access/traffic, zoning, and surrounding land use, concluded that the plot of land north of Bridge Street, east of Bancroft Street, on the bank of the Merrimack River would be the best location for a treatment facility. This site remains available for a screening and disinfection facility for flows discharged from the East Hollis Street CSO (005).

NWTF Wet Weather Treatment Unit

The hydraulic model predicted that the NWTF wet weather treatment unit would activate 10 times in a typical year, discharging 16.6 mgal of combined sewage. Alternatives sized at this location included:

- storage tank sized to allow four overflows in a typical year
- storage tank sized to allow one overflow in a typical year
- storage tank sized to allow no overflows in a typical year
- screening and disinfection facility
- detention/treatment facility
- high-rate, chemically enhanced sedimentation unit

The estimated sizes and estimated costs for these facilities are presented in Table 10-3.

TABLE 10-3. ALTERNATIVES SIZED FOR THE NWTF WET WEATHER TREATMENT UNIT (NWTF)

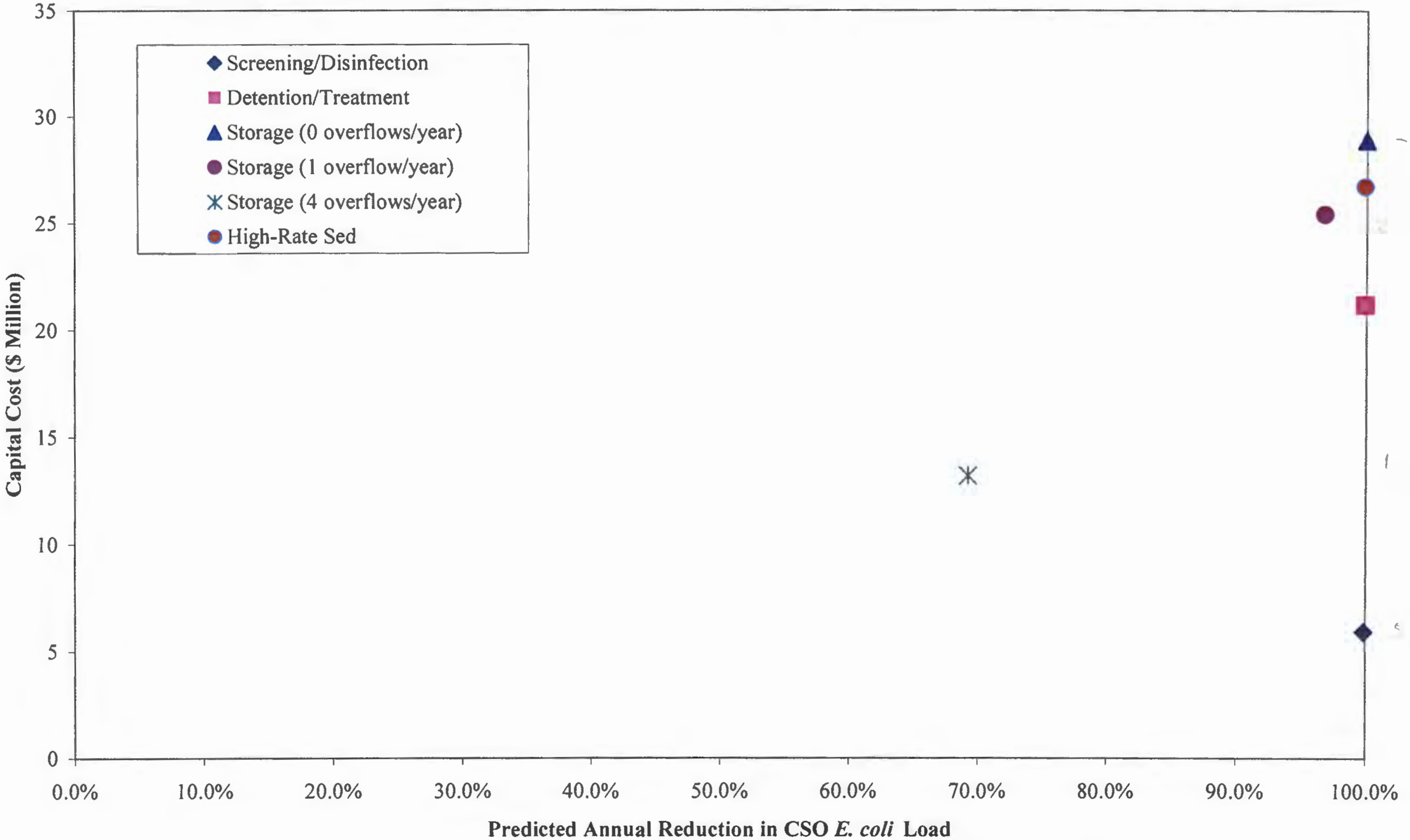
Alternative	Capital Cost (millions)	Details of Design Level of Control
Storage, 4 overflows/year	$13.2	Storage volume: 1.52 mgal Untreated discharge in typical year: 4.75 mgal Basin size: 15 feet deep, 165 feet long, 82 feet wide
Storage, 1 overflow/year	$25.4	Storage volume: 3.32 mgal Untreated discharge in typical year: 0.53 mgal Basin size: 15 feet deep, 243 feet long, 122 feet wide
Storage, 0 overflows/year	$28.9	Storage volume: 3.85 mgal Untreated discharge in typical year: 0.00 mgal Basin size: 15 feet deep, 262 feet long, 131 feet wide
Screening/Disinfection	$5.9	Sized to treat Q_{pk}= 92.1 cfs 15 minutes of detention at Q_{pk}, Volume = 0.62 mgal Reduces *E. coli* concentration in discharge to 126 col/100mL Treated CSO discharged in typical year: 10.72 mgal
Detention/Treatment	$ 21.2	Sized to treat Q_{pk}= 92.1 cfs Overflow rate: 4,500 gpd/ft^2 29 minutes of detention at Q_{pk}, Volume = 1.19 mgal Reduces *E. coli* concentration in discharge to 126 col/100mL Treated CSO discharged in typical year: 6.74 mgal
High-rate, chemically enhanced Sedimentation	$26.7	Sized to treat Q_{pk}= 92.1 cfs Includes disinfection with 15 minutes of detention time at Q_{pk} Provides high level of BOD_5 and TSS removals.

Figure 10-4 shows the relationship between capital cost and the percent reduction in *E. coli* loading to the rivers for the NWTF wet weather treatment unit for the six control alternatives under consideration. This figure illustrates that four of the approaches under consideration:

1. detention and treatment;
2. storage sized for no overflows in a typical year;
3. screening and disinfection; and
4. high-rate, chemically enhanced sedimentation

would each achieve virtually a 100% reduction in *E. coli* discharges to the river from the NWTF wet weather treatment unit. Of these three alternatives, the screening and disinfection approach would have the lowest capital cost.

FIGURE 10-4. COMPARISON OF COST VS. PERFORMANCE FOR ALTERNATIVES AT NWTF WET WEATHER TREATMENT UNIT (NWTF)



Figures 10-5 and 10-6 present this information in a different format, showing that the screening and disinfection alternative is one of the four alternatives with the highest performance in terms of bacterial reduction, and has the lowest capital cost per trillion colonies of *E. coli* removed.

This option, however, would not reduce BOD and would not significantly reduce TSS. Due to the large overflow volumes at this wet weather treatment location, storage tanks would be extremely large and very expensive, and essentially infeasible to site at the NWTF. Even the storage tank sized for four overflows per year would be significantly more expensive than a screening and disinfection facility. The detention/treatment facility option would also require a substantial land area. The high-rate, chemically enhanced sedimentation unit would require less land than the detention/treatment option, and would provide a higher level of BOD and TSS removal.

For the purpose of this report, it has been assumed that the flows discharged from the existing treatment facility and the NWTF wet weather treatment unit will be blended. It is therefore, necessary to provide an appropriate degree of treatment for the wet weather flows to remove BOD and TSS. Therefore, this approach would favor the detention/treatment and the high-rate, chemically enhanced sedimentation alternatives. Of these alternatives, high-rate, chemically enhanced sedimentation requires a much smaller footprint than detention/treatment, and can handle higher surface overflow rates since this technology relies on ballasted floc formation and lamellar settlers. High rate, chemically enhanced sedimentation units would also be able to attain a higher degree of BOD and TSS removal than detention/treatment and would therefore be the preferred alternative if wet weather treatment unit flow is to be blended with the NWTF effluent.

If the NWTF wet weather treatment unit is located adjacent to the NWTF, just upstream of the headworks of the facility, it will not be necessary to increase the capacity of the pumps at NWTF headworks. The control weir (or other bypass control device) could be set to activate only after the NWTF is receiving its peak capacity of 50 mgd. Since the treatment facility can only accept flow at this rate for a limited period of time (refer to table 2-3) during longer storms, the main gate at the NWTF could be partially closed, raising the hydraulic grade in the pipe network

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FIGURE 10-5. COMPARISON OF ALTERNATIVES IN TERMS OF PERFORMANCE, NWTF WET WEATHER DISCHARGE (NWTF)

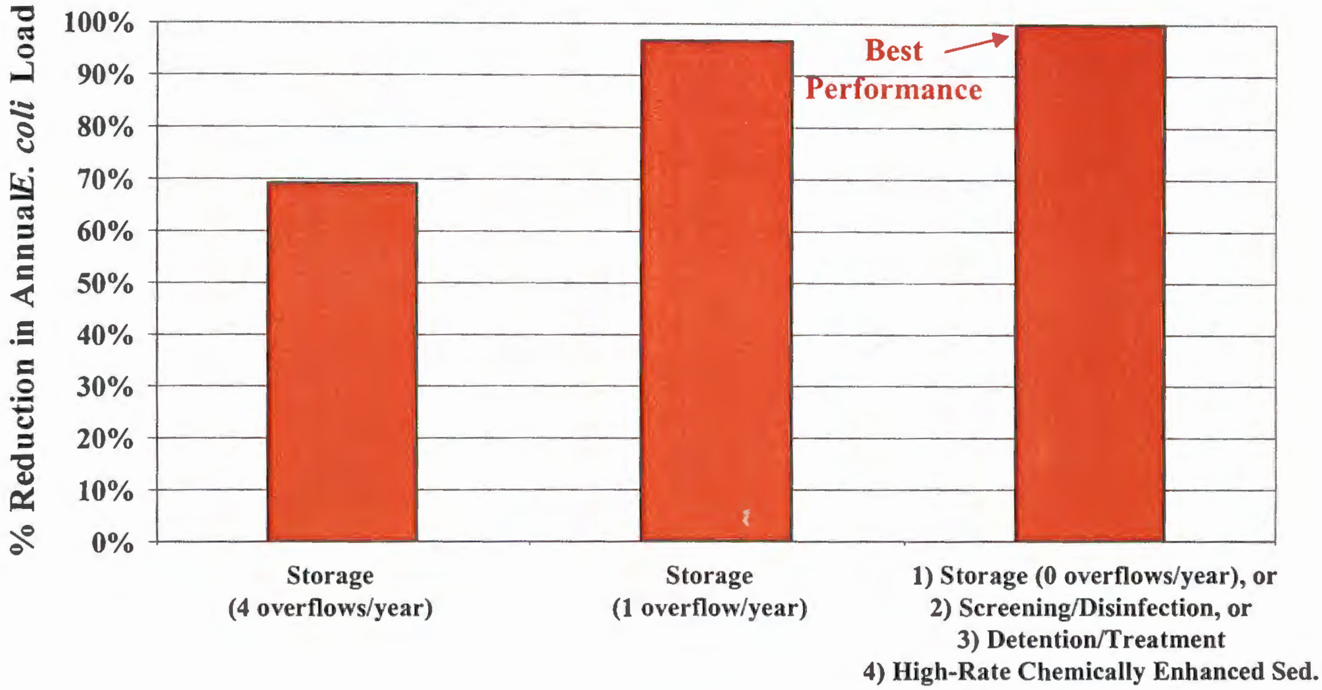
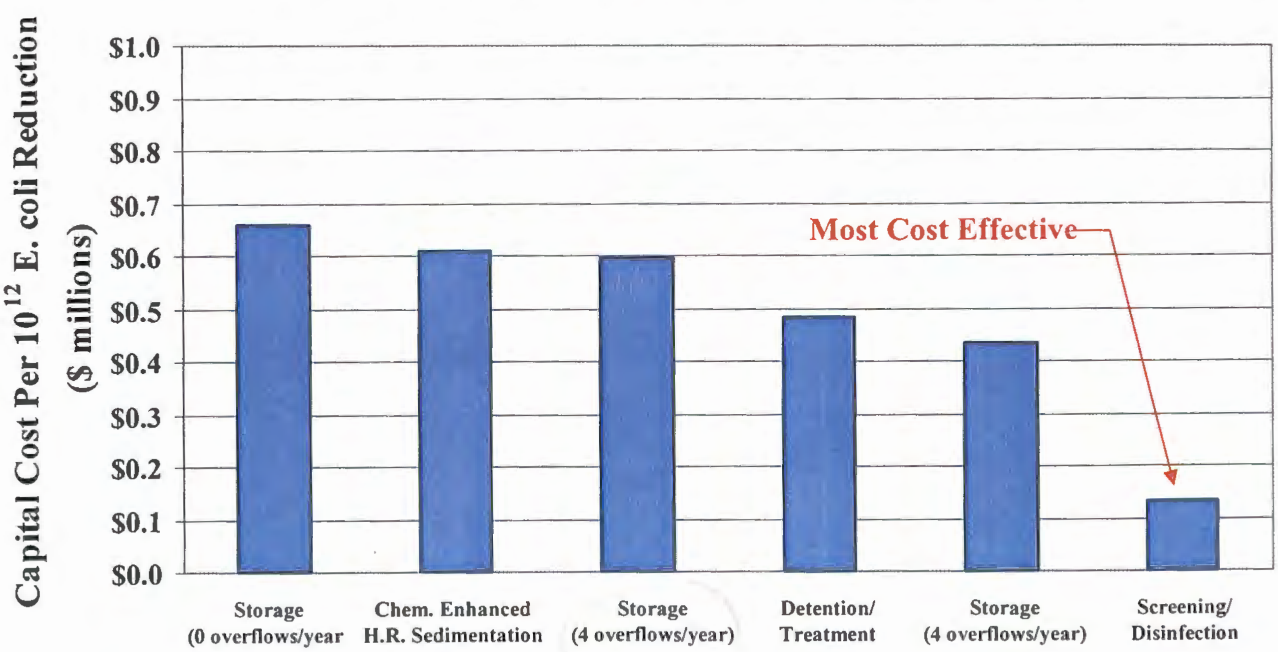


FIGURE 10-6. COMPARISON OF ALTERNATIVES IN TERMS OF COST-EFFECTIVNESS, NWTF WET WEATHER DISCHARGE (NWTF)



upstream of the plant. As the hydraulic grade rises in response to the gate throttling, more water would be diverted to the wet weather treatment unit.

SYSTEMWIDE ANALYSIS OF ALTERNATIVES

The plan proposed in this report has been compared against sewer separation, Nashua's current recommended plan.

Sewer Separation

Sewer separation is an alternative that is often considered for control of CSOs. Removing stormwater runoff from the combined sewer system can dramatically reduce system overflows. However, not all of the stormwater inflow can be removed from older, urban area sewer systems under a sewer separation program. Some stormwater runoff would still enter the combined system through internal roof drain connections, sump pumps, and other connections that would be difficult (if not impossible) to eliminate. Sewer separation projects in densely populated urban areas have shown to be effective at removing only up to approximately 80 percent of the stormwater inflow.

Comparison of Alternatives

When comparing various alternative approaches to CSO pollution control, it is important to look at the "big picture", the net effect of the action being considered. This is particularly important when looking at the alternative of complete sewer separation. For example, while a program to completely separate the sewers will remove 80 percent of the storm water inflow to the combined sewers, that flow does not disappear. Instead, that runoff is discharged to the rivers through separate storm sewer discharges.

Storm sewers also introduce pollutants to the rivers, from urban runoff. For example, the recent wet weather sampling program confirmed that Nashua stormwater discharges have a typical *E. coli* load of 5,000 col./100mL. Therefore, although a sewer separation program in Nashua would eliminate the bacterial loading to the rivers from CSOs during a typical year, it would at the same time **increase** the bacterial loading to the rivers from storm sewer discharges.

When the environmental benefits of sewer separation are compared with those of a CSO treatment alternative, it is necessary to consider the net loading to the rivers from both sources, the CSOs and the storm water discharges.

Providing screening/disinfection facilities at the Hollis Street CSO (005) and at the NWTF treatment unit would reduce bacterial loading from CSOs to the rivers from those two discharges by 97.5% on an annual basis. The complete sewer separation program would reduce the CSO loading from those two discharges by 100%. However, if stormwater is considered also, the picture changes considerably. There would be a net annual reduction in bacterial loading to the rivers (from both CSOs and stormwater) of 30% with the screening/disinfection approach, but only a 10% reduction with complete separation. This is presented graphically in Figure 10-7.

Therefore, since bacterial loading to the rivers is the primary concern, the CSO treatment approach provides greater net environmental benefits than the sewer separation program. The treatment alternative also is significantly less expensive and can be implemented more quickly.

Figure 10-8 shows the predicted stormwater and CSO loadings under the sewer separation plan, over the proposed implementation schedule, which continues through 2019. As seen in Figure 10-8, complete elimination of bacteria loading from CSO sources will take the entire 20 year period; and in the end, the increase in loading from stormwater sources will offset a considerable portion of the benefit realized by the reduction from CSO sources. Figure 10-9 shows the comparative benefits of the approach now being considered which includes treatment at the NWTF wet weather treatment unit and at the East Hollis Street CSO (005). Constructing these two treatment facilities would take less time than complete separation. Also, the bacterial loading from CSOs would be dramatically reduced in a shorter period of time, and those gains would not be offset by an increase in the stormwater load.

FIGURE 10-7. TOTAL BACTERIA LOADING IN A TYPICAL YEAR

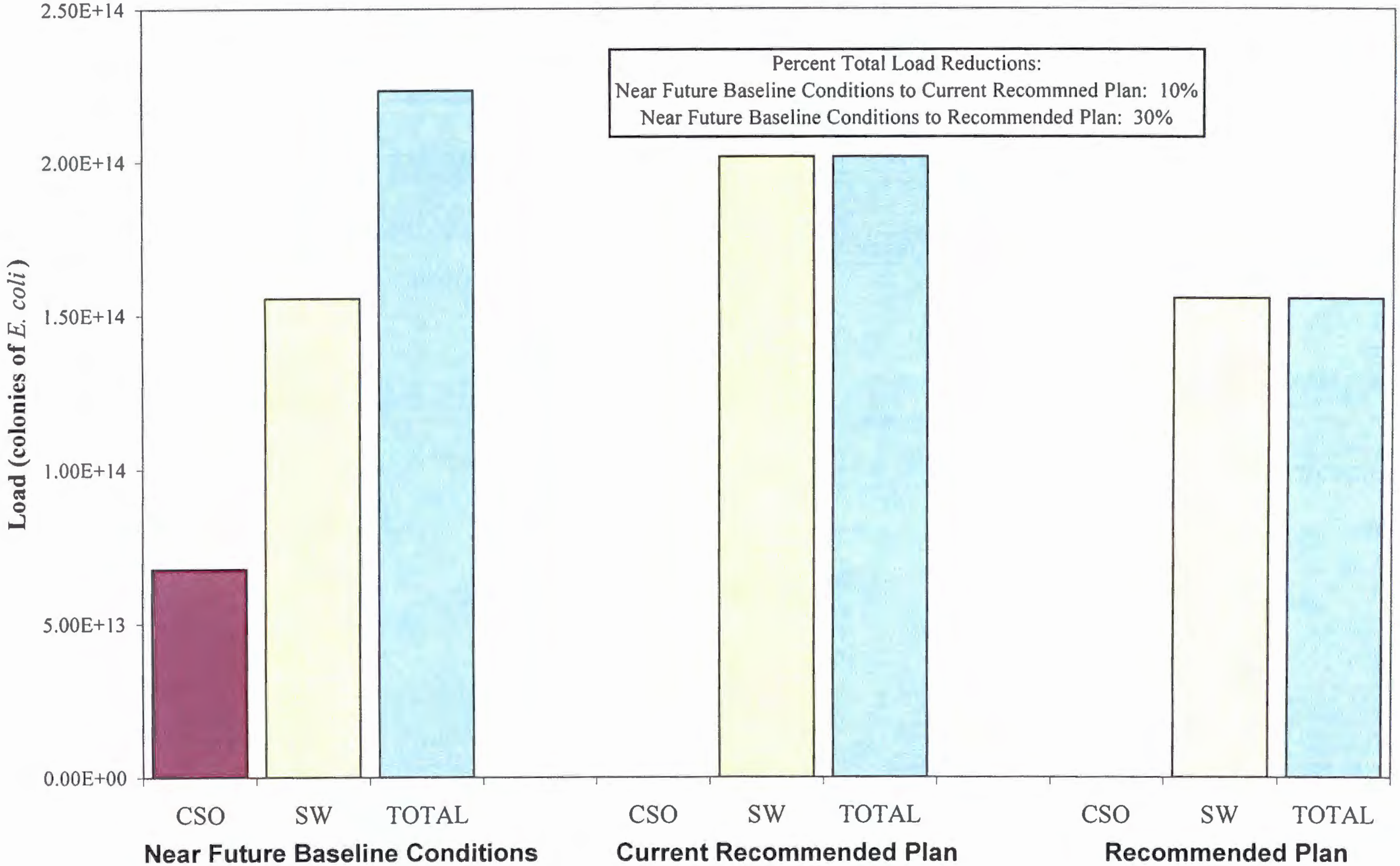
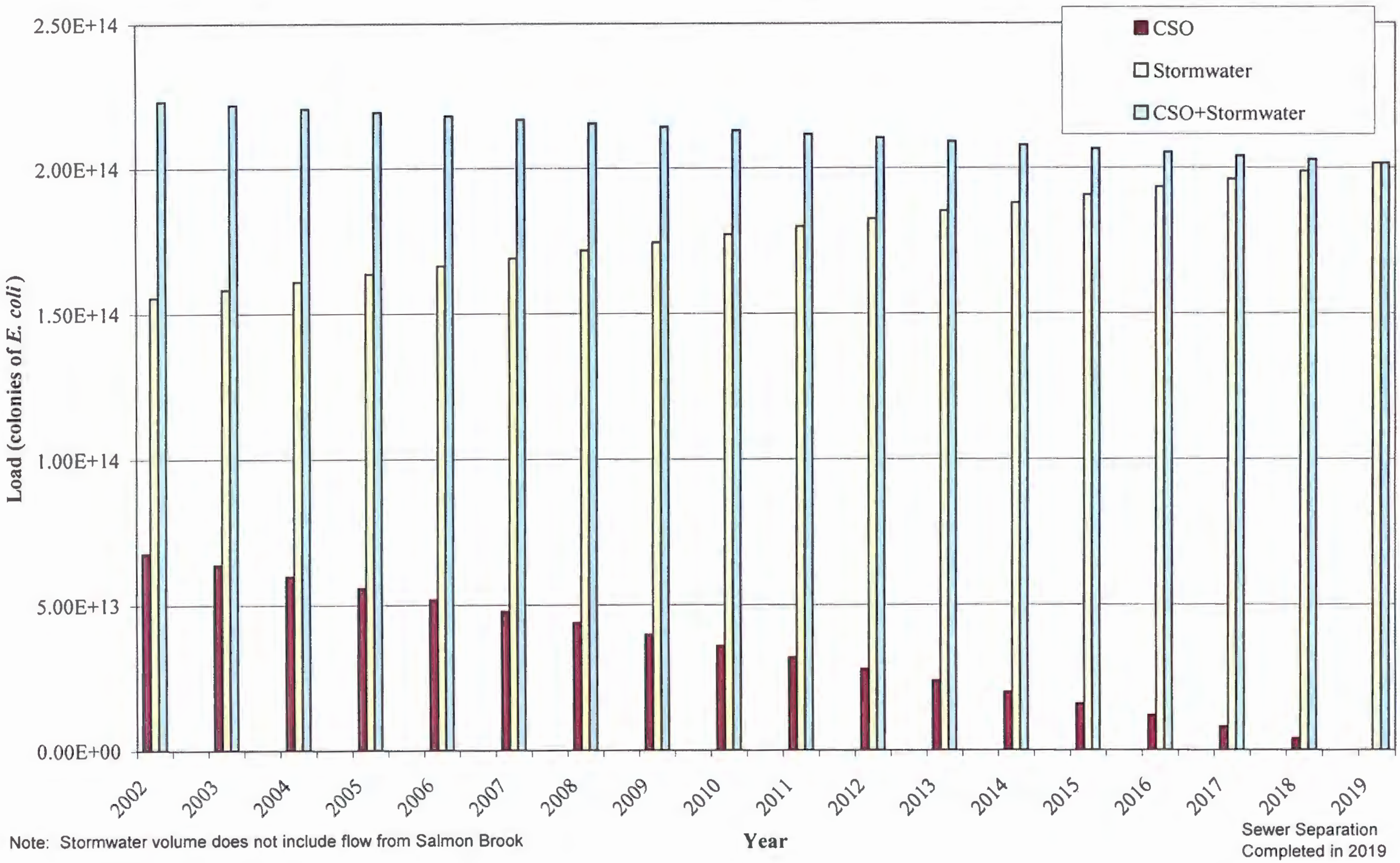
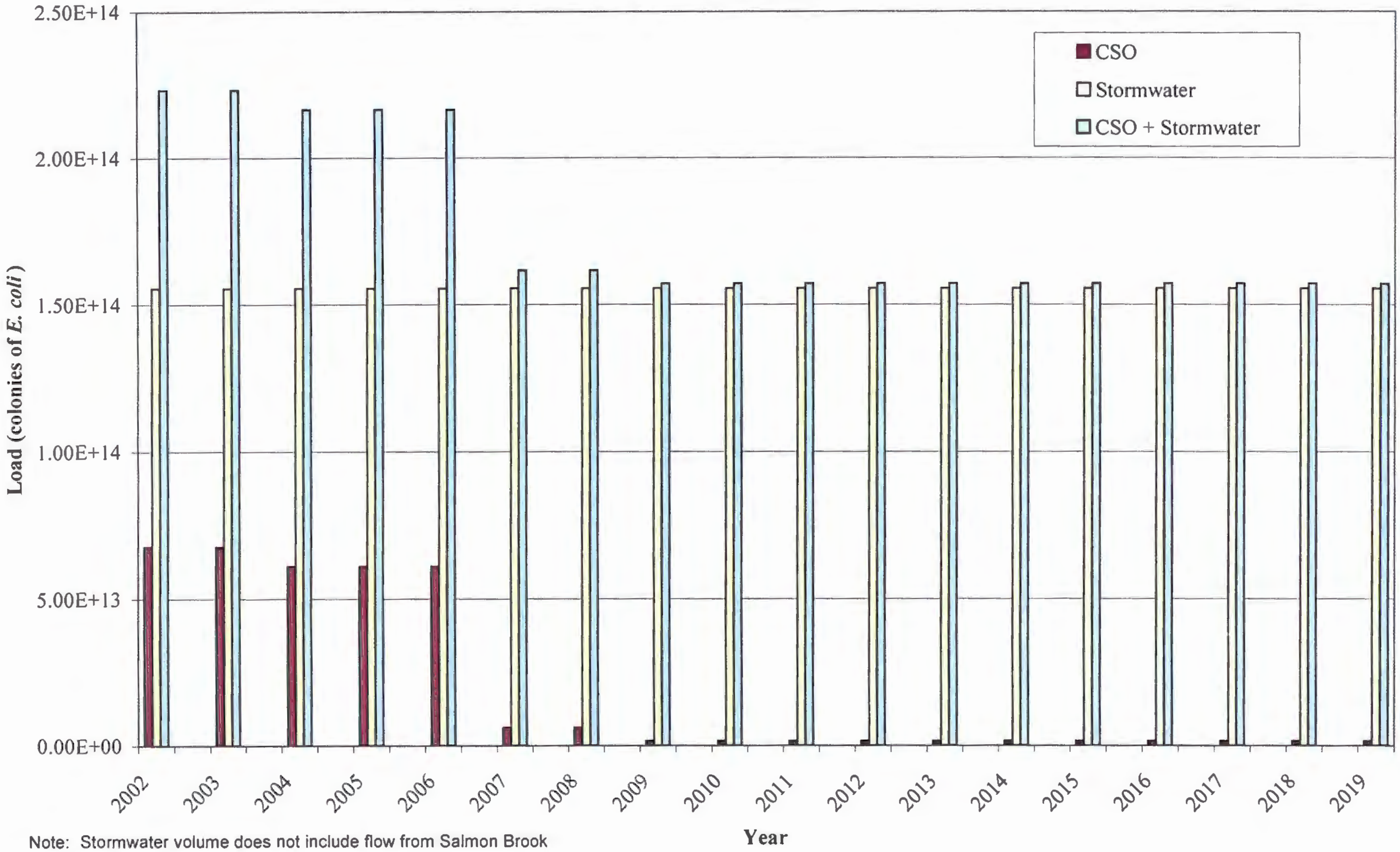


FIGURE 10-8. PROJECTED ANNUAL CSO AND STORMWATER BACTERIAL LOAD TO RIVERS UNDER CURRENT RECOMMENDED PLAN (SEWER SEPARATION)



Note: Stormwater volume does not include flow from Salmon Brook

TABLE 10-9. PROJECTED ANNUAL CSO AND STORMWATER BACTERIAL LOAD TO RIVERS UNDER NEW PLAN (TREATMENT AT NWTF AND CSO 005)



Note: Stormwater volume does not include flow from Salmon Brook

The cumulative (20-year) CSO, stormwater, and total (CSO plus stormwater) E. coli loadings for both the sewer separation plan and the approach now being considered are summarized in Figure 10-10. This figure shows that the alternative approach for CSO control presented in this report will result in lower bacterial loadings from both CSO and stormwater as compared to the sewer separation plan.

In the typical year simulation, one overflow occurred at the Farmington Road (003), Burke Street (004) and Nashua River (006) CSOs. Details of the alternatives evaluated for these locations are presented below.

Farmington Road (003). At this location, storage and screening/disinfection were considered for control of the single, 0.04 mgal annual overflow event. Model output showed the peak overflow rate to be 6.60 cfs. Therefore, a 0.04 mgal detention basin would be required to provide 15 minutes of contact time at peak flow. Since the entire volume of overflow would be retained in a contact basin this size, chlorination facilities would not be required, since flow retained in the basin could be pumped back into the collection system after the peak of the storm.

Estimated capital cost of the storage tank is $2.1 million.

Burke Street (004). The model indicates that that the only overflow from this location during a typical year will be 0.01 Mgal. Therefore a treatment system would not be appropriate. A small storage tank providing 0.01 Mgal of storage could be sited in the wooded area, adjacent to the regulator structure, for $1.6 million.

Nashua River CSO (006). The model predicted only one overflow event at this location during a typical year. However, the volume overflowing during that event was much larger than at other CSOs that activated only once in a typical year. The one activation at this location resulted in 0.42 Mgal of CSO, comparable in volume to the to the largest overflow event in the typical year at CSO 005. Therefore, the alternatives developed for CSO 005 served as a basis for alternatives considered at this location Since the storage alternative and the

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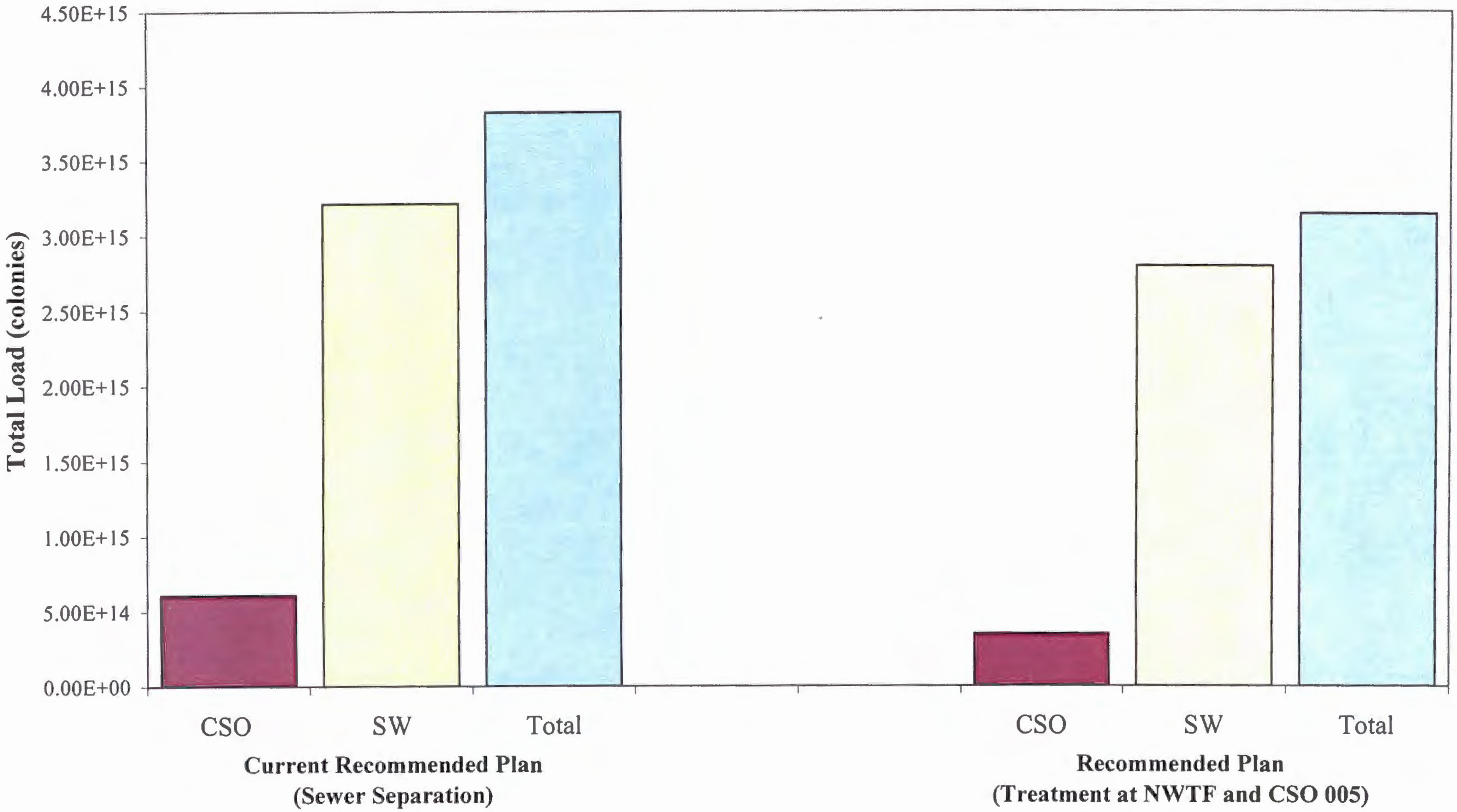
FIGURE 10-10. TOTAL TREATED AND UNTREATED CSO AND STORMWATER LOAD, *E. coli* BACTERIA, 2002-2019



screening/disinfection alternative proved to be the most viable options at CSO 005, these approaches were used for the Nashua River CSO as well.

- **Storage.** A 0.42 mgal storage tank, to achieve zero CSO discharge in a typical year, would be 15 feet deep, 87 feet long, and 43 feet wide. The total cost estimated for this storage facility is $5.3 million

- **Screening/Disinfection.** A screening/disinfection facility at this site would be sized to treat a peak flow of 21.5 mgd, the unit would have a contact tank volume of 0.22 Mgal, and has an estimated capital cost of $5.2 million. Since the facility will essentially store 0.22 Mgal of the overflow in the contact tank, only 0.20 Mgal of treated discharge would be released from this facility in a typical year.

In siting a screening/disinfection facility for the Nashua River CSO (006), it became evident that this facility should be located on or near the same parcel of land as the facility for the East Hollis Street CSO (005). Rather than having two separate systems, side-by-side, it would be more economical to construct a larger combined facility. This would have an estimated capital cost of $6.7 million, much less than the sum of the two individual units ($10.2 million). The combined facility would be sized to treat a peak flow of 49.4 mgd, and would provide 15 minutes of detention time at peak flow, in a 0.41 Mgal tank. Treated CSO discharge from this combination facility would be 0.97 Mgal per typical year, 0.18 Mgal less than the 1.15 Mgal of treated flow that would be discharged from two separate units.

Summary

Based on the initial sizing and cost-performance analysis, the initially preferred CSO control alternatives include:

- **Farmington Road CSO (003).** Provide 40,000 gal. storage basin
- **Burke Street CSO (004).** Provide 10,000 gal. storage basin

- **East Hollis Street (005) & Burke Street (006).** Provide a single, combined screening/disinfection facility for overflows from both CSOs, capable of treating a peak overflow of 49.4 Mgd.
- **NWTF Wet Weather Treatment Unit (NWTF).** Provide a screening/disinfection facility, capable of treating a peak flow of 59.5 Mgd, or a high-rate, chemically enhanced sedimentation unit, capable of treating a peak flow of 59.5 Mgd.

Implementing these recommended control measures would eliminate all discharges of untreated combined sewers in a typical year. Since overflow volumes for the largest storm in the typical year were nearly equal to the overflow volumes produced in the 2-year and 5-year actual storm events (Table 10-4), the initially preferred CSO control options presented above would nearly eliminate the discharge of CSO, even for these larger-sized, relatively infrequent occuring storms.

CSO CONTROL, GREATER THAN TYPICAL YEAR

In previous sections of this report, the CSO control alternatives considered, including complete sewer separation, have been compared on the basis of performance of the alternatives during a typical year. In this section, system performance during more intense storm events, which would occur less frequently than once per year, is examined.

Sewer Separation

At the time the City of Nashua's current Administrative Order on CSO improvements was issued, it was generally believed that separating all of the combined sewers in Nashua would eliminate all combined sewer overflow events, and would allow the city to seal all off the existing CSOs. However, the new collection system model developed for this study shows that sewer separation would not allow the CSOs to be eliminated.

Based on sewer separation work done in communities similar to Nashua, a program to separate all of the combined sewers in the city can be expected to remove approximately 80% of stormwater inflow currently entering the sewer system. The remaining 20%, including flow

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from sources such as roof drains, sump pumps, and other miscellaneous connections, has proven to be infeasible to remove from the system based on experience in other communities.

TABLE 10-4. OVERFLOW VOLUMES AND PEAK OVERFLOW RATES FOR DESIGN STORMS

		Largest Storm Typical Year		2-Year (Actual) Design Storm		5-Year (Actual) Design Storm	
NPDES Discharge No.	**Location**	**Volume (Mgal)**	**Peak Flow (cfs)**	**Volume (Mgal)**	**Peak Flow (cfs)**	**Volume (Mgal)**	**Peak Flow (cfs)**
002	Salmon Brook	0.00	0.00	0.00	0.00	0.00	0.00
003	Farmington Road	0.04	6.60	0.04	8.25	0.01	2.00
004	Burke Street	0.01	1.10	0.01	1.93	0.02	3.06
005	E. Hollis St.	0.96	43.20	0.92	45.60	0.81	43.67
006	Nashua River	0.42	33.20	1.11	57.49	0.31	16.70
007	Tampa St.	0.00	0.00	0.00	0.00	0.00	0.00
008	Broad St.	0.00	0.00	0.01	6.13	0.03	0.96
009	Lock St.	0.00	0.00	0.00	0.13	0.00	0.29
TOTAL		**1.43**		**2.09**		**1.18**	
005/006	Combination	1.38	76.40	2.03	103.09	1.12	60.37
NWTF	Treatment unit	3.85	92.10	6.84	93.98	8.00	87.10

The collection system model indicates that this remaining 20% of inflow would result in significant adverse impacts during the 5-year and 10-year frequency TP-40 storms if the CSOs are closed. If the CSOs are not closed, CSO discharges would not be eliminated, even during the 5-year and 10-year TP-40 storms.

As indicated in Table 10-5, the collection system model predicts that overflows will occur at six of the eight CSOs during the 5-year storm, and at seven of the eight during the 10-year storm, even after separating all of the combined sewers in Nashua. This was based on the assumption that a complete sewer separation program would remove 80% of the stormwater inflow from the sewer system. The total amount of overflow during these storms would be 8.12 Mgal for the 5-year storm, and 12.41 Mgal for the 10-year storm.

TABLE 10-5. OVERFLOWS DURING 5-YEAR AND 10-YEAR TP-40 STORMS WITH COMPLETE SEWER SEPARATION

NPDES Discharge No.	Location	Overflow Volume and Peak Flow during Selected Design Storms[1]			
		5-Year (TP-40)		10-Year (TP-40)	
		Vol. (Mgal)	Q_{pk} (cfs)	Vol. (Mgal)	Q_{pk} (cfs)
002	Salmon Brook	0.00	0.00	0.08	5.82
003	Farmington Road	0.21	7.57	0.57	16.68
004	Burke St.	0.19	7.33	0.37	11.55
005	E. Hollis St.	1.89	49.51	2.56	58.67
006	Nashua River	5.27	119.70	7.95	170.55
007	Tampa St.	0.00	0.00	0.00	0.00
008	Broad St.	0.42	13.85	0.68	18.28
009	Lock St.	0.14	5.91	0.20	7.85
TOTAL		**8.12**		**12.41**	

Note: [1] Overflow volumes and peak flows in these columns are based on complete sewer separation, with 80% of the stormwater inflow removed from the collection system.

As a check on the sensitivity of the percent removal of stormwater inflow selected for evaluating the performance of complete sewer separation, a model simulation was run using 90% removal of stormwater inflow from the sewer system. Even with this degree of separation, which would not be attainable based on experience in other communities, there still would be overflows from the CSOs: 2.72 Mgal released during the 5-year storm, and 5.1 Mgal during the 10-year storm.

The collection system model shows that if the CSOs are bulkheaded following a sewer separation program, the sewers will exceed their capacity and surcharge. Ultimately, the sewers will relieve themselves through the lowest connection points in the system: for example, through building basements, floor drains, and manholes at low points. These manholes are generally located adjacent to the rivers. This uncontrolled release of sewage would present an unacceptable public health hazard. For that reason, it will not be possible to eliminate the overflows, even after a long-term program of complete sewer separation.

Figure 10-11 shows the locations where flooding is predicted to occur in a 10-year storm, under separated conditions with the outfalls sealed. Red dots indicate places were the peak hydraulic grade will be above the rim of the manhole, and green dots indicate where the peak hydraulic grade will come within 5 feet of the ground surface, typically the elevation of basement drain connections.

Expansion of Initially Preferred CSO Control Alternatives

One of the advantages of the CSO control approach recommended in this report is that the end-of-pipe treatment alternatives can be expanded if necessary. By using a modular approach for the construction of these units, additional modules can be added, providing a higher level of CSO control, if and when necessary.

It is imperative to note that expansion of the initially preferred CSO control alternatives **is not** recommended at this time. Expansion of the initially preferred CSO control alternatives should only be considered after the initially preferred CSO control alternatives have been implemented and there is a documented need for further CSO control that would result in commensurate water quality benefits. However, options that could be implemented to expand these alternatives have been developed in response to regulatory agency requests that Nashua develop such options, and to present a comparison to the current complete sewer separation plan. It is expected that the ongoing Army Corps of Engineers (ACOE) study of wet weather pollutant impacts on the Merrimack River will provide high quality data over a long-term monitoring program. In addition, the ACOE study will provide extensive data interpretation and river quality modeling that will aid in understanding the impacts of various pollution sources (e.g., dry weather sources, CSOs and stormwater) on the Merrimack River. Furthermore, once the initially preferred CSO control alternatives have been implemented, the beneficial impact of the alternatives on water quality should be assessed in order to better be able to evaluate and recommend additional CSO control alternatives if necessary.

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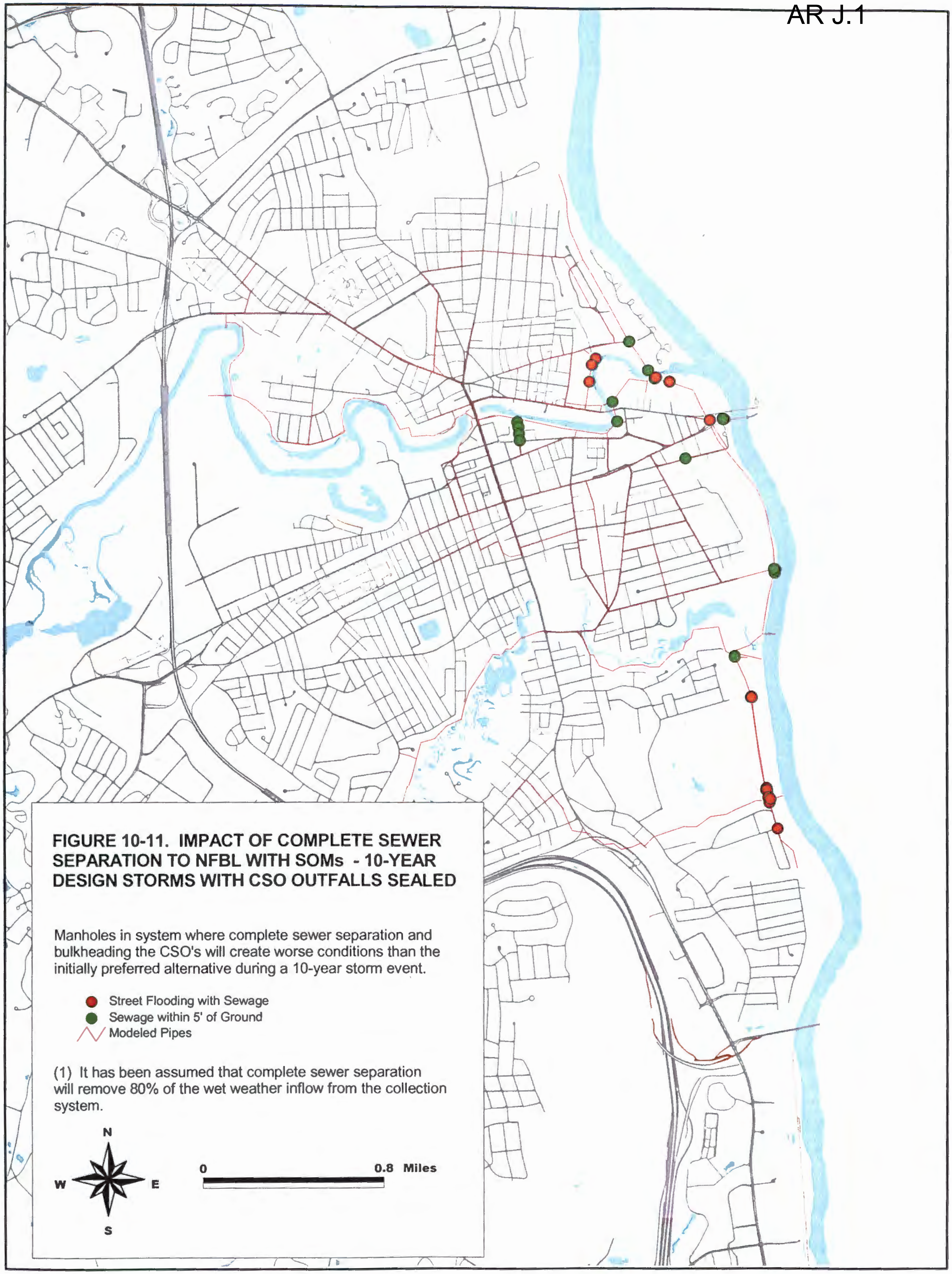

FIGURE 10-11. IMPACT OF COMPLETE SEWER SEPARATION TO NFBL WITH SOMs - 10-YEAR DESIGN STORMS WITH CSO OUTFALLS SEALED

Manholes in system where complete sewer separation and bulkheading the CSO's will create worse conditions than the initially preferred alternative during a 10-year storm event.

(1) It has been assumed that complete sewer separation will remove 80% of the wet weather inflow from the collection system.

Preliminary design of the end-of-pipe treatment facilities recommended for the NWTF wet weather treatment unit, and for the E. Hollis Street (005)/Nashua River (006) combined discharge, has been based on peak flow rates for the largest storm in the typical year. Converging to a higher level of control at these facilities would be based on the maximum possible flowrate capable of passing through the overflow. These maximum flowrates were determined by plotting the peak flow through each overflow from 1-year to 25-year design storm events. Plots were evaluated to determine if a finite flow capacity through these overflows was evident. Figure 10-12 presents the plot for the NWTF wet weather treatment unit and Figure 10-13 shows the plot for the 005/006 combination facility.

NWTF Wet Weather Treatment Unit. Reviewing Figure 10-12 shows that the peak flow to the NWTF wet weather treatment unit appears to level off at approximately 120 cfs. Although rainfall depth and intensity increase going from the 2-year storm up to the 25-year storm, flow to the NWTF does not rise considerably for the larger, less frequency storms. This is due to limiting capacity in the interceptors that deliver flow to the NWTF.

East Hollis Street (005)/Nashua River (006) Combination. The peak flow at the combined facility appears to level off at approximately 550 to 600 cfs. Based on experience with modeling peak flows during extreme storm events (greater than 5-year recurrence interval), inlet capacity may limit peak flows to a greater extent than pipe capacity. In other words, even though a substantially surcharge combined sewer may be predicted to convey a particular peak flow, limitations on the capacity of the catch basins and roof drainage system components typically prevent this peak flow from reaching the combined sewer. Prior to up-sizing the wet weather treatment capacity at the East Hollis Street (005)/Nashua River (006) combination (if such upsizing can be justified based on water quality benefit), more detailed hydraulic investigations are recommended to be performed to establish an appropriate peak flow for design. *

Comparison to Sewer Separation

Increasing the capacity of the NWTF wet weather treatment unit, and at the 005/006 combined screening/disinfection facility would dramatically reduce the volume of

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FIGURE 10-12. PEAK FLOW BY DESIGN STORM AT NWTF WET WEATHER TREATMENT UNIT

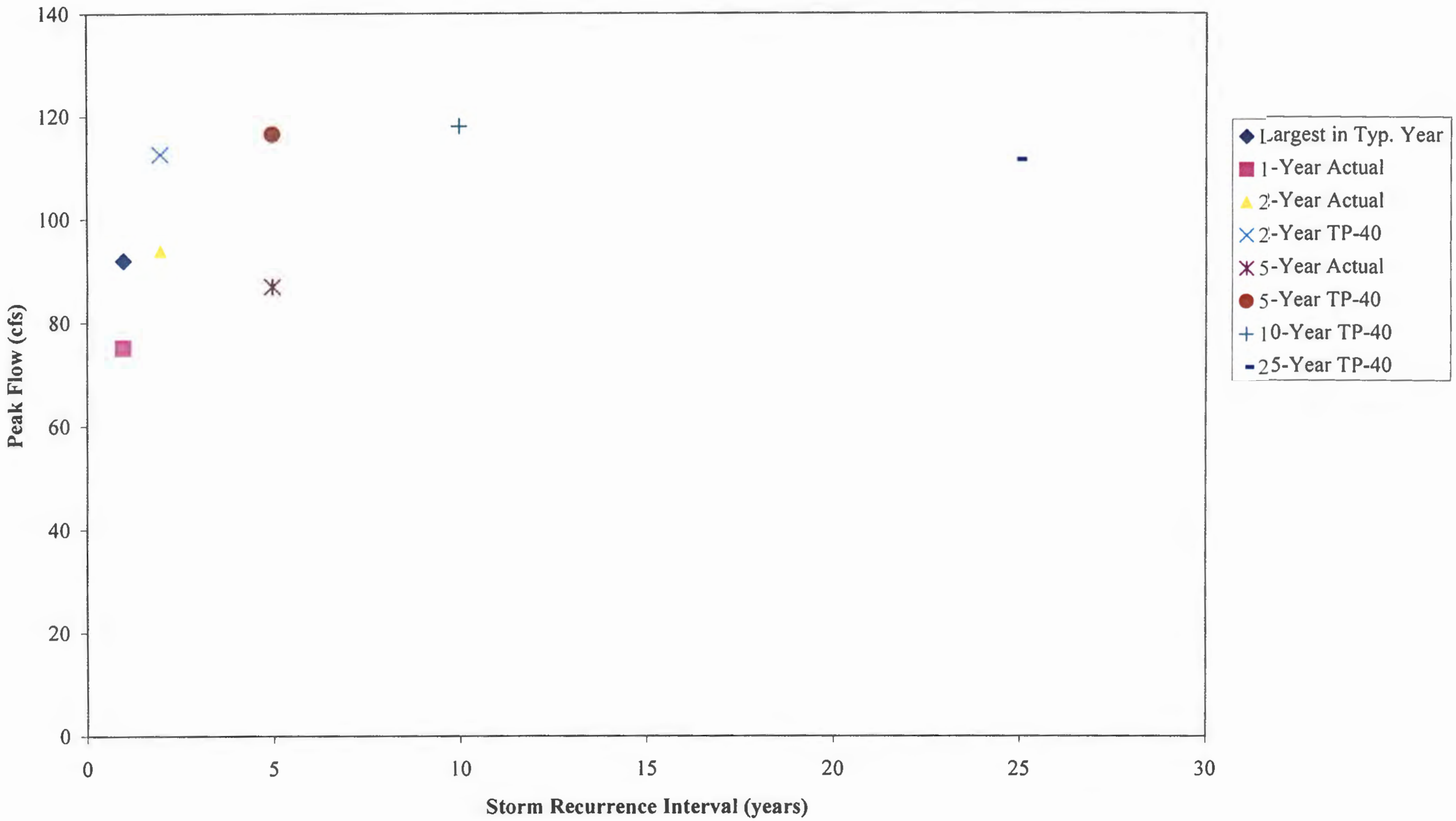
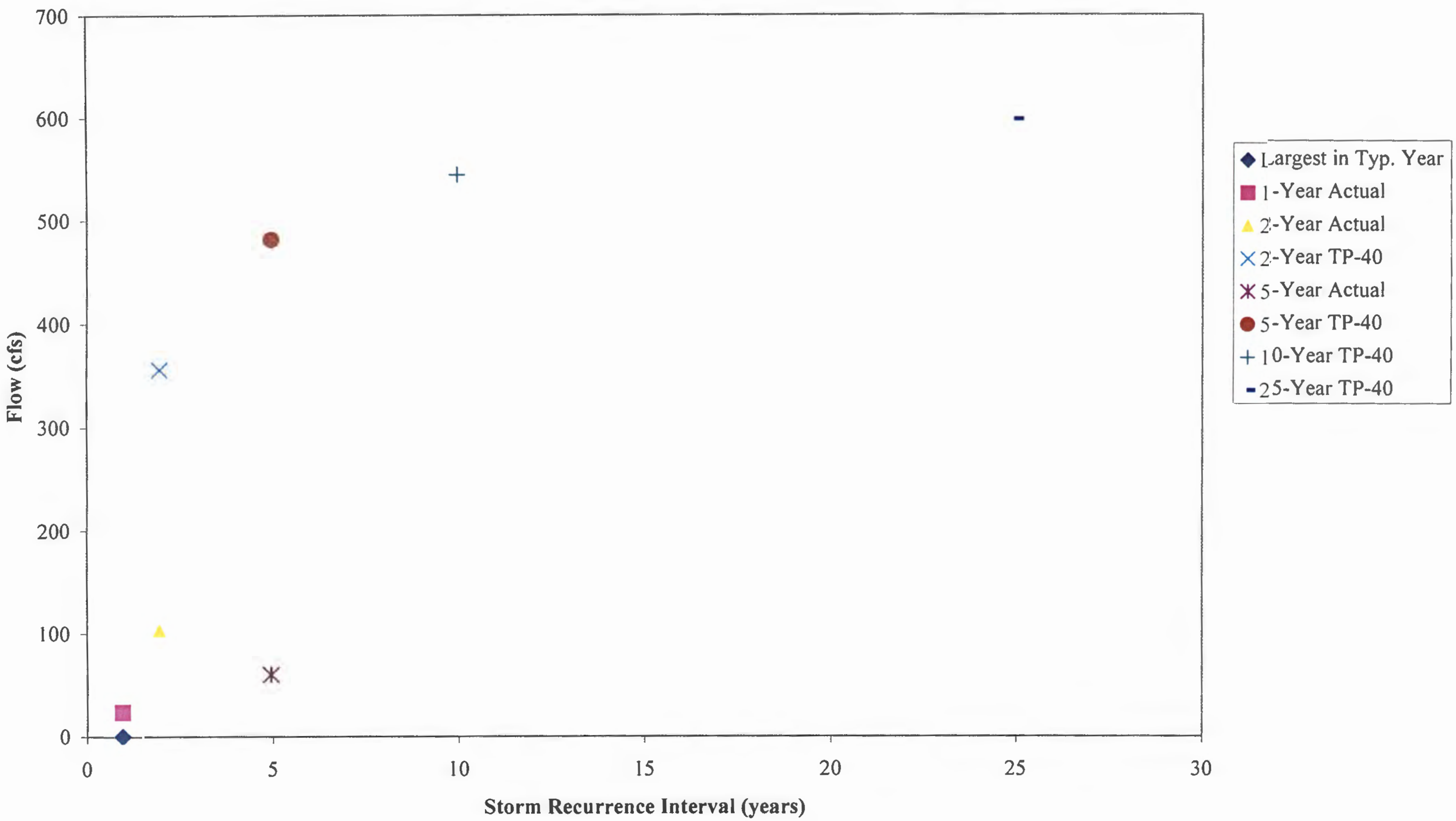


FIGURE 10-13. PEAK FLOW BY DESIGN STORM AT CSO 005/CSO 006 COMBINATION FACILITY



untreated CSO discharged systemwide during a 10-year storm. In addition, further improvements could be made at certian other CSOs to further reduce, or to treat, combined sewage discharges during extreme storm events. These alternatives are listed in Table 10-6. Also presented in Table 10-6 is the expected volume of untreated combined sewage discharge from each CSO under the recommended plan and under the current complete sewer separation plan.

Continuing to follow the current program of separating all combined sewers in Nashua would not prevent CSO discharges during very large, infrequent storms, as documented earlier in this chapter. The end-of-pipe treatment approach presented in this report offers greater potential than does sewer separation to reduce untreated CSO discharges during extreme storm events. The end-of-pipe CSO treatment approach provides the flexibility to attain a higher degree of capture and treatment of CSO through future expansion of facilities if warranted based on achieving commensurate water quality benefits. With this approach it would be possible to control untreated discharges even during extremely rare storm events, if that high level of control is warranted in the future.

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TABLE 10-6. COMPARATIVE PERFORMANCE OF EXPANSION OF INITIALLY PREFERRED CSO CONTROL ALTERNATIVES TO SEWER SEPARATION DURING EXTREME STORM EVENTS

NPDES Discharge No.	Location	Description of CSO Control Alternative(1)	Untreated CSO Discharge Vol. (Mgal)(2)(3)	Untreated CSO Discharge Vol. Sewer Separation (Mgal)(3)(4)
CSO 002	Salmon Brook	Re-route to NWTF treatment unit	0.00	0.08
CSO 003	Farmington Rd.	Sewer Separation + Storage	0.00	0.57
CSO 004	Burke St.	None	0.65	0.37
CSO 005	E. Hollis St.	Expand modular treatment	0.00	10.51
CSO 006	Nashua River			
CSO 007	Tampa St.	Sewer separation	0.00	0.00
CSO 008	Broad St.	None	1.60	0.68
CSO 009	Lock St.	None	0.15	0.20
NWTF	Treatment unit	Expand modular treatment	0.00	N/A
TOTAL			**2.40**	**12.41**

Note: [1] The CSO control alternatives listed in this table represent an expansion of the initially preferred CSO control alternatives presented earlier in this chapter. These alternatives shall only be considered if an extraordinary level of CSO control is deemed warranted in the future.

[2] With expansion of initially preferred CSO control alternatives

[3] Untreated CSO volumes are based on a 10-Year TP-40 storm event

[4] Untreated CSO volumes in this column are based on complete sewer separation, with 80 percent of stormwater inflow removed from the collection system. For comparative purposes, the total untreated CSO volume with 90 percent of the inflow removed would be 5.1 Mgal, which is still greater than the untreated CSO volume predicted with expansion of initially preferred CSO control alternatives.

CHAPTER 11

RECOMMENDED PLAN

This chapter presents the recommended plan for the control of CSO discharges in Nashua as an alternative to the current recommended plan (CRP) for complete sewer separation. The information in this chapter is organized as follows:

- Summary of Recommended Plan
- Benefits of Recommended Plan as compared to the CRP
- Stormwater Controls
- Infrastructure Improvements
- Implementation of Recommended Plan

SUMMARY OF RECOMMENDED PLAN

Based on the results of this study, the projects presented in Table 11-1 constitute the recommended plan for CSO control in Nashua, as an alternative to the CRP for complete sewer separation. The recommended plan also includes a continued commitment to maintaining and improving the aging wastewater collection system and a commitment to implement stormwater controls as the most appropriate means to realize incremental water quality benefits beyond those achieved by the CSO controls presented in this document.

The total estimated capital cost for the recommended plan is less than $38 million, substantially less than the $250 million cost of the CRP.

BENEFITS OF RECOMMENDED PLAN AS COMPARED TO THE CRP

The recommended plan represents an improvement over the CRP for the following reasons:

- The recommended plan will result in greater water quality benefits, specifically less bacterial pollution of the Nashua and Merrimack Rivers, as compared to the CRP. With complete sewer separation, stormwater volume, and hence, stormwater pollutant loading to the Nashua and Merrimack Rivers would increase. The recommended plan will reduce annual bacterial loading to the rivers from CSOs without increasing stormwater discharges. Furthermore, the recommended plan will result in better receiving water quality as compared to the CRP, based on the aerial extent, magnitude, and duration of predicted violations of water quality standards.

TABLE 11-1. SUMMARY OF RECOMMENDED PLAN

Priority	Action	Description	Report Reference	Cost ($ million)
1	Implement SOMs	Raise weirs/increase diameters of dry weather connections	Table 8-4	**$ 1.0**
2	NWTF	Wet weather bypass high-rate, chemically enhanced sedimentation treatment unit	Table 10-3	**$ 26.0**
3	CSO 005/006	Screening/disinfection treatment unit	Table 10-2 Page 10-11	**$ 6.0**
4	CSO 003	40,000 gallon storage tank	Page 10-10	**$ 2.5**
5	CSO 004	10,000 gallon storage tank	Page 10-11	**$ 2.0**
			Total Project Cost	**$ 37.5**

- The recommended plan will achieve environmental benefits much more quickly than the CRP. The recommended plan can be implemented in less than half the time it would take to separate all of the sewers in Nashua.

- The recommended plan offers flexibility to achieve higher degrees of CSO control in the future, to control untreated overflows during extreme storm events, if this ever is deemed necessary. With a program based solely on complete sewer separation, it will not be feasible to control CSO discharges during extreme storm events. If the existing CSO outfalls were sealed following complete sewer separation, flooding of homes and businesses and the overtopping of manholes along the receiving waters would result during these extreme events.

- The recommended plan maximizes the use of existing infrastructure by maximizing system storage through the implementation of system optimization measures. This is consistent with State and National CSO control policies.

- The recommended plan is much more cost effective in reducing pollution and can be implemented at significantly lower capital cost than complete sewer separation. The estimated cost of the recommended plan is $38 million, compared to over $250 million for the CRP.

These benefits of the recommended plan as compared to the CRP are discussed in more detail in the paragraphs that follow.

Recommended Plan Will Result in Greater Water Quality Benefits

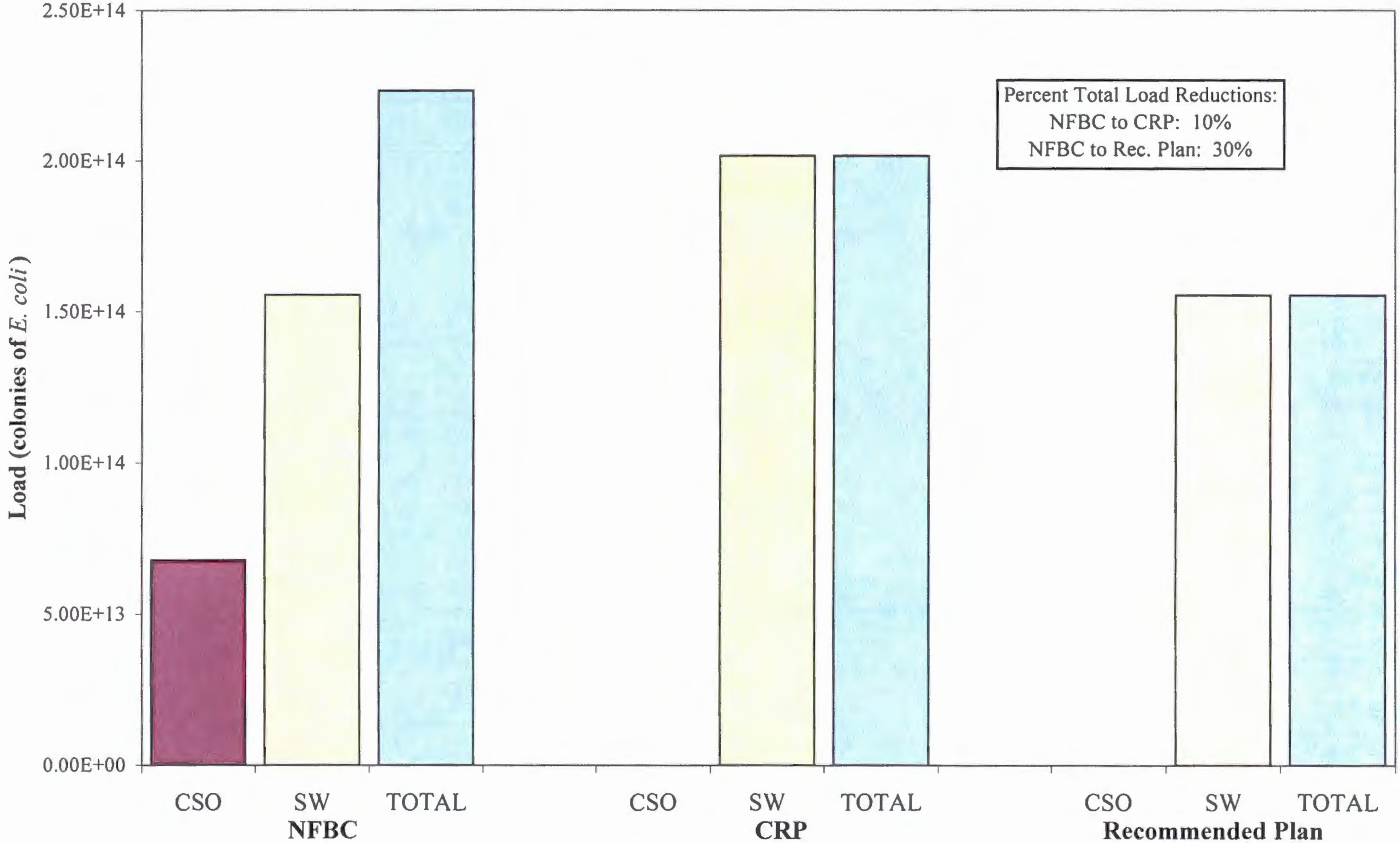
One of the main benefits of the recommended plan is that urban runoff, which is currently captured by the combined sewer system, would continue to be collected and treated as a component of combined sewage. Separating the combined sewers would increase stormwater pollution, partially offsetting the benefit of decreased pollution from CSOs. Based on the collection system model, sewer separation would increase the volume of stormwater by approximately 250 Mgal in a typical year. This quantity of increased stormwater represents a 29% increase in annual stormwater volume and annual stormwater bacterial load during a typical year. This increase in bacterial load from stormwater offsets the reduction of CSO bacterial loading that would be achieved from complete sewer separation, such that the net effect of complete sewer separation is only a 10% reduction in *E. coli* based on annual CSO and stormwater loads.

The recommended plan will provide a similar level of CSO control as sewer separation during a typical year, but without generating additional stormwater runoff. By achieving zero untreated CSO discharges in a typical year, the recommended plan will reduce total annual *E. coli* loading by 30%. Since the recommended plan does not result in additional stormwater volume, the benefit of this annual CSO *E. coli* load reduction is not offset by an increase in stormwater.

The net effect on the CRP and the Recommended Plan on reduction of total (CSO plus stormwater) *E. coli* load is presented graphically in Figure 11-1.

As documented in Chapter 7, the recommended plan achieves greater water quality benefits based on output from the receiving water quality model. For example, at location RIV-3 (on the

FIGURE 11-1. TOTAL BACTERIA LOADING IN A TYPICAL YEAR



Note: NFBC: Near Future Baseline Conditions
CRP: Current Recommended Plan

Merrimack River near its confluence with the Nashua River) a total of 5 hours of violation of the water quality standard (406 *E. coli* colonies per 100mL) are predicted if the CRP were implemented, while 3 hours of violation are predicted under the recommended plan. In addition, the magnitude of predicted violation at this location is lower under the recommended plan (560 *E. coli* colonies per 100mL) as compared to the CRP (740 *E. coli* colonies per 100mL). This trend of superior performance of the recommended plan versus the CRP was evident at other locations examined in the receiving water quality model.

Recommended Plan Will Achieve Environmental Benefits More Quickly Than CRP

The CRP would not be completed until 2019, and the full benefit of the sewer separation program in terms of reducing CSOs would not be realized until that time. One of the drawbacks complete sewer separation is that benefits are often delayed until near the end of the program, when separated flows can be "daylighted" to discharge to receiving waters. During the course of sewer separation programs, it is often necessary to temporarily re-combine upstream separated areas until downstream separation projects can be completed.

The recommended plan, however, can be implemented in a much shorter period of time, with the completion of each phase providing measurable water quality benefits. The work associated with implementing the recommended plan could be completed in approximately 9 years, as shown in Figure 11-2.

Each of the projects shown in Figure 11-2 provides incremental CSO control benefits that are independent of other projects, and will be realized as soon as each project is completed.

Recommended Plan Offers Flexibility to Achieve Higher Degrees of CSO Control in Future

As documented in Chapter 10, the CRP will not result in elimination of CSOs during extreme storm events due to the impact of remaining inflow that cannot be removed from the combined sewer system. The recommended plan will achieve zero CSO discharges in a typical year, and based on application of the collection system model, CSOs would nearly be eliminated in the

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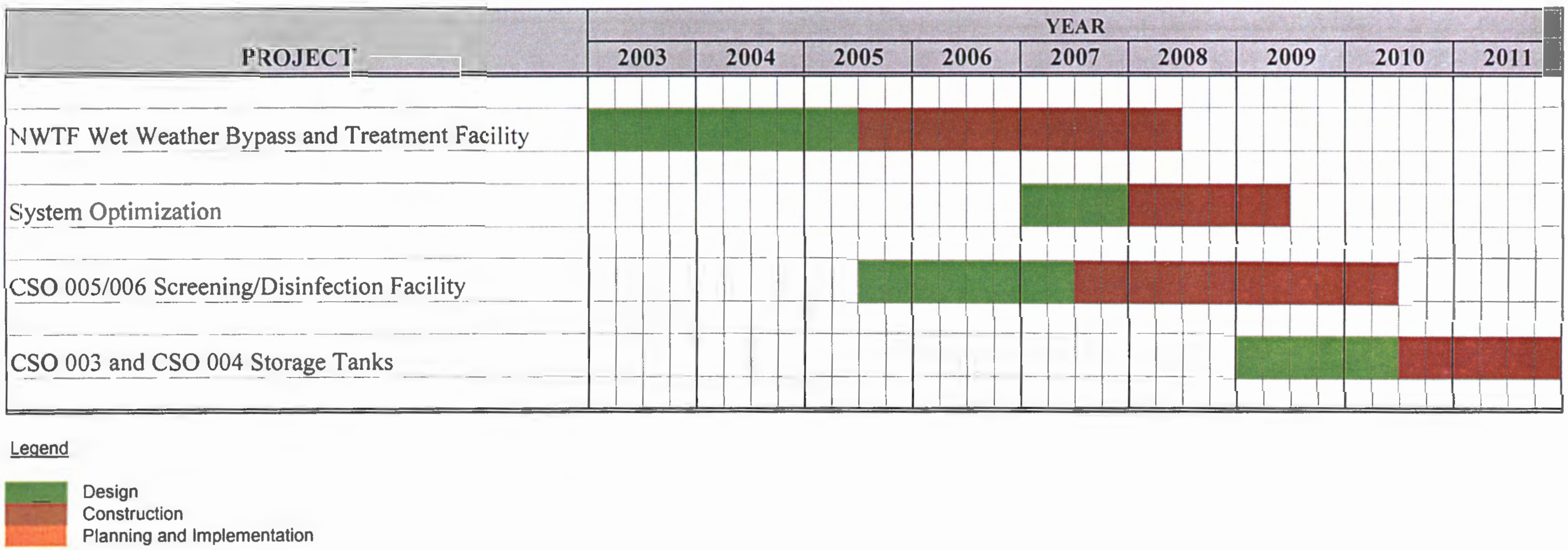
FIGURE 11-2. IMPLEMENTATION SCHEDULE



2-year and 5-year design storms derived in the 1997 CSO LTCP. If there is a documented need for CSO control beyond the level provided by the recommended plan, an advantage of the recommended plan is its suitability for expansion to achieve higher levels of control, as described in Chapter 10.

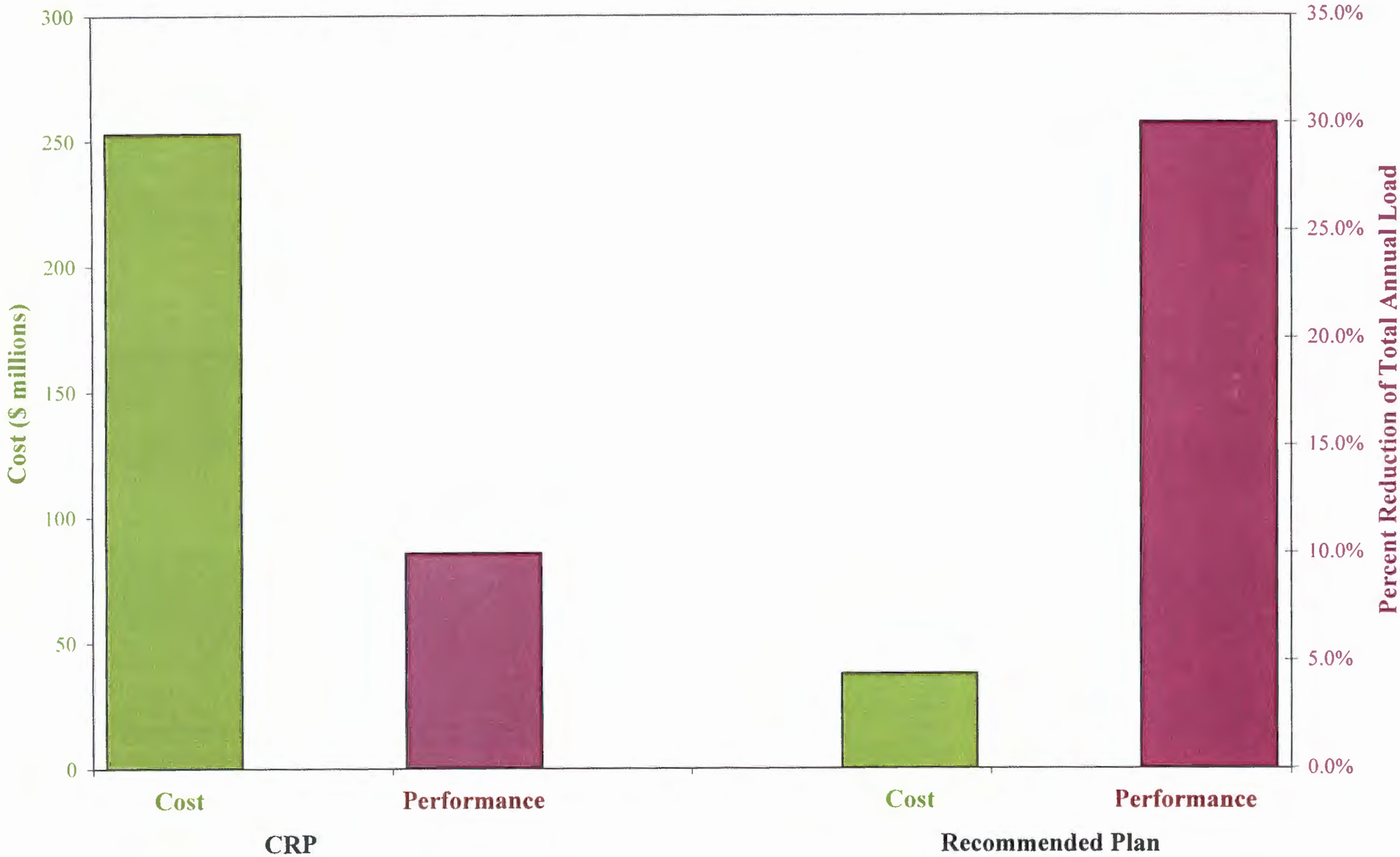
Recommended Plan Maximizes Use of Existing Infrastructure

The Nashua Wastewater Treatment Facility (NWTF) has a finite capacity, which is exceeded during moderate to large wet weather events. When NWTF capacity is exceeded, flow backs up in the large interceptors that deliver flow to the NWTF. By optimizing current operations of the NWTF and by installing a wet weather bypass just upstream of the NWTF, flows from nearly all storms that occur in an average rainfall year can be conveyed to the vicinity of the NWTF, greatly reducing the frequency of activation at upstream CSOs. This maximization of wet weather flow to just upstream of the NWTF results in maximizing the use of the existing interceptor network, and is a key component of the recommended plan.

Recommended Plan Can Be Implemented at Significantly Lower Cost than CRP

Based on sewer separation work completed in Nashua to date, the cost to separate one mile of combined sewer is approximately \$2.3 million. Therefore, separating the 110 miles of existing combined sewers in Nashua would cost an estimated \$250 million (2002 dollars). Inflation and other factors will increase that cost by the time the project is completed in 2019. The recommended plan, at a cost of \$38 million, is approximately one-quarter of the estimated capital cost for complete sewer separation, and can be completed in less than half the time. Since the recommended plan will also achieve a greater reduction in bacterial pollution on a total load basis (CSO plus stormwater) as compared to the CRP, the recommended plan is more cost effective than sewer separation, and is more "environmentally friendly." The cost effectiveness of the recommended plan as compared to the CRP is presented graphically in Figure 11-3.

FIGURE 11-3. COMPARISON OF CRP TO RECOMMENDED PLAN IN TERMS OF COST AND EFFECTIVENESS



RECOMMENDED PLAN IS CONSISTENT WITH STATE AND NATIONAL CSO POLICIES AND WITH CSO CONTROL IN OTHER COMMUNITIES

The recommended plan presented in this report has been developed in accordance with the NH DES and the national CSO control policies. Elimination of CSOs has been considered and found to be infeasible, and a high level of CSO control that achieves substantial environmental benefit has been proposed. The level of CSO control to be provided by the recommended plan is also appropriate when compared to the various approaches to CSO control currently being implemented in other communities nation-wide. While each CSO community must develop a unique approach for CSO control based on its collection and treatment system and receiving water characteristics, it is clear that the level of CSO control proposed to be implemented in Nashua is consistent with or greater than the level of CSO control being implemented by other communities.

INFRASTRUCTURE IMPROVEMENTS

One benefit of a comprehensive sewer separation program is replacement of aging infrastructure. The combined sewer areas in Nashua contain some of the city's oldest water and sewer lines. Based on the results of this study, the CRP for complete sewer separation is not an appropriate plan for water quality improvement in the Nashua and Merrimack Rivers, and is no longer recommended for implementation. Nashua does, however, remain committed to continued investigation and repair/replacement of aging sections of the collection system. It is expected that capital expenditures to fund continued improvements to the city's wastewater collection system will occur throughout the 9-year period required for implementation of the recommended plan.

IMPLEMENTATION OF STORMWATER CONTROLS

As noted throughout this report, stormwater is a significant source of bacterial contamination to the Nashua and Merrimack Rivers. While the CRP would increase stormwater pollutant loadings, the recommended plan will not. In addition, the city of Nashua is currently implementing innovative stormwater control projects, which will augment the benefits to be achieved by the recommended CSO control plan. These stormwater control projects will reduce stormwater pollution to the receiving waters, while the CRP would increase stormwater discharges. Furthermore, separate stormwater discharges will likely require pollution control measures in the future, potentially at great additional cost to Nashua. Controlling CSOs by maximizing use of existing infrastructure and limited use of wet weather treatment facilities will avoid the negative impact of increased separate stormwater loadings on water quality, and the cost of future facilities to treat separate stormwater. The city is committed to the development and implementation of cost-effective projects to reduce the volume and impact of separate stormwater on the Nashua and Merrimack Rivers, and to develop public education programs to inform citizens of the importance of proper watershed management and the benefits of stormwater runoff control. These stormwater control projects are proposed to be implemented as part of a comprehensive approach to wet weather pollution control in conjunction with the recommended CSO control plan presented in this report.

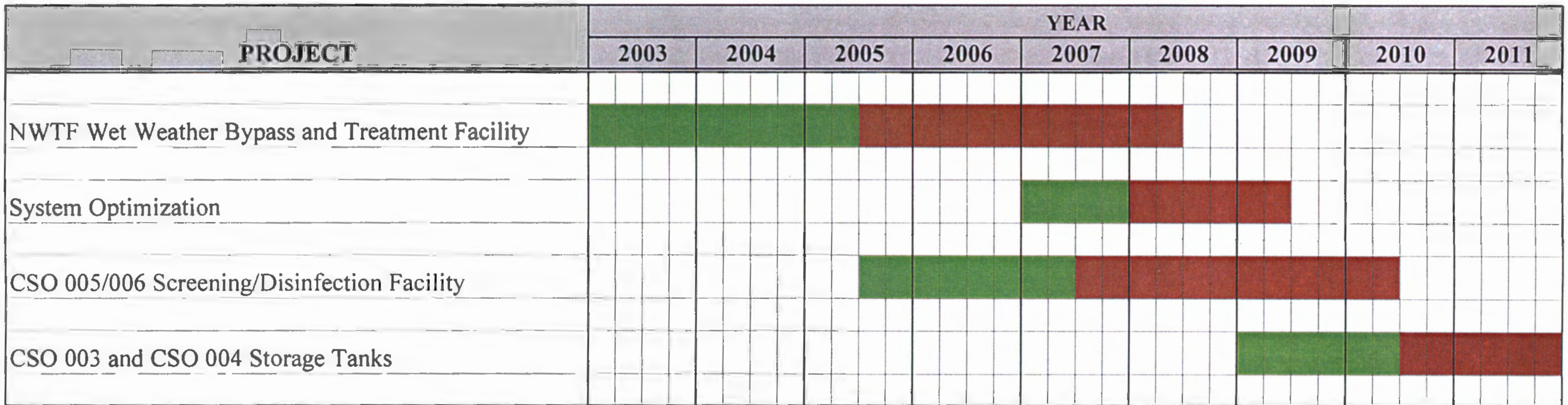
IMPLEMENTATION OF RECOMMENDED PLAN

As presented earlier in this chapter, the recommended plan can be completed in approximately 9 years (refer to Figure 11-2). This implementation schedule considers the critical path for project implementation and prioritizes projects based on relative CSO control benefit.

The cash flow projection, presented in Figure 11-4, shows the estimated capital expenditure by year, for the 9 year implementation schedule. For the cash flow analysis, engineering cost incurred during the design phase of the projects is estimated to be 10% of the total project cost. The remaining 90% of the project cost is for construction, incurred during the construction phase.

The first project that must be implemented is the wet weather bypass just upstream of the NWTF. This project must be implemented prior to system optimization measures (SOMs) because SOM implementation is dependent on the lower hydraulic grade lines in the main

FIGURE 11-4. CASH FLOW



	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total Cost per Year	$ 0.96	$ 0.96	$ 4.53	$ 8.30	$ 9.25	$ 6.50	$ 2.50	$ 2.20	$ 2.30

Legend

Design
Construction
Planning and Implementation

interceptors that will result from the wet weather bypass. It will be necessary to construct the treatment facility concurrent with construction of the wet weather bypass so that the treatment facility can come on-line as soon as the wet weather bypass is placed into operation. Once completed, this project will achieve system-wide CSO control benefits by lowering the hydraulic grade line in the vicinity of many of the CSOs, thereby reducing untreated CSO discharges.

Once the hydraulic grade line in the major interceptors has been lowered, SOMs can be implemented on a system-wide basis. Once implemented, these measures will eliminate upstream CSOs along the Nashua River and will reduce CSOs along the Merrimack River in the typical year.

The major untreated CSO discharges that will remain following implementation of SOMs are the East Hollis Street (CSO 005) and Nashua River (006) CSOs. Accordingly, the third project recommended for implementation will be the screening and disinfection facility to treat these discharges. Completion of this project will result in nearly eliminating untreated CSOs in the City in a typical year.

After completion of the screening and disinfection facility for CSOs 005 and 006, untreated CSOs in the typical year will be limited to small discharges at Farmington Road (003) and Burke Street (004). The final project in the recommended plan will involve construction of small storage basins to eliminate these untreated discharges in the typical year.

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APPENDIX A. RESULTS OF WATER QUALITY SAMPLING PROGRAM

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APPENDIX A. RESULTS OF WATER QUALITY SAMPLING PROGRAM
WET WEATHER SAMPLING DATA

Location	Sample Point - Nash				Sample Point - Mid				Sample Point -Huds				Sample blank			
	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)
RIV-1	02110063-01	3-0-Nash	11/6/02 5:25 AM	60	02110063-02	3-0-Mid	11/6/02 5:28 AM	20	02110063-03	3-0-Huds	11/6/02 5:30 AM	200				
	02110072-15	3-3-Nash	11/6/02 8:45 AM	60	02110072-16	3-3-Mid	11/6/02 8:48 AM	40	02110072-17	3-3-Huds	11/6/02 8:51 AM	<20				
	02110088-01	3-6-Nash	11/6/02 11:40 AM	380	02110088-02	3-6-Mid	11/6/02 11:45 AM	200	02110088-03	3-6-Huds	11/6/02 11:50 AM	200				
					02110088-14	3-6-Mid-Dup	11/6/02 11:45 AM	280								
	02110089-01	3-12-Nash	11/6/02 4:00 PM	120	02110089-02	3-12-Mid	11/6/02 4:04 PM	200	02110089-03	3-12-Huds	11/6/02 4:07 PM	180				
	02110094-02	3-24-Nash	11/7/02 7:58 AM	220	02110094-03	3-24-Mid	11/7/02 8:01 AM	1880	02110094-04	3-24-Huds	11/7/02 8:04 AM	440				
	02110108-03	3-48-Nash	11/8/02 7:45 AM	1160	02110108-02	3-48-Mid	11/8/02 7:48 AM	1080	02110108-04	3-48-Huds	11/8/02 7:51 AM	440				
RIV-2	02110063-04	3-0-Nash	11/6/02 6:18 AM	<200	02110063-05	3-0-Mid	11/6/02 6:21 AM	20	02110063-06	3-0-Huds	11/6/02 6:24 AM	<400				
	02110072-18	3-3-Nash	11/6/02 9:31 AM	40	02110072-19	3-3-Mid	11/6/02 9:40 AM	<20	02110072-20	3-3-Huds	11/6/02 9:43 AM	40				
	02110088-04	3-6-Nash	11/6/02 12:28 PM	40	02110088-05	3-6-Mid	11/6/02 12:31 PM	120	02110088-06	3-6-Huds	11/6/02 12:34 PM	220				
	02110089-04	3-12-Nash	11/6/02 4:25 PM	[illegible]	02110089-05	3-12-Mid	11/6/02 4:28 PM	1400	02110089-06	3-12-Huds	11/6/02 4:31 PM	240				
	02110094-05	3-24-Nash	11/7/02 8:28 AM	120	02110094-06	3-24-Mid	11/7/02 8:31 AM	440	02110094-07	3-24-Huds	11/6/02 8:34 AM	560				
RIV-3	02110063-07	3-0-Nash	11/6/02 5:53 AM	60	02110063-08	3-0-Mid	11/6/02 5:56 AM	100	02110063-09	3-0-Huds	11/6/02 5:50 AM	60				
	02110072-21	3-3-Nash	11/6/02 9:10 AM	40	02110072-22	3-3-Mid	11/6/02 9:13 AM	80	02110072-01	3-3-Huds	11/6/02 9:16 AM	40				
	02110088-07	3-6-Nash	11/6/02 12:05 PM	60	02110088-08	3-12-Mid	11/6/02 12:08 PM	120	02110088-09	3-6-Huds	11/6/02 12:11 PM	420				
	02110089-07	3-12-Nash	11/6/02 4:17 PM	<20	02110089-08	3-12-Mid	11/6/02 4:20 PM	100	02110089-09	3-12-Nash	11/6/02 4:23 PM	<20				
RIV-4					02110063-10	3-0-Mid	11/6/02 5:42 AM	80								
					02110072-02	3-3-Mid	11/6/02 9:02 AM	260								
					02110088-10	3-6-Mid	11/6/02 11:55 AM	80								
					02110089-10	3-12-Mid	11/6/02 4:11 PM	<20								
RIV-5					02110063-11	3-0-Mid	11/6/02 5:30 AM	140								
					02110072-03	3-3-Mid	11/6/02 8:30 AM	480								
					02110088-11	3-6-Mid	11/6/02 11:45 AM	440					02110089-13	3-Blank	11/6/02 4:20 PM	<20
					02110088-13	3-6-Mid-Dup	11/6/02 11:45 AM	80								
					02110089-11	3-12-Mid	11/6/02 4:10 PM	40								
					02110094-01	3-24-Mid	11/7/02 7:22 AM	300								
					02110108-01	3-48-Mid	11/8/02 7:15 AM	260								
RIV-6					02110063-12	3-0-Mid	11/6/02 6:06 AM	260								
					02110072-04	3-3-Mid	11/6/02 9:22 AM	80								
					02110088-12	3-6-Mid	11/6/02 12:15 PM	280								
					02110089-12	3-12-Mid	11/6/02 4:25 PM	120								

Location	CSO-1				CSO-2				SD-1				SD-2			
	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)
CSO/SD	02110063-17	3-1	11/6/02 5:04 AM	308000		3-1	No Flow		02110063-13	3-1	11/6/02 5:10 AM	220	02110072-05	3-3 Micro	11/6/02 8:45 AM	1320
CSO/SD	02110063-18	3-2	11/6/02 6:03 AM	220000		3-2	No Flow		02110063-14	3-2	11/6/02 6:30 AM	640	02110072-06	3-3 Micro Dup	11/6/02 8:45 AM	1460
CSO/SD	02110063-19	3-3	11/6/02 6:46 AM	198000		3-3	No Flow		02110063-20	3-3	11/6/02 7:05 AM	4200	02110063-15	3-1	11/6/02 5:00 AM	[illegible]
CSO/SD	02110072-11	3-3a Micro	11/6/02 10:05 AM	5500		3-3a Micro	No Flow		02110072-12	3-4	11/6/02 8:05 AM	3800	02110063-16	3-2	11/6/02 6:05 AM	11000
CSO/SD	02110072-07	3-5	11/6/02 8:18 AM	1300		3-5	No Flow		02110072-13	3-5	11/6/02 9:05 AM	1580	02110072-09	3-4 Micro	11/6/02 10:05 AM	1660
CSO/SD	02110072-08	3-6	11/6/02 9:10 AM	2100		3-6	No Flow		02110072-14	3-6	11/6/02 10:05 AM	940	02110072-10	3-Blank	11/6/02 10:05 AM	<20

Notes:
(light shading) Concentration reported is greater than 126 col/100 ml, and less than 406 col/ml
(dark shading) Concentration reported is greater than 406 col/100 ml

APPENDIX A. RESULTS OF WATER QUALITY SAMPLING PROGRAM

WET WEATHER SAMPLING DATA

Location	Sample Point - Nash				Sample Point - Mid				Sample Point -Huds				Sample blank			
	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)
RIV-1	02100151-10	2-0-Nash	10/16/02 3:10 PM	<20	02100151-09	2-0-Mid	10/16/02 3:07 PM	20	02100151-11	2-0-Huds	10/16/02 3:05 PM	20				
	02100152-04	2-3-Nash	10/16/02 5:18 PM	160	02100152-05	2-3-Mid	10/16/02 5:16 PM	180	02100152-06	2-3-Huds	10/16/02 5:14 PM	300				
	02100153-07	2-6-Nash	10/16/02 8:20 PM	260	02100153-05	2-6-Mid	10/16/02 8:17 PM	60	02100153-08	2-6-Huds	10/16/02 8:15 PM	460				
					02100153-06	2-6-Mid-Dup	10/16/02 8:17 PM	<20								
	02100154-03	2-12-Nash	10/16/02 10:55 PM	<20	02100154-04	2-12-Mid	10/16/02 10:53 PM	20	02100154-05	2-12-Huds	10/16/02 10:50 PM	<20				
	02100155-01	2-18-Nash	10/17/02 8:00 AM	100	02100155-02	2-18-Mid	10/17/02 8:04 AM	<20	02100155-03	2-18-Huds	10/17/02 8:07 AM	60	02100155-04	2-18-Blank	10/17/02 8:00 AM	<20
	02100159-01	2-24-Nash	10/17/02 1:50 PM	<400	02100159-02	2-24-Mid	10/17/02 1:54 PM	<200	02100159-03	2-24-Huds	10/17/02 1:58 PM	100				
	02100170-01	2-48-Nash	10/18/02 10:05 AM	40	02100170-02	2-48-Mid	10/18/02 10:07 AM	<20	02100170-03	2-48-Huds	10/18/02 10:10 AM	<20				
RIV-2	02100151-13	2-0-Nash	10/16/02 2:15 PM	40	02100151-12	2-0-Mid	10/16/02 2:20 PM	40	02100151-14	2-0-Huds	10/16/02 2:25 PM	<20				
	02100152-07	2-3-Nash	10/16/02 4:30 PM	260	02100152-08	2-3-Mid	10/16/02 4:30 PM	140	02100152-09	2-3-Huds	10/16/02 4:35 PM	420				
	02100153-09	2-6-Nash	10/16/02 7:30 PM	<20	02100153-10	2-6-Mid	10/16/02 7:35 PM	29600	02100153-11	2-6-Huds	10/16/02 7:37 PM	710				
	02100154-06	2-12-Nash	10/16/02 9:55 PM	400	02100154-07	2-12-Mid	10/16/02 9:58 PM	260	02100154-08	2-12-Huds	10/16/02 10:02 PM	160				
	02100154-05	2-18-Nash	10/17/02 8:30 AM	40	02100155-06	2-18-Mid	10/17/02 8:34 AM	<20	02100155-07	2-18-Huds	10/17/02 8:37 AM	100				
	02100159-04	2-24-Nash	10/17/02 2:18 PM	60	02100159-04	2-24-Mid	10/17/02 2:21 PM	80	02100159-06	2-24-Huds	10/17/02 2:24 PM	40				
RIV-3	02100151-16	2-0-Nash	10/16/02 2:45 PM	100	02100151-15	2-0-Mid	10/16/02 2:50 PM	<20	02100151-17	2-0-Huds	10/16/02 2:55 PM	120				
	02100152-10	2-3-Nash	10/16/02 5:00 PM	220	02100152-11	2-3-Mid	10/16/02 4:56 PM	160	02100152-12	2-3-Huds	10/16/02 4:53 PM	420				
	02100153-12	2-6-Nash	10/16/02 7:57 PM	3000	02100153-13	2-6-Mid	10/16/02 8:00 PM	2600	02100153-14	2-6-Huds	10/16/02 8:03 PM	1400				
	02100154-09	2-12-Nash	10/16/02 10:25 PM	20	02100154-10	2-12-Mid	10/16/02 10:28 PM	120	02100154-11	2-12-Huds	10/16/02 10:31 PM	<20				
RIV-4					02100151-18	2-0-Mid	10/16/02 3:00 PM	60								
					02100152-13	2-3-Mid	10/16/02 5:04 PM	800								
					02100153-15	2-6-Mid	10/16/02 8:08 PM	240								
					02100154-12	2-12 Mid	10/16/02 10:36 PM	<20								
					02100155-08	2-18 Mid	10/17/02 8:08 AM	20								
RIV-5					02100151-19	2-0-Mid	10/16/02 2:25 PM	<20								
					02100153-03	2-3 Mid	10/16/02 4:40 PM	600								
					02100153-04	2-6 Mid	10/16/02 7:20 PM	1240								
					02100154-01	2-12 Mid	10/16/02 10:20 PM	<20					02100154-02	2-Blank	10/16/02 10:30 PM	<20
					02100155-09	2-18 Mid	10/17/02 7:15 AM	120								
RIV-6					02100151-20	2-0-Mid	10/16/02 2:32 PM	380								
					02100152-14	2-3-Mid	10/16/02 4:45 PM	1040								
					02100153-16	2-6-Mid	10/16/02 7:50 PM	660								
					02100154-13	2-12 Mid	10/16/02 10:15 PM	200								
					02100155-10	2-18 Mid	10/17/02 8:18 AM	260								

Location	CSO-1				CSO-2				SD-1				SD-2			
	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)	Sample #	Sample ID	Date & Time	E-coli Concentration (col./100 ml)
CSO/SD	02100150-04	2-1	10/16/02 12:30 PM	TNTC*	02100152-03	2-1	10/16/02 5:00 PM	TNTC*	02100150-01	2-1	10/16/02 11:15 AM	2600	02100150-05	2-1	10/16/02 11:30 AM	780
CSO/SD	02100151-01	2-2	10/16/02 1:55 PM	230000		2-2	No Flow		02100150-02	2-2	10/16/02 12:30 PM	5200	02100150-06	2-2	10/16/02 11:50 AM	1800
CSO/SD	02100151-03	2-3	10/16/02 3:00 PM	226000		2-3	No Flow		02100151-05	2-3	10/16/02 1:45 PM	6800	02100151-07	2-3	10/16/02 3:45 PM	2420
CSO/SD	02100151-04	2-4	10/16/02 4:15 PM	304000		2-4	No Flow		02100151-06	2-4	10/16/02 3:00 PM	44000		2-4	No Flow	
CSO/SD	02100152-01	2-5	10/16/02 5:15 PM	108000		2-5	No Flow		02100153-01	2-5	10/16/02 5:15 PM	4,600		2-5	No Flow	
CSO/SD	02100152-02	2-6	10/16/02 6:15 PM	760000		2-6	No Flow		02100153-02	2-6	10/16/02 7:00 PM	800		2-6	No Flow	

Notes:

All dilutions too numerous to count. Highest dilution was 1:2000

Concentration reported is greater than 126 col/100 ml, and less than 406 col/ml

Concentration reported is greater than 406 col/100 ml

APPENDIX A. RESULTS OF WATER QUALITY SAMPLING PROGRAM
DRY WEATHER SAMPLING DATA

Location	Sample Point - Nash		Sample Point - Nash (field dup)		Sample Point - Mid		Sample Point -Mid (field dup)		Sample Point -Huds		Sample Point -Huds (field dup)	
	Date & Time	E-coli Concentration (col./100 ml)	Date & Time	E-coli Concentration (col./100 ml)	Date & Time	E-coli Concentration (col./100 ml)	Date & Time	E-coli Concentration (col./100 ml)	Date & Time	E-coli Concentration (col./100 ml)	Date & Time	E-coli Concentration (col./100 ml)
RIV-1	07/22/2002	23			07/22/2002	17			07/22/2002	14	07/22/2002	5
	07/23/2002	>80			07/23/2002	>80			07/23/2002	>80	07/23/2002	>80
	07/29/2002	18			07/29/2002	22			07/29/2002	8	07/29/2002	12
	07/31/2002	4			07/31/2002	4			07/31/2002	4	07/31/2002	10
	08/05/2002	15			08/05/2002	9			08/05/2002	5	08/05/2002	5
	08/07/2002	6			08/07/2002	7			08/07/2002	5	08/07/2002	17
	08/19/2002	12			08/19/2002	8			08/19/2002	8	08/19/2002	5
	08/26/2002	17			08/26/2002	15			08/26/2002	17	08/26/2002	16
RIV-2	07/22/2002	20			07/22/2002	29			07/22/2002	29		
	07/23/2002	22			07/23/2002	32			07/23/2002	44		
	07/29/2002	>160			07/29/2002	>160			07/29/2002	>160		
	07/31/2002	28			07/31/2002	32			07/31/2002	40		
	08/05/2002	14			08/05/2002	13			08/05/2002	8		
	08/07/2002	32			08/07/2002	29			08/07/2002	22		
	08/19/2002	22			08/19/2002	4			08/19/2002	8		
	08/26/2002	60			08/26/2002	52			08/26/2002	•		
RIV-3	07/22/2002	57			07/22/2002	26			07/22/2002	7		
	07/23/2002	>80			07/23/2002	>80			07/23/2002	>80		
	07/29/2002	>160			07/29/2002	2			07/29/2002	4		
	07/31/2002	12			07/31/2002	4			07/31/2002	40		
	08/05/2002	21			08/05/2002	5			08/05/2002	•		
	08/07/2002	55			08/07/2002	14			08/07/2002	13		
	08/19/2002	60			08/19/2002	8			08/19/2002	24		
	08/26/2002	24			08/26/2002	11			08/26/2002	34		
RIV-4					07/22/2002	152						
					07/23/2002	490						
					07/29/2002	90						
					07/31/2002	86						
					08/05/2002	72						
					08/07/2002	30						
					08/19/2002	16						
					08/26/2002	400						
RIV-5					07/22/2002	>80	07/22/2002	26				
					07/23/2002	8	07/23/2002	25				
					07/29/2002	30	07/29/2002	25				
					07/31/2002	4	07/31/2002	25				
					08/05/2002	10	08/05/2002	27				
					08/07/2002	34	08/07/2002	28				
					08/19/2002	57	08/19/2002	26				
					08/26/2002	14	08/26/2002	26				
RIV-6					07/22/2002	72						
					07/23/2002	140						
					07/29/2002	310						
					07/31/2002	116						
					08/05/2002	108						
					08/07/2002	114						
					08/19/2002	96						
					08/26/2002	68						

Notes:

Concentration reported is greater than 126 col/100 ml, and less than 406 col/ml

Concentration reported is greater than 406 col/100 ml

EXHIBIT G
AR J.1

APPENDIX A. RESULTS OF WATER QUALITY SAMPLING PROGRAM
DRY WEATHER SAMPLING DATA

Location	Sample Point - Nash		Sample Point - Mid		Sample Point -Huds	
	Date & Time	E-coli Concentration (col./100 ml)	Date & Time	E-coli Concentration (col./100 ml)	Date & Time	E-coli Concentration (col./100 ml)
RIV-1	06/28/2001	48	06/28/2001	58	06/28/2001	46
	07/23/2001	4	07/23/2001	2	07/23/2001	<2
	07/24/2001	5	07/24/2001	8	07/24/2001	10
	07/25/2001	4	07/25/2001	2	07/25/2001	7
	07/30/2001	8	07/30/2001	5	07/30/2001	12
	08/01/2001	4	08/01/2001	2	08/01/2001	3
	08/07/2001	15	08/07/2001	33	08/07/2001	12
	08/08/2001	>80	08/08/2001	5	08/08/2001	11
	08/10/2001	80	08/10/2001	48	08/10/2001	36
RIV-2	06/28/2001	78	06/28/2001	37	06/28/2001	54
	07/23/2001	8	07/23/2001	8	07/23/2001	2
	07/24/2001	16	07/24/2001	9	07/24/2001	8
	07/25/2001	11	07/25/2001	8	07/25/2001	12
	07/30/2001	8	07/30/2001	7	07/30/2001	6
	08/01/2001	13	08/01/2001	20	08/01/2001	13
	08/07/2001	56	08/07/2001	78	08/07/2001	80
	08/08/2001	>80	08/08/2001	>80	08/08/2001	>80
	08/10/2001	48	08/10/2001	20	08/10/2001	32
RIV-3	06/28/2001	37	06/28/2001	26	06/28/2001	26
	07/23/2001	40	07/23/2001	<2	07/23/2001	<2
	07/24/2001	9	07/24/2001	6	07/24/2001	16
	07/25/2001	<1	07/25/2001	5	07/25/2001	15
	07/30/2001	14	07/30/2001	8	07/30/2001	16
	08/01/2001	2	08/01/2001	5	08/01/2001	1
	08/07/2001	>80	08/07/2001	>80	08/07/2001	>80
	08/08/2001	>80	08/08/2001	4	08/08/2001	30
	08/10/2001	4	08/10/2001	4	08/10/2001	8
RIV-4			06/28/2001	78		
			07/23/2001	53		
			07/24/2001	180		
			07/25/2001	63		
			07/30/2001	31		
			08/01/2001	72		
			08/07/2001	116		
			08/08/2001	132		
			08/10/2001	330		
RIV-5			06/28/2001	42		
			07/23/2001	13		
			07/24/2001	16		
			07/25/2001	14		
			07/30/2001	5		
			08/01/2001	68		
			08/07/2001	19		
			08/08/2001	>80		
			08/10/2001	32		
RIV-6			06/28/2001	180		
			07/23/2001	141		
			07/24/2001	93		
			07/25/2001	200		
			07/30/2001	86		
			08/01/2001	>80		
			08/07/2001	131		
			08/08/2001	117		
			08/10/2001	240		

Notes:
Concentration reported is greater than 126 col/100 ml, and less than 406 col/ml
Concentration reported is greater than 406 col/100 ml

APPENDIX A. RESULTS OF WATER QUALITY SAMPLING PROGRAM Date Sampled: 10/18/2002					
Method #	**Analyte**	**Unit of Measure**	**Concentration Results**		
			Sample # : 02100176-01 **Metcalf & Eddy ID: Comp SD-1-2**	**Sample # : 02100176-02** **Metcalf & Eddy ID: Comp SD-2-2**	**Sample # : 02100176-03** **Metcalf & Eddy ID: Comp SD-2-2-Dup**
160.2	Total Suspended Solids	mg/L	8	15	12
160.5	Settleable Solids	ml/L	<0.2	<0.2	<0.2
351.3	Kjeldahl-N	mg/L	0.82	0.966	0.573
365.2	Phosphorus-P	mg/L	0.15	201	0.242
405.1	BOD	mg/L	6	6	7
SW 3015	Aqueous Microwave Digestion	N/A	N/A	N/A	N/A
SW 6010B	Copper	mg/L	<0.010	0.021	0.165
SW 6010B	Zinc	mg/L	0.05	0.042	0.129
SW 7421	Lead	mg/L	<0.005	0.019	0.008

APPENDIX B. RESULTS OF WATER QUALITY SAMPLING PROGRAM Date Sampled: 11/6/2002					
Method #	**Analyte**	**Unit of Measure**	**Concentration Results**		
			Sample # : 02110123-02 **Metcalf & Eddy ID: Comp SD-1-3**	**Sample # : 02110123-01** **Metcalf & Eddy ID: Comp SD-2-3**	**Sample # : 02110123-03** **Metcalf & Eddy ID: Comp SD-2-3 Dup**
160.2	Total Suspended Solids	mg/L	8	<4	<4
160.5	Settleable Solids	ml/L	<0.2	<0.2	<0.2
351.3	Kjeldahl-N	mg/L	0.281	0.86	0.774
365.2	Phosphorus-P	mg/L	0.126	0.374	0.368
405.1	BOD	mg/L	126	218	155
SW 3015	Aqueous Microwave Digestion	N/A	N/A	N/A	N/A
SW 6010B	Copper	mg/L	<0.010	0.01	0.01
SW 6010B	Zinc	mg/L	0.026	0.103	0.103
SW 7421	Lead	mg/L	<0.005	<0.005	<0.005

EXHIBIT G
AR J.1

APPENDIX B. CALIBRATION PLOTS

Calibration volumes (MG)

Meter Location	Metered			Modeled		
	6/2-3/2001	6/11-12/20	6/17/2001	6/2-3/2001	6/11-12/20	6/17/2001
2	8.50	7.38	4.46	7.27	6.12	4.54
2OF	0.00	0.00	0.09	0.00	0.00	0.13
3	5.57	5.20	2.85	4.89	3.93	3.19
3OF	0.40	0.11	0.41	0.13	0.01	0.59
4	1.81	0.89	1.32	2.00	1.11	1.67
4OF	0.73	0.26	2.05	0.75	0.17	1.00
5	9.48	5.67	6.36	9.27	5.34	6.79
5OF	0.52	0.12	1.45	1.28	0.02	2.09
6	18.67	14.40	11.43	17.01	12.51	13.29
6OF	1.93	1.23	5.74	2.10	0.00	6.09
7	0.42	0.39	0.35	0.56	0.41	0.41
7OF	0.00	0.00	0.09	0.00	0.00	0.08
8OF	0.03	0.04	0.52	0.38	0.06	0.66
9	1.21	0.55	0.56	0.89	0.52	0.74
9OF	0.28	0.17	0.18	0.22	0.04	0.35
12	1.75	1.25	0.95	1.36	0.83	1.10
12OF	0.00	0.00	0.00	0.00	0.00	0.00
21	5.62	5.43	3.18	5.52	5.10	3.07
22	6.36	6.44	3.52	6.47	6.09	3.53
23	0.81	0.78	0.42	0.83	0.79	0.44
24	2.85	2.60	1.73	3.03	2.75	1.70
25	8.02	7.43	3.82	8.05	7.10	4.48

EXHIBIT G
AR J.1

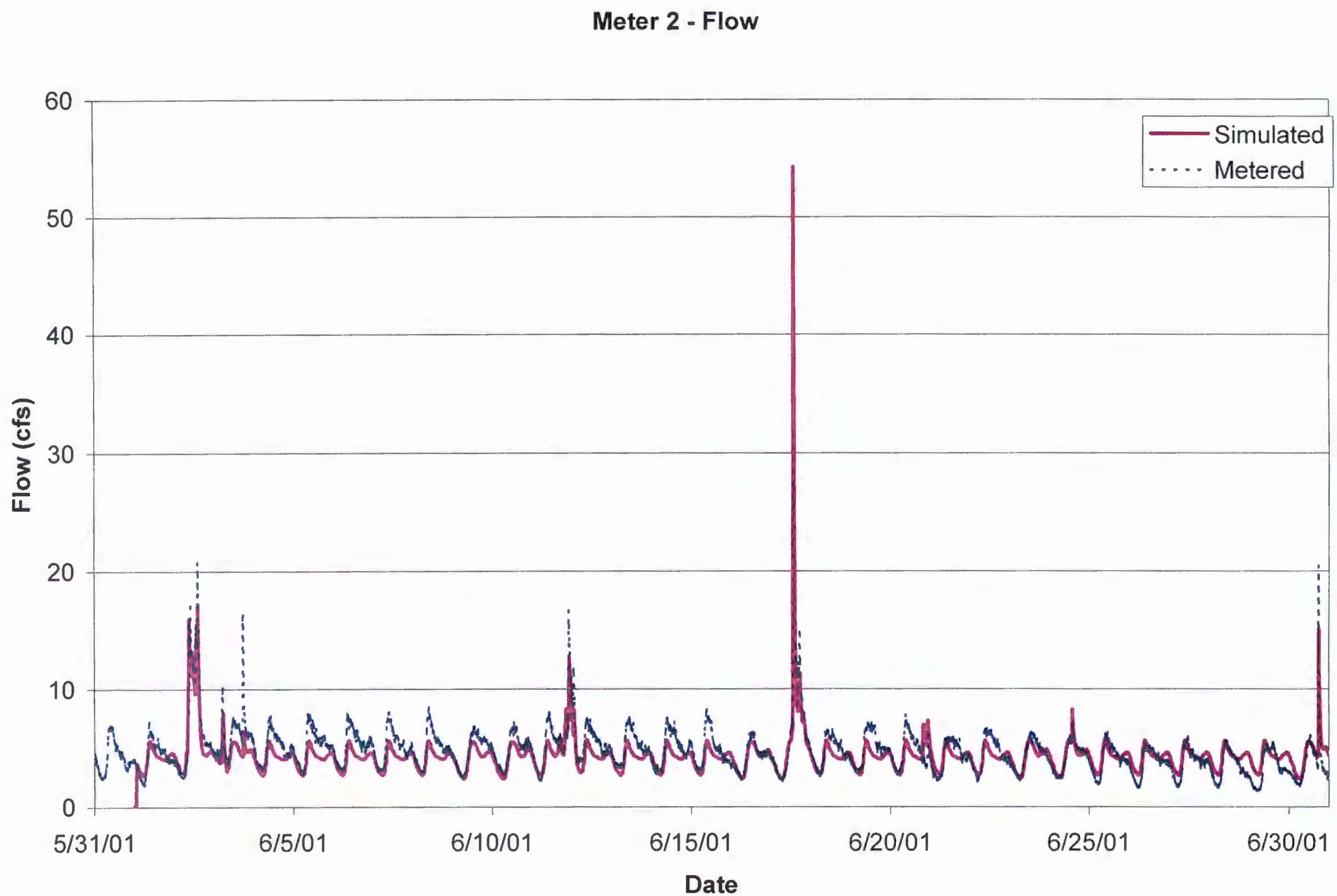


EXHIBIT G
AR J.1

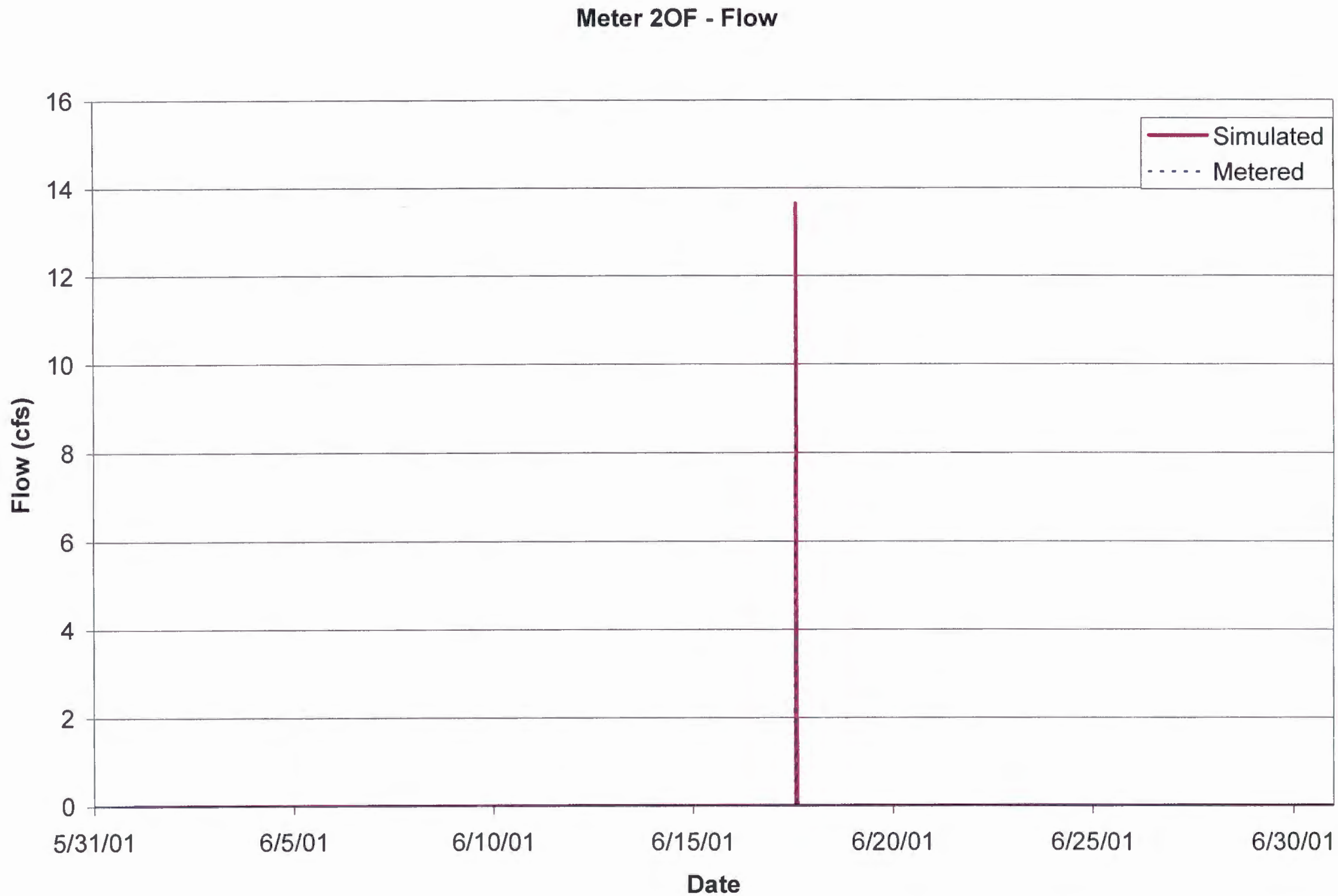


EXHIBIT G
AR J.1

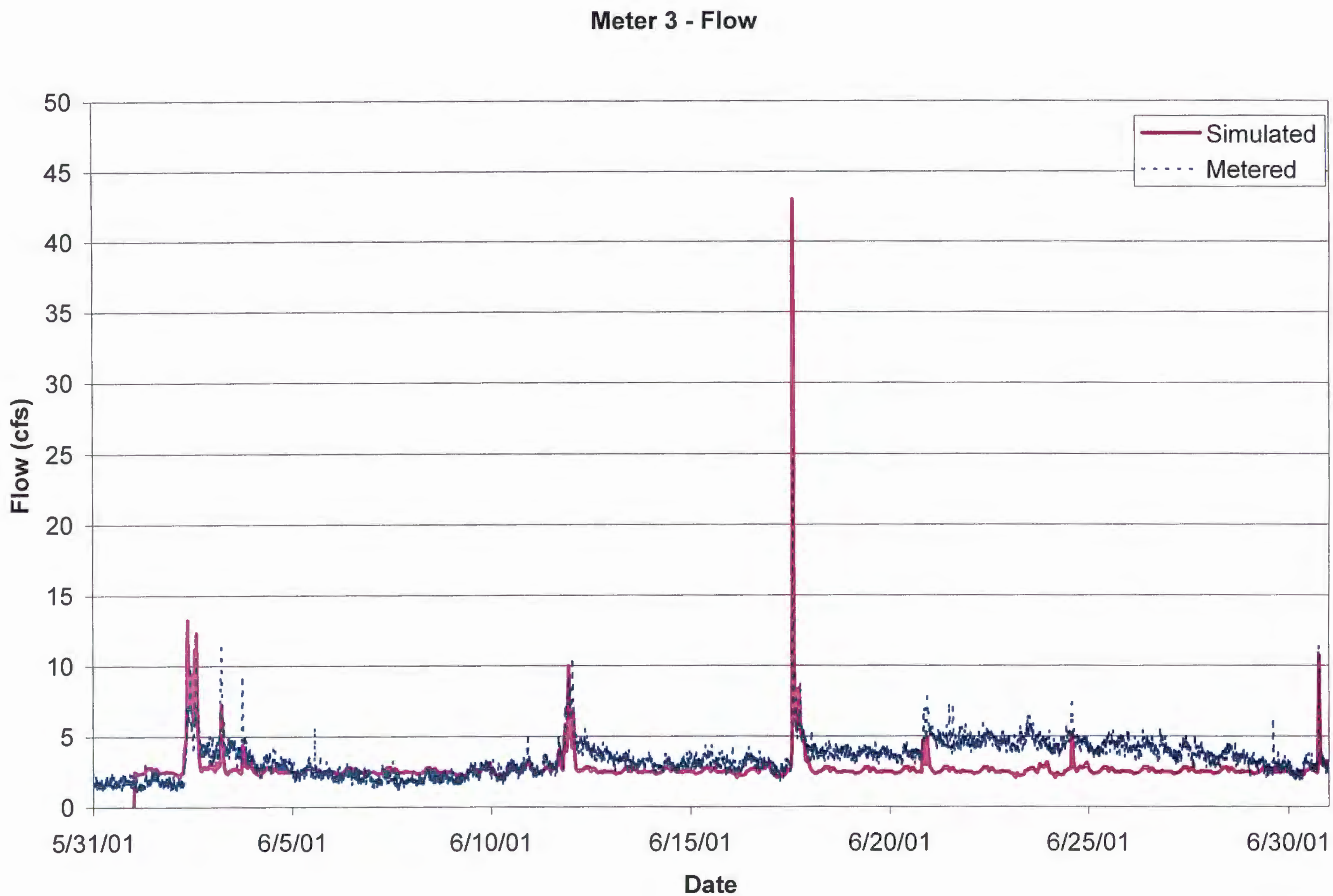
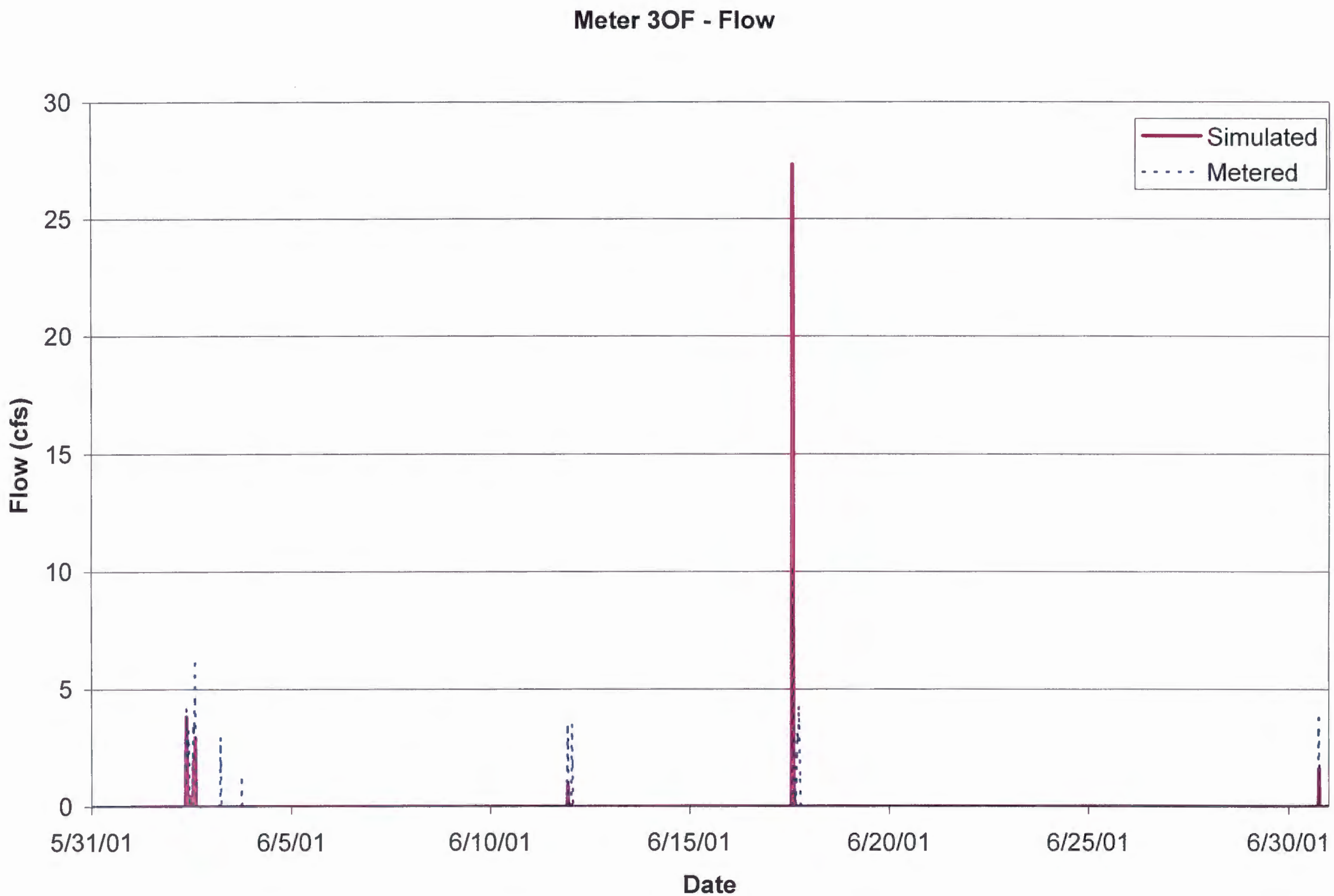
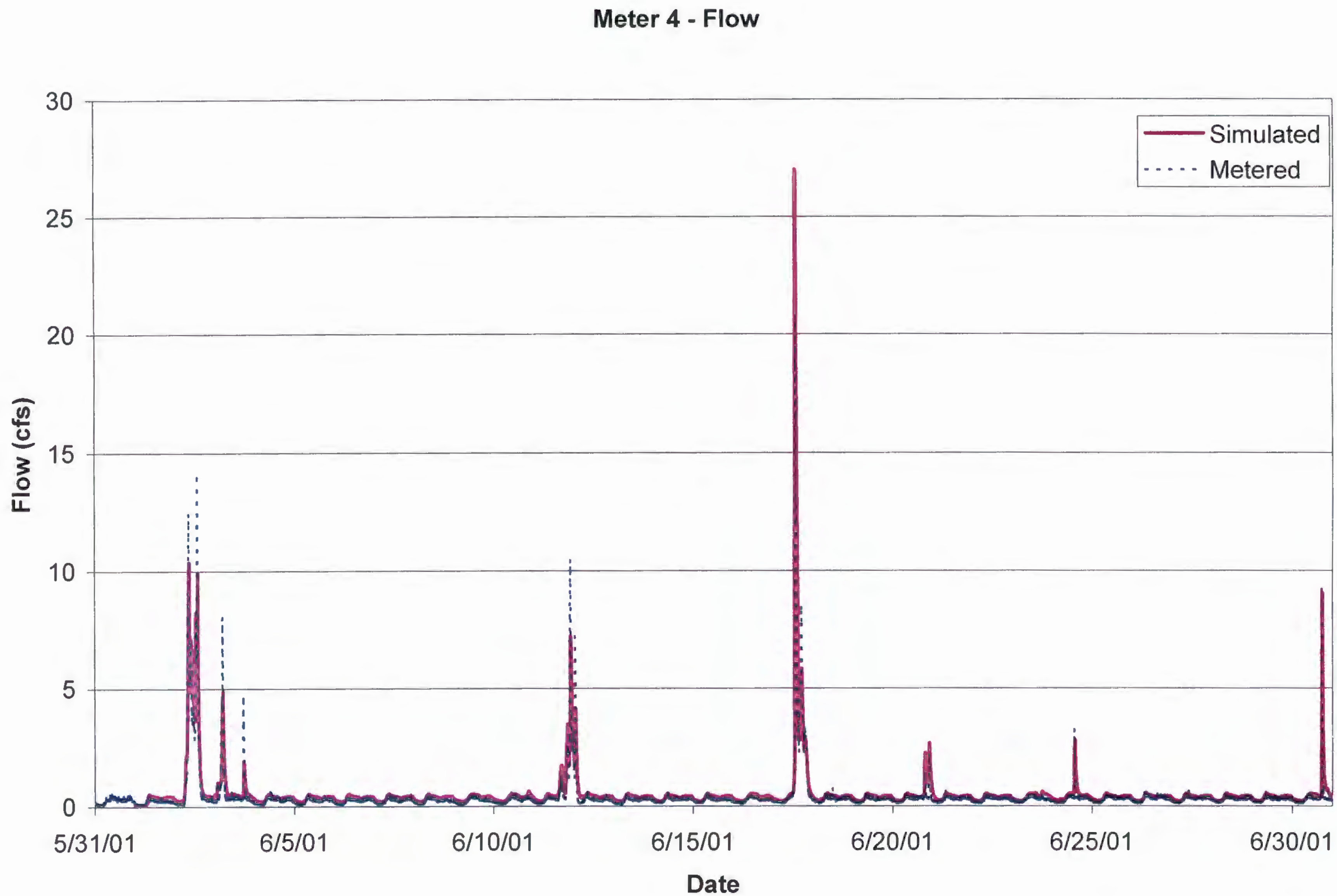


EXHIBIT G
AR J.1

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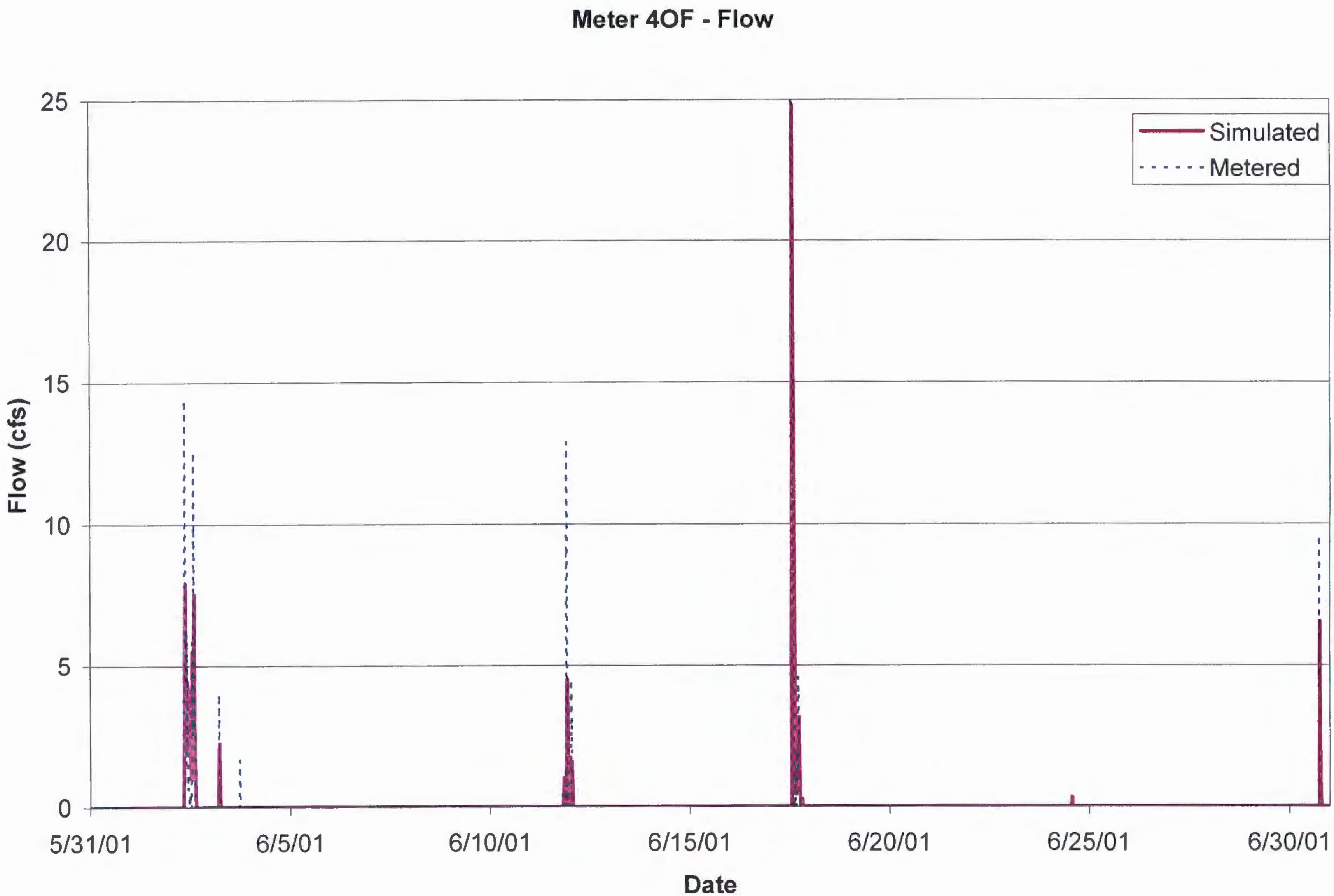
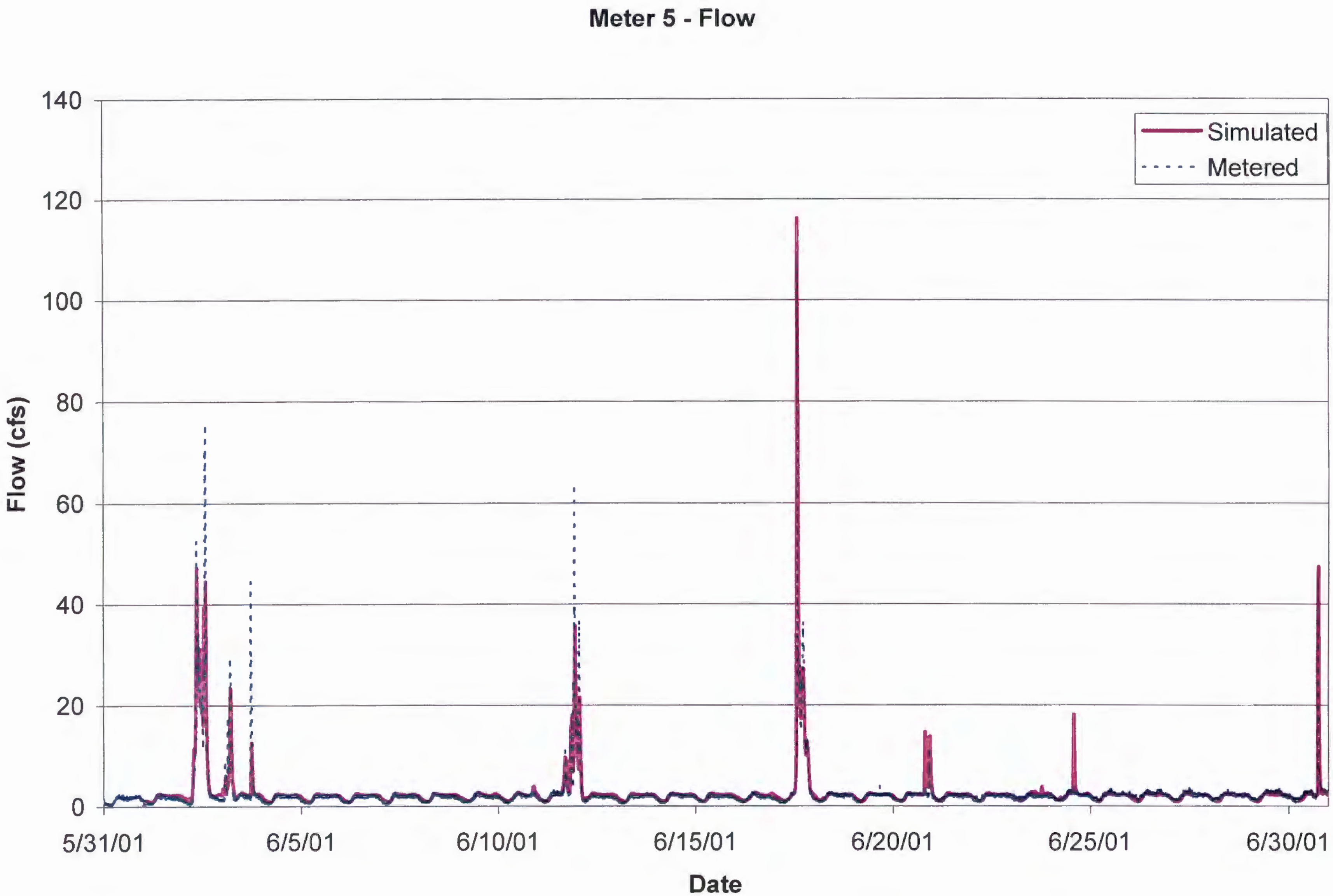
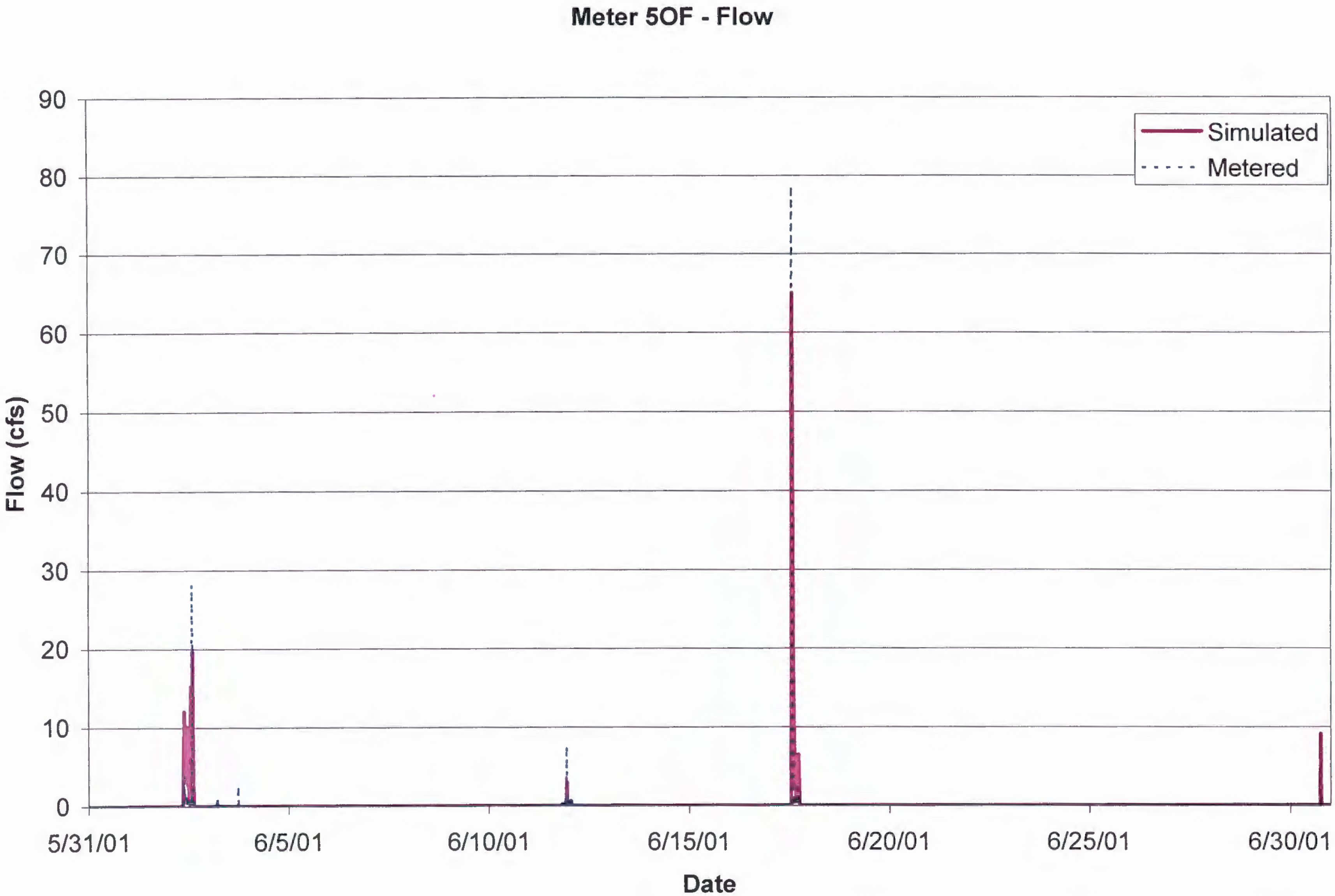
Simulated
Metered
Flow (cfs)
30
25
20
15
10
5
0
5/31/01
6/5/01
6/10/01
6/15/01
6/20/01
6/25/01
6/30/01
Date

EXHIBIT G
AR J.1




Meter 5 - Flow
140
120
100
80
60
40
20
0
Flow (cfs)
Simulated
Metered
5/31/01
6/5/01
6/10/01
6/15/01
6/20/01
6/25/01
6/30/01
Date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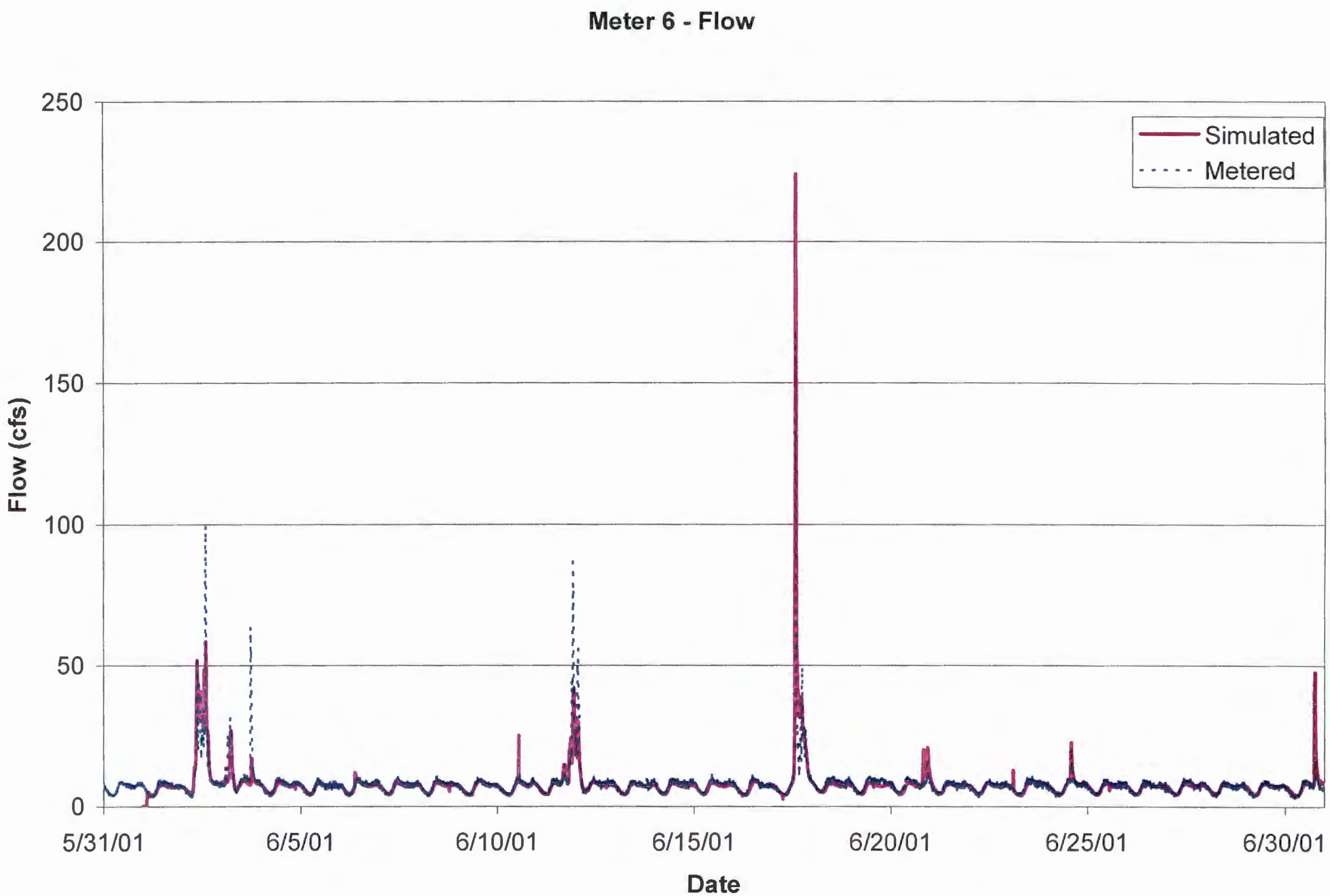
Simulated
Metered
Flow (cfs)
90
80
70
60
50
40
30
20
10
0
5/31/01
6/5/01
6/10/01
6/15/01
6/20/01
6/25/01
6/30/01
Date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200
150
100
50
0
Flow (cfs)
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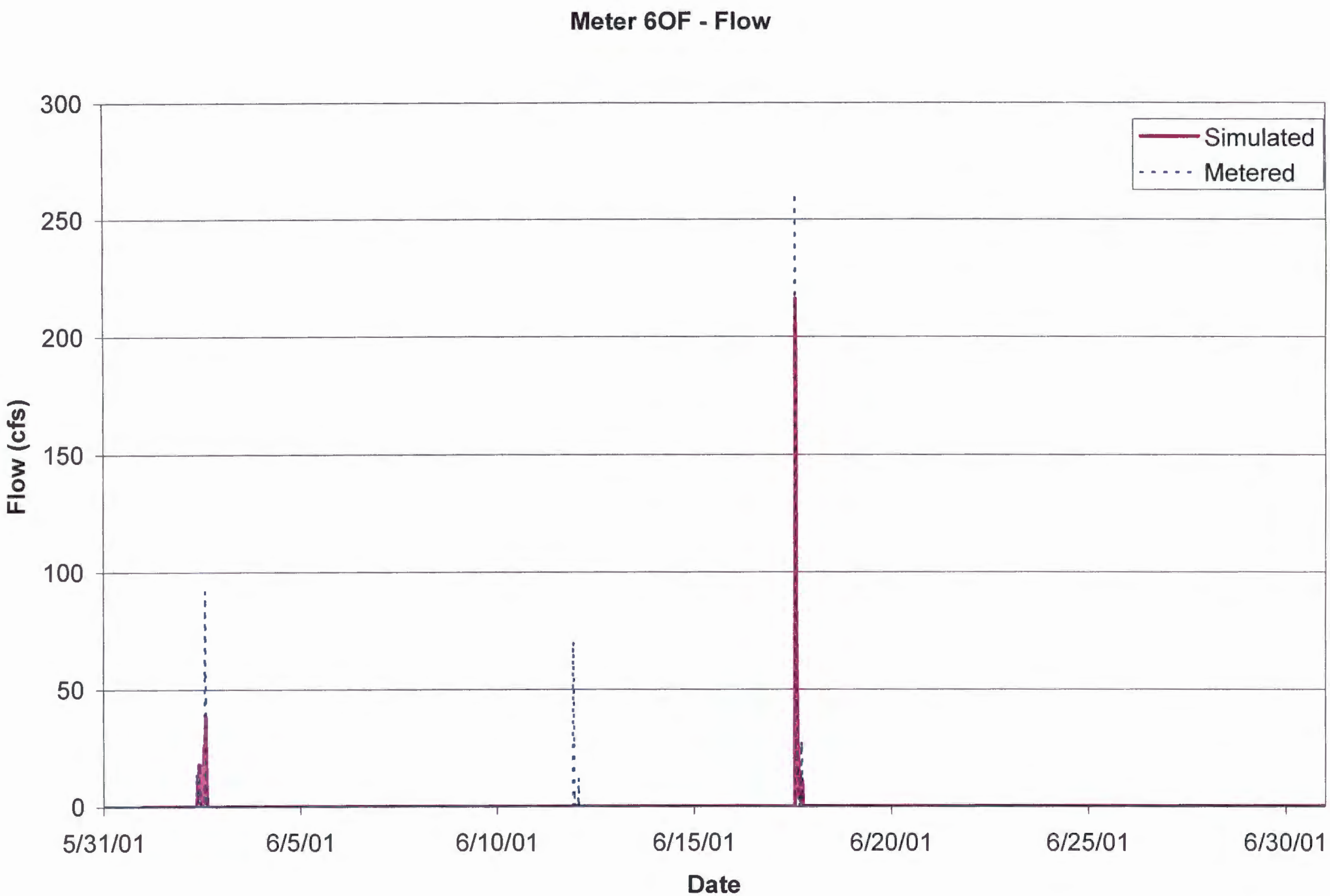
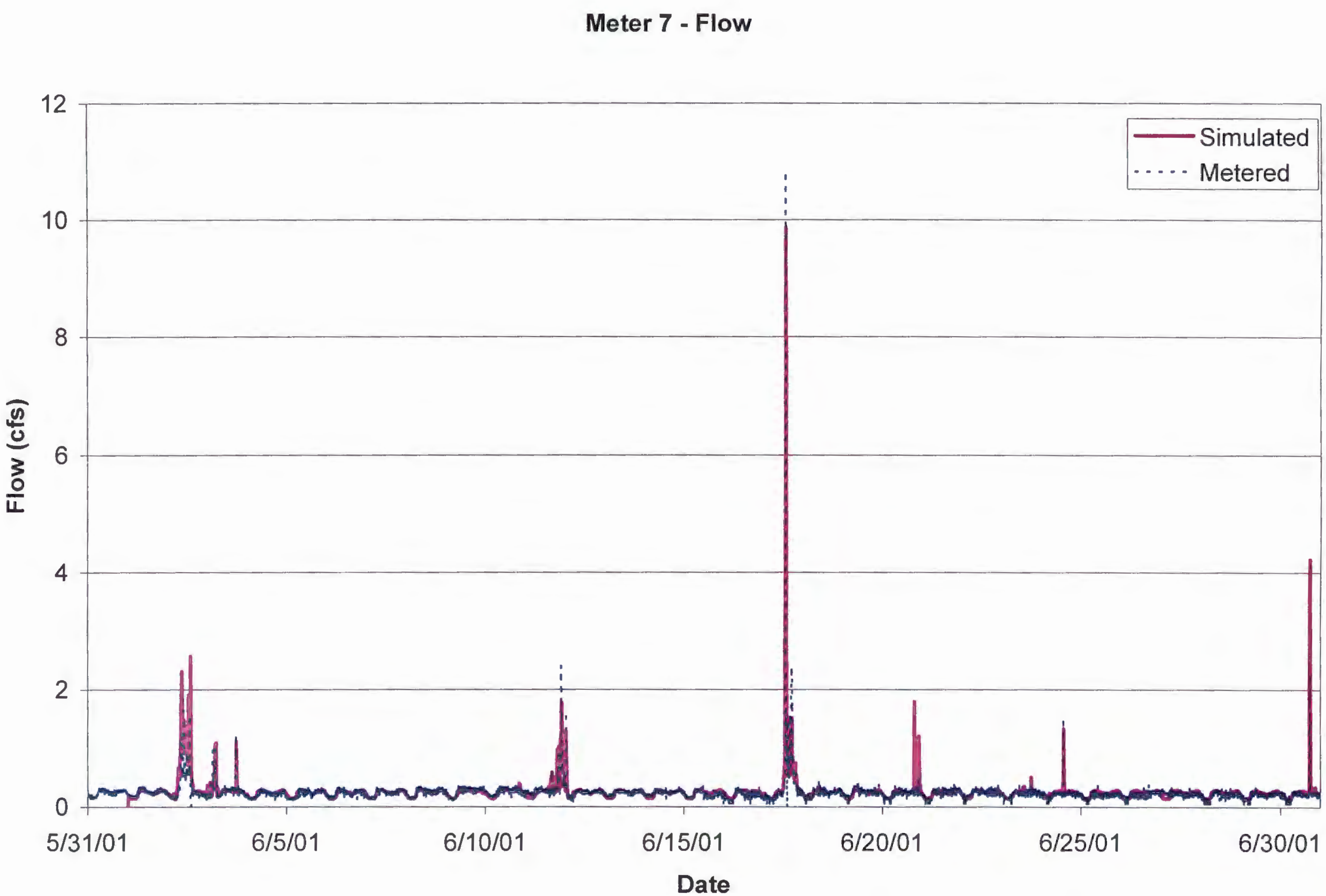
6/5/01
6/10/01
6/15/01
6/20/01
6/25/01
6/30/01
Date
Simulated
Metered

EXHIBIT G
AR J.1

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12
10
8
6
4
2
0
Flow (cfs)
Simulated
Metered
5/31/01
6/5/01
6/10/01
6/15/01
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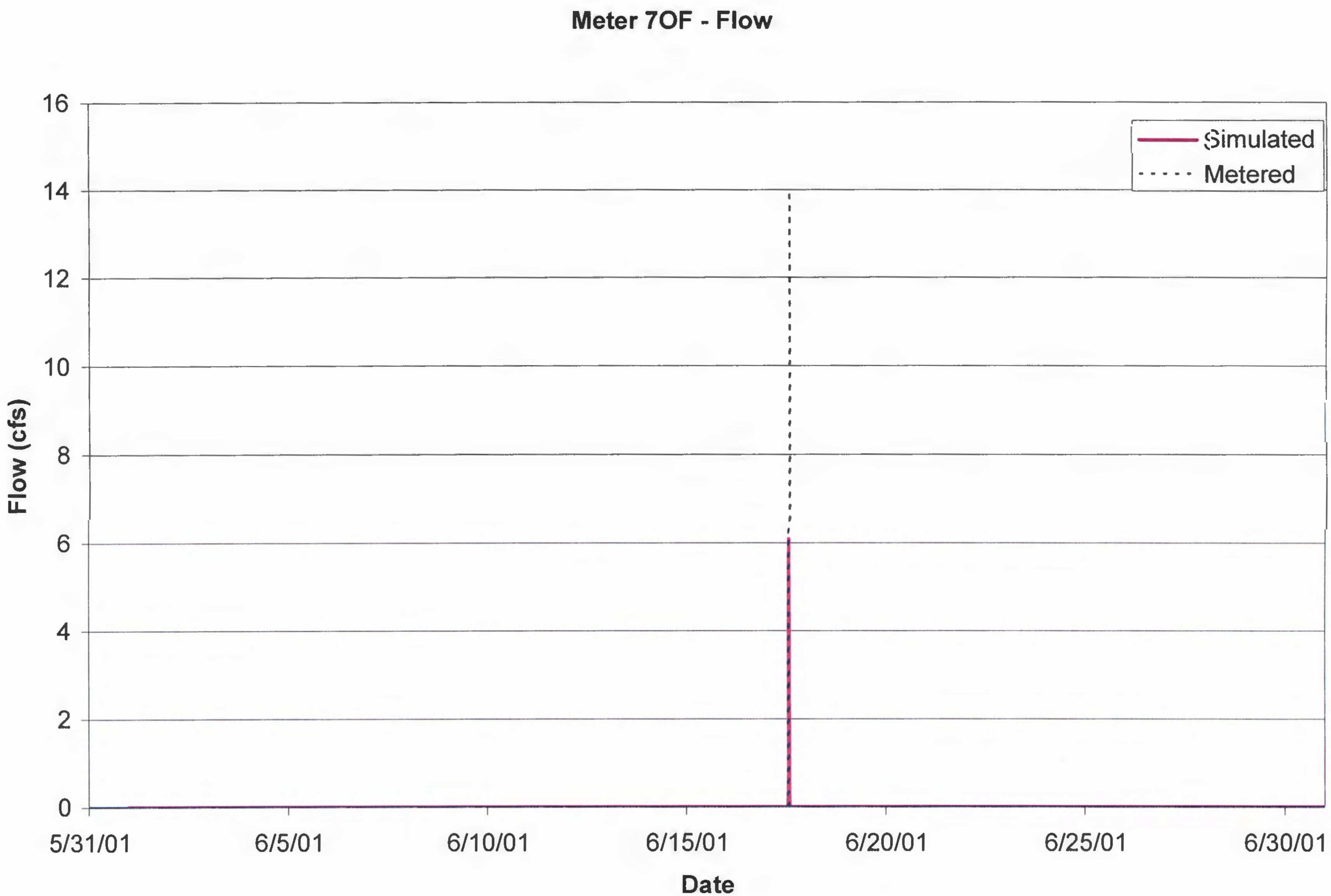
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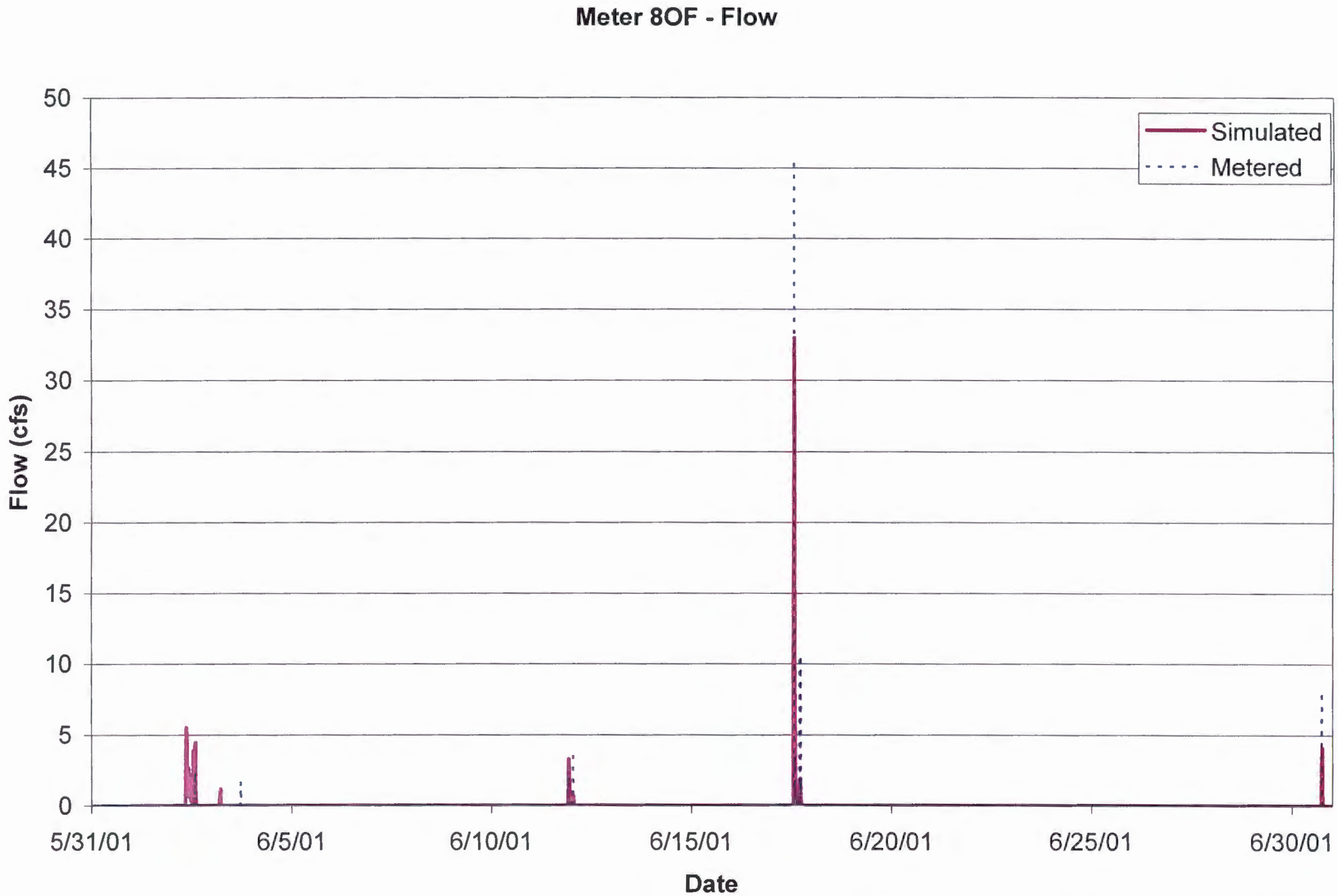
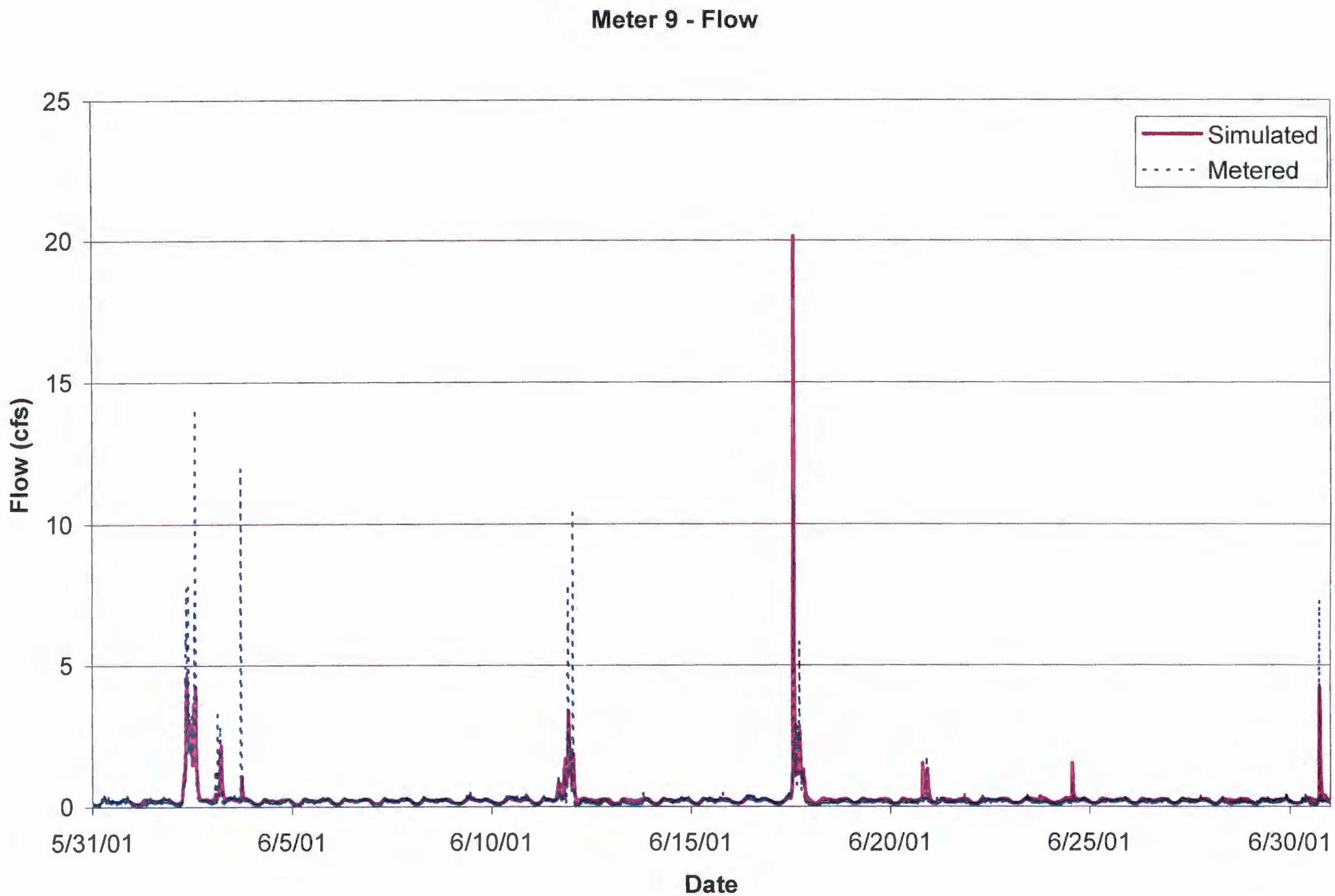
Date

EXHIBIT G
AR J.1

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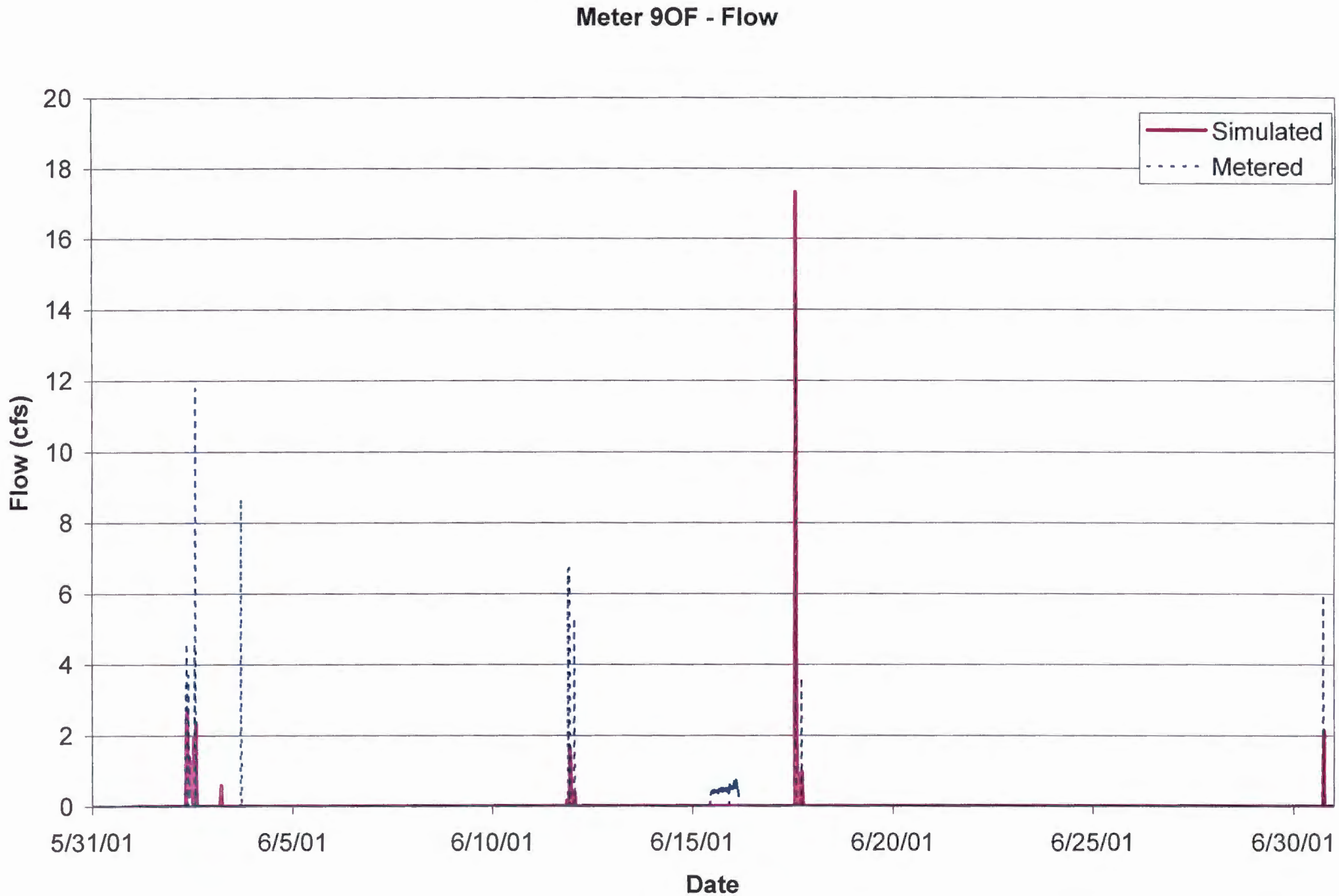
Date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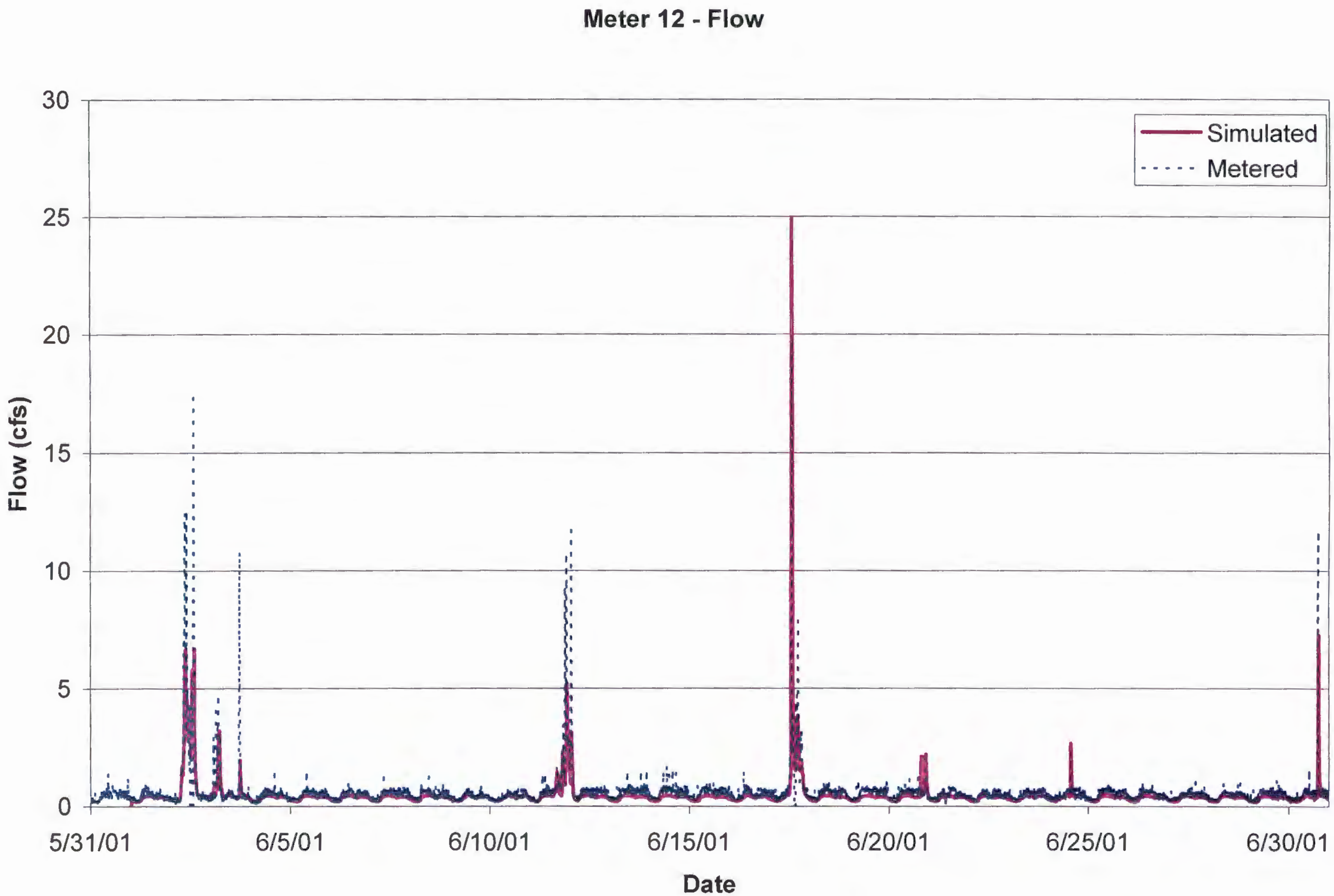
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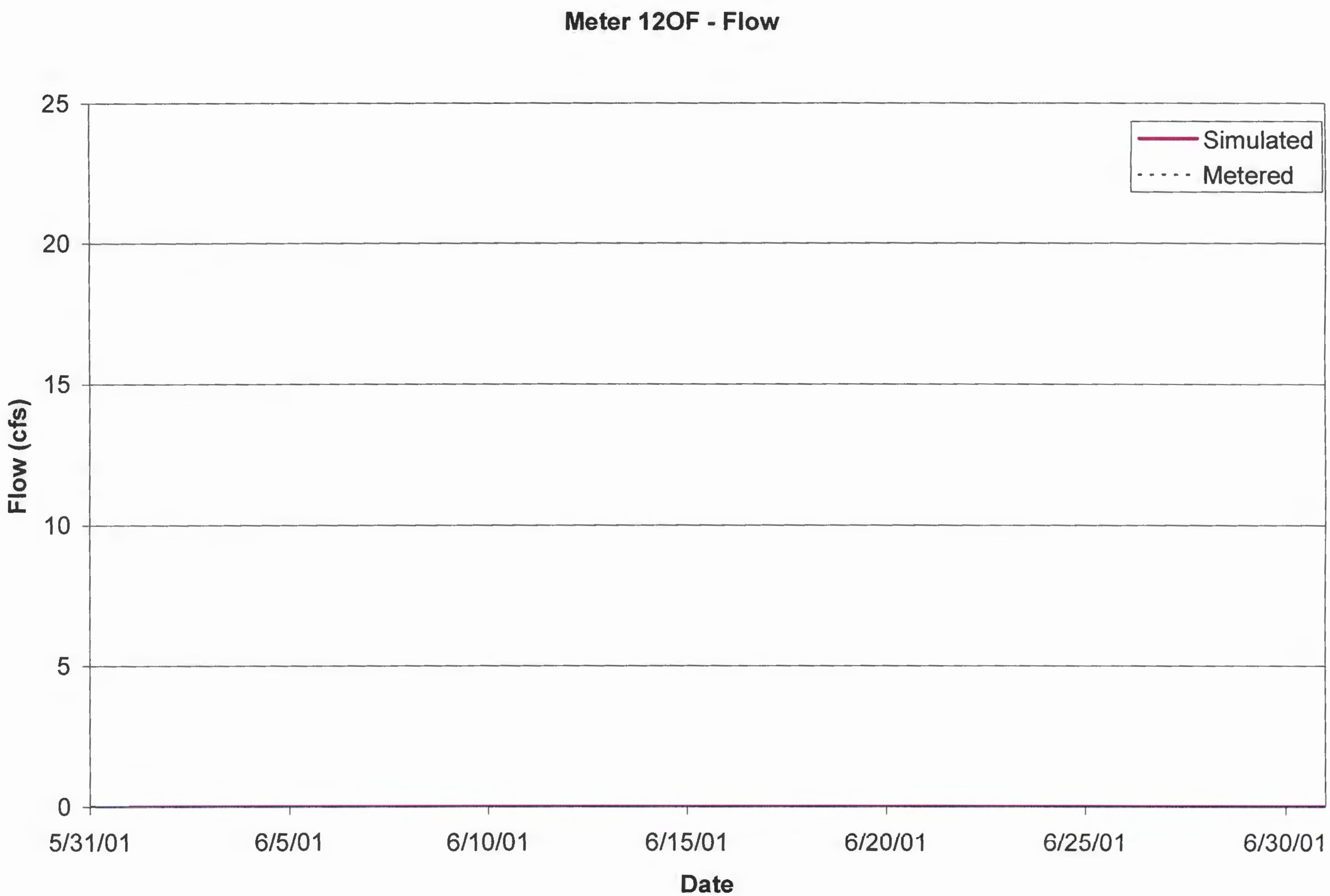
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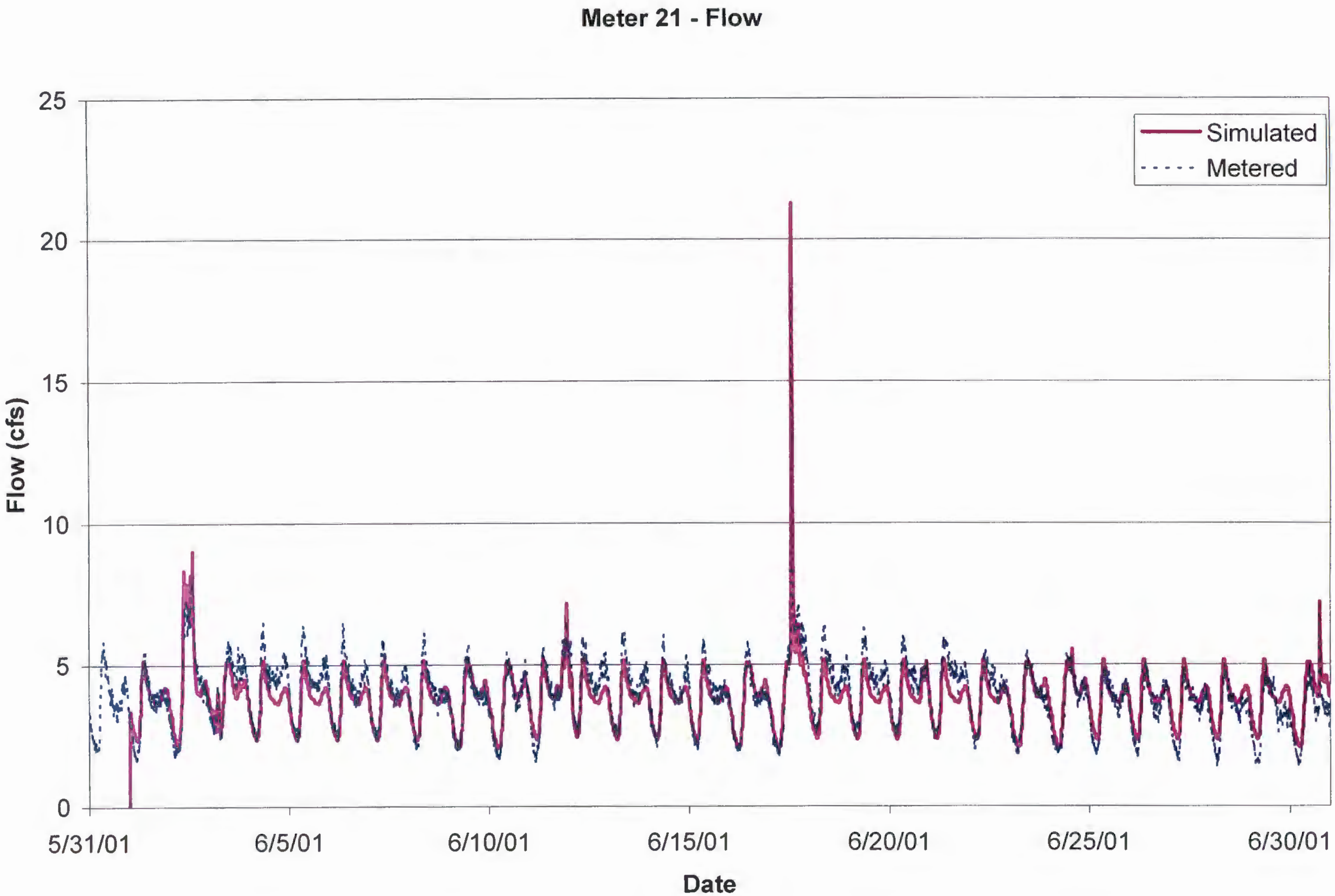
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Date

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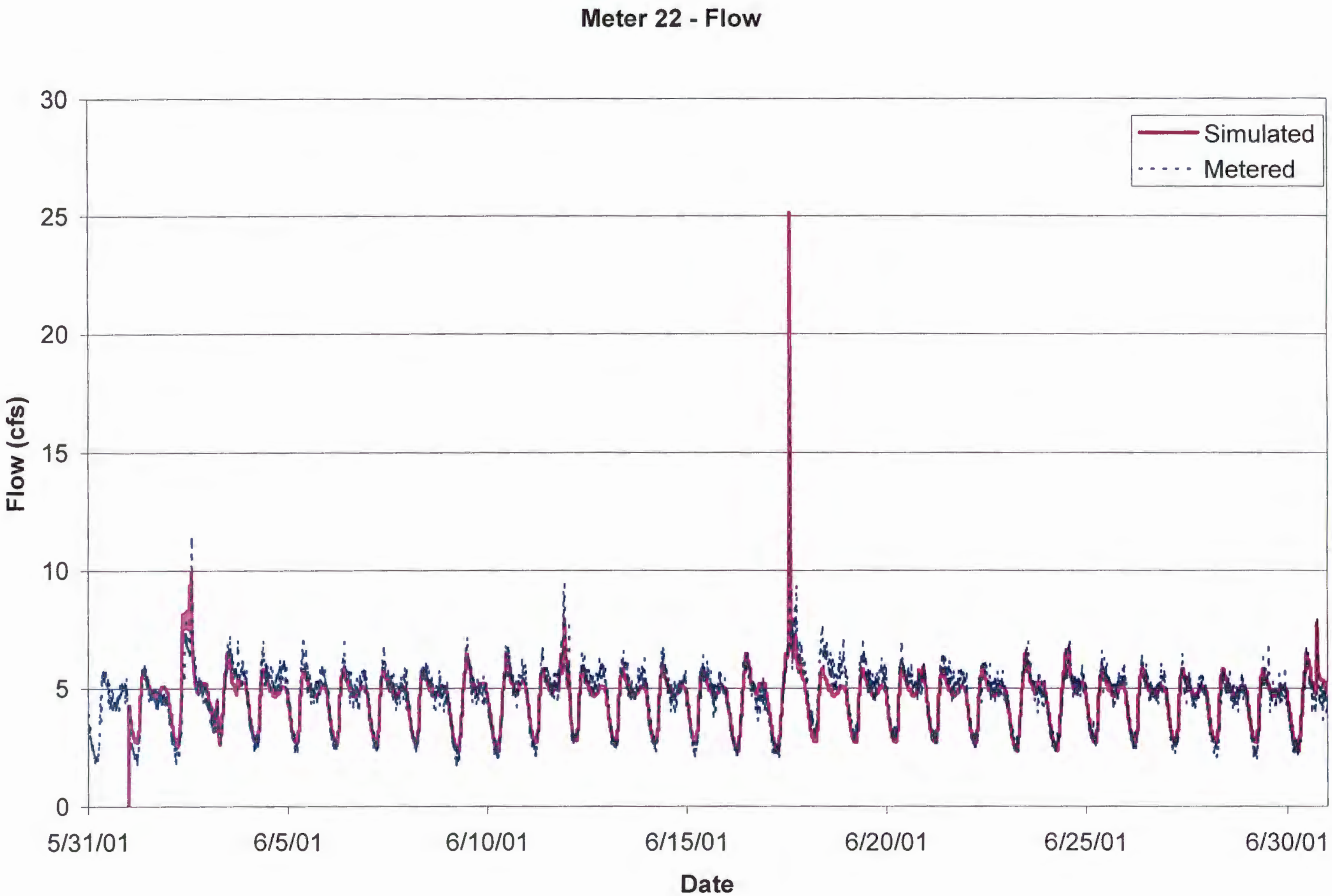
AR J.1



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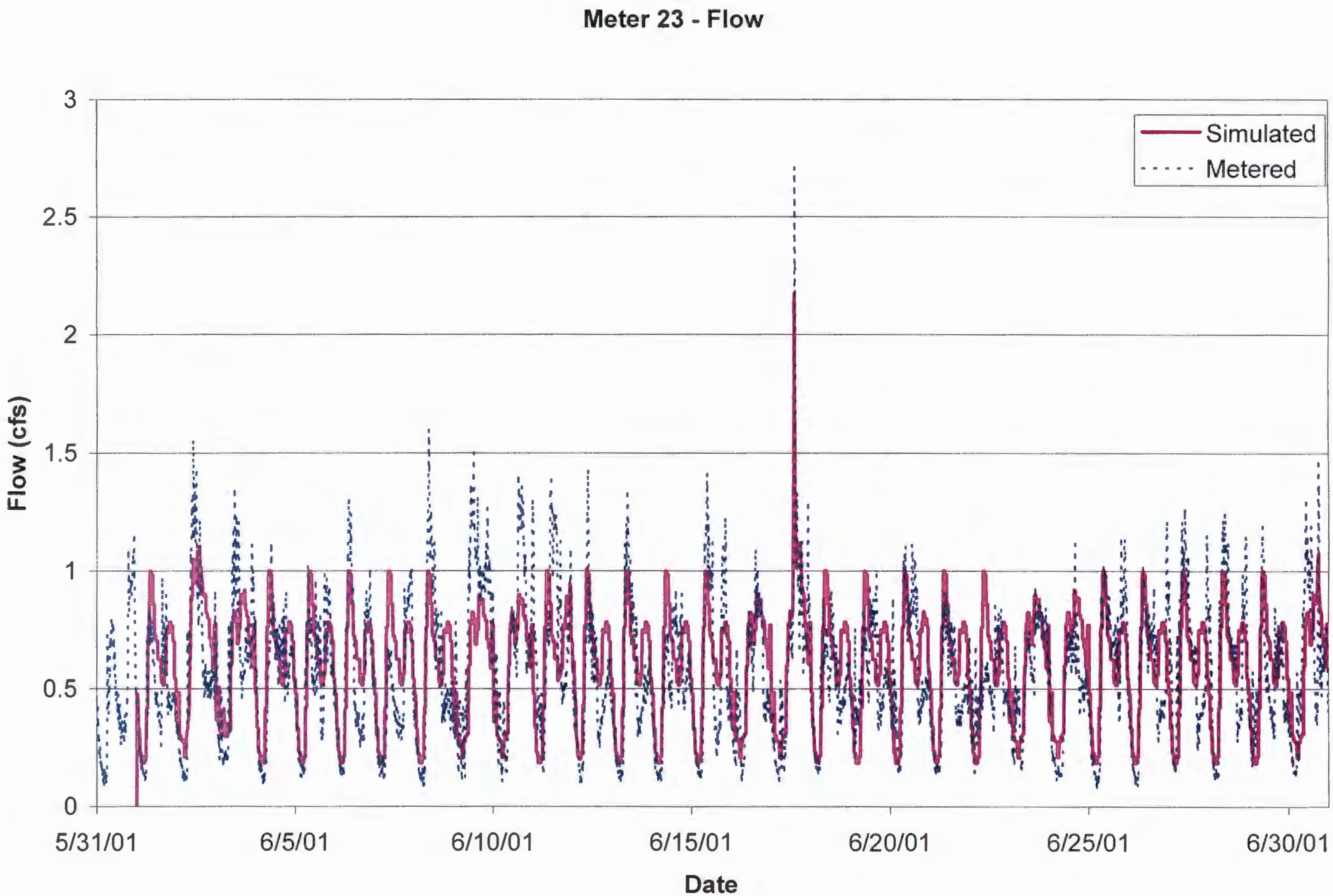

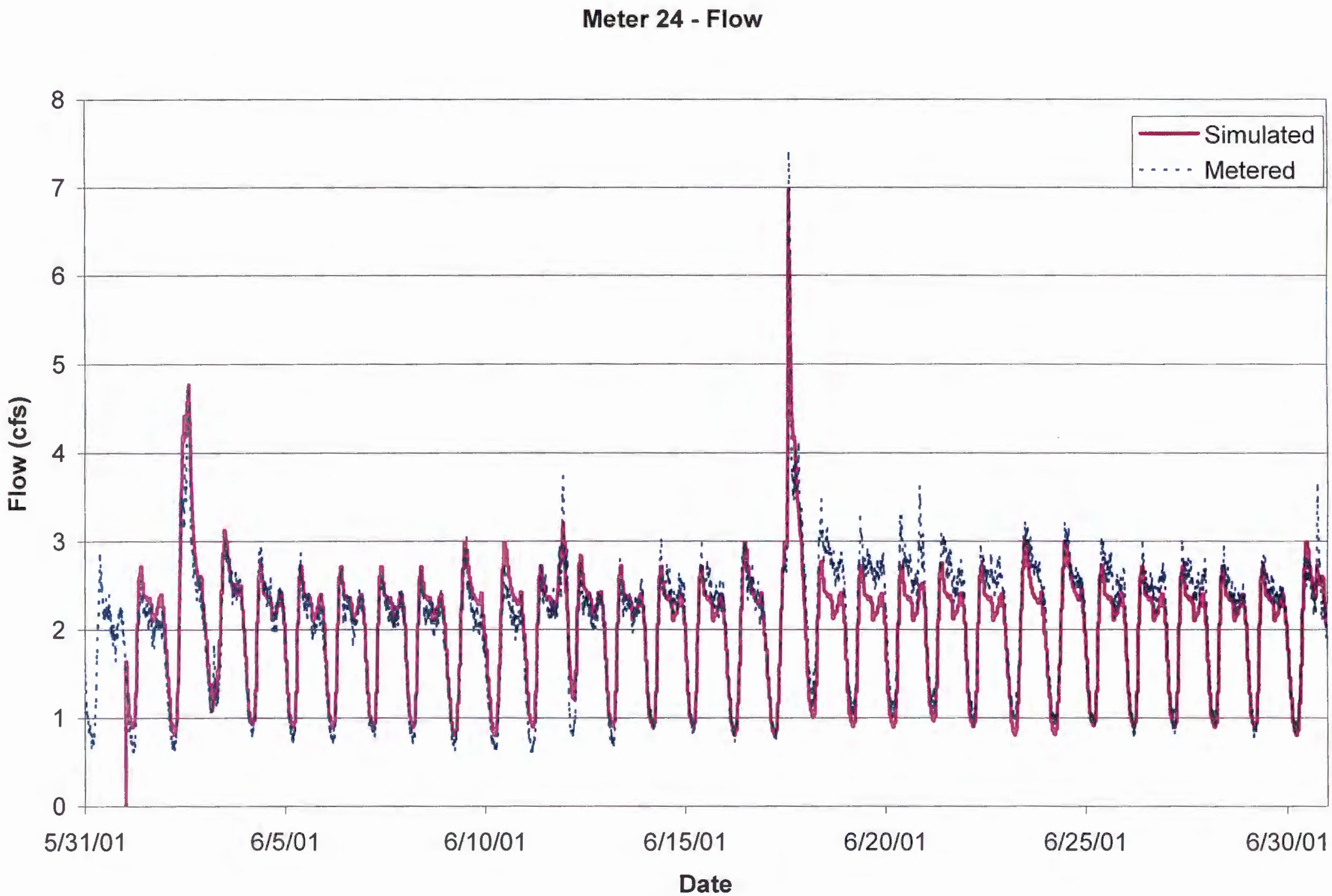
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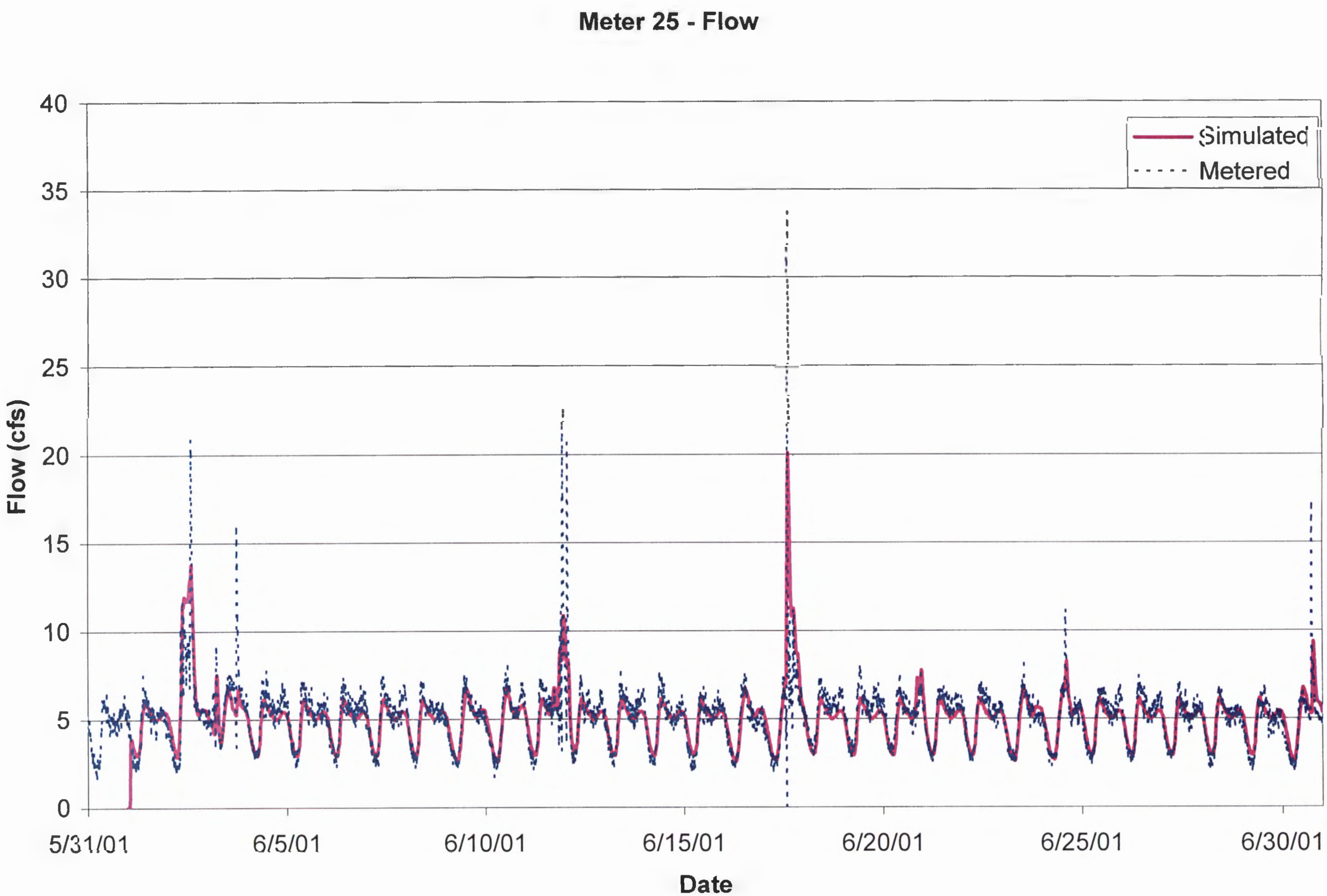
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Date

EXHIBIT G
AR J.1

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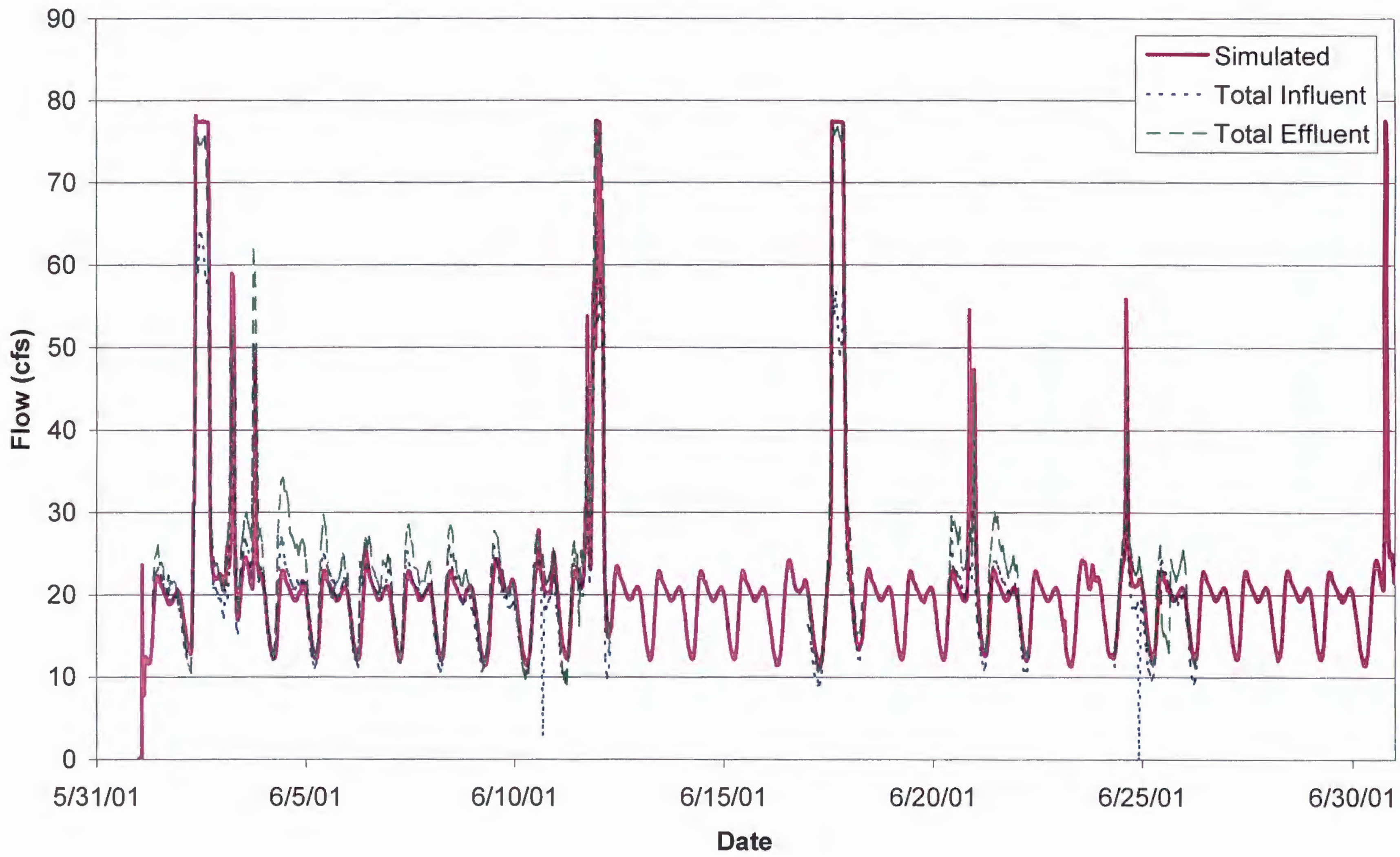

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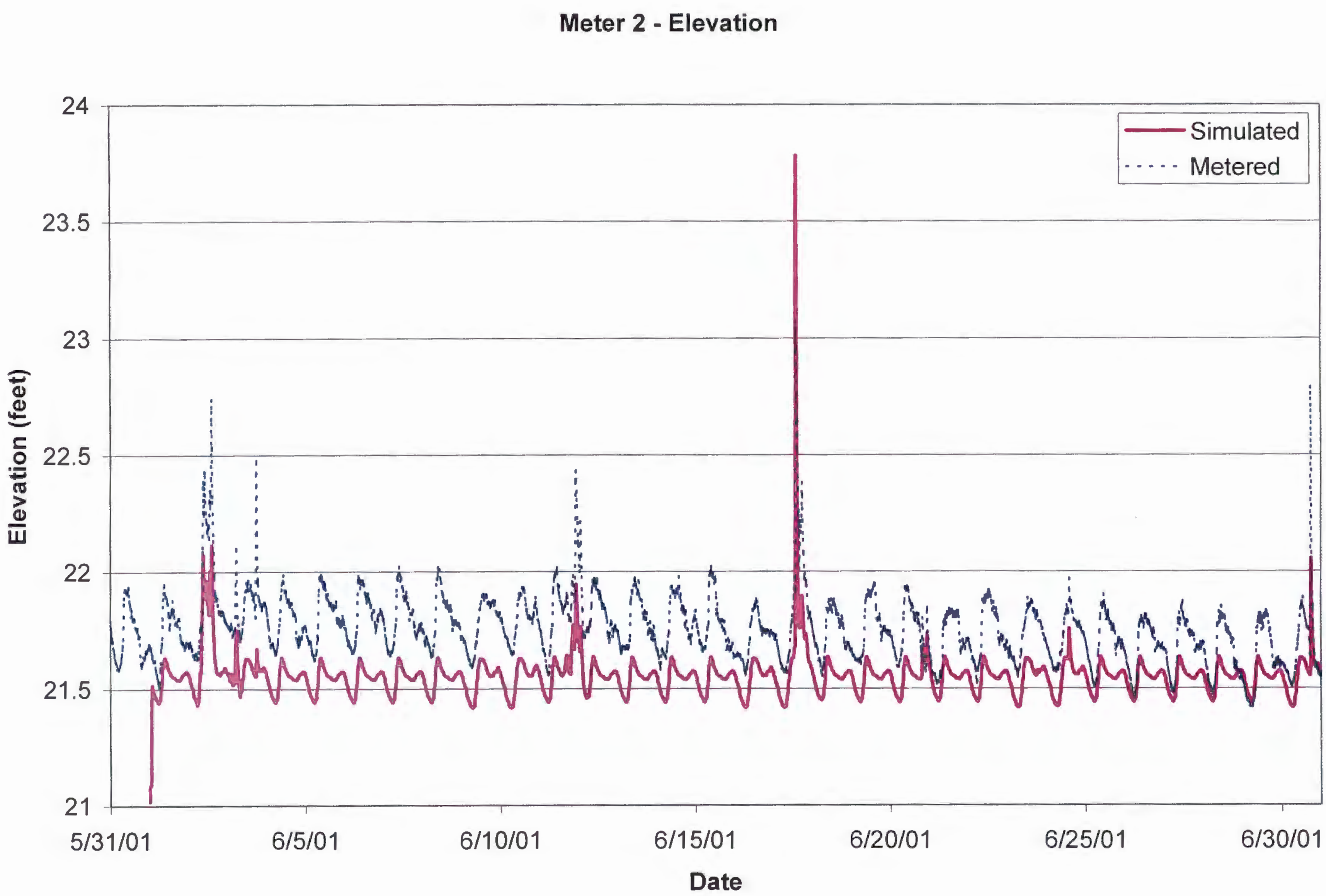

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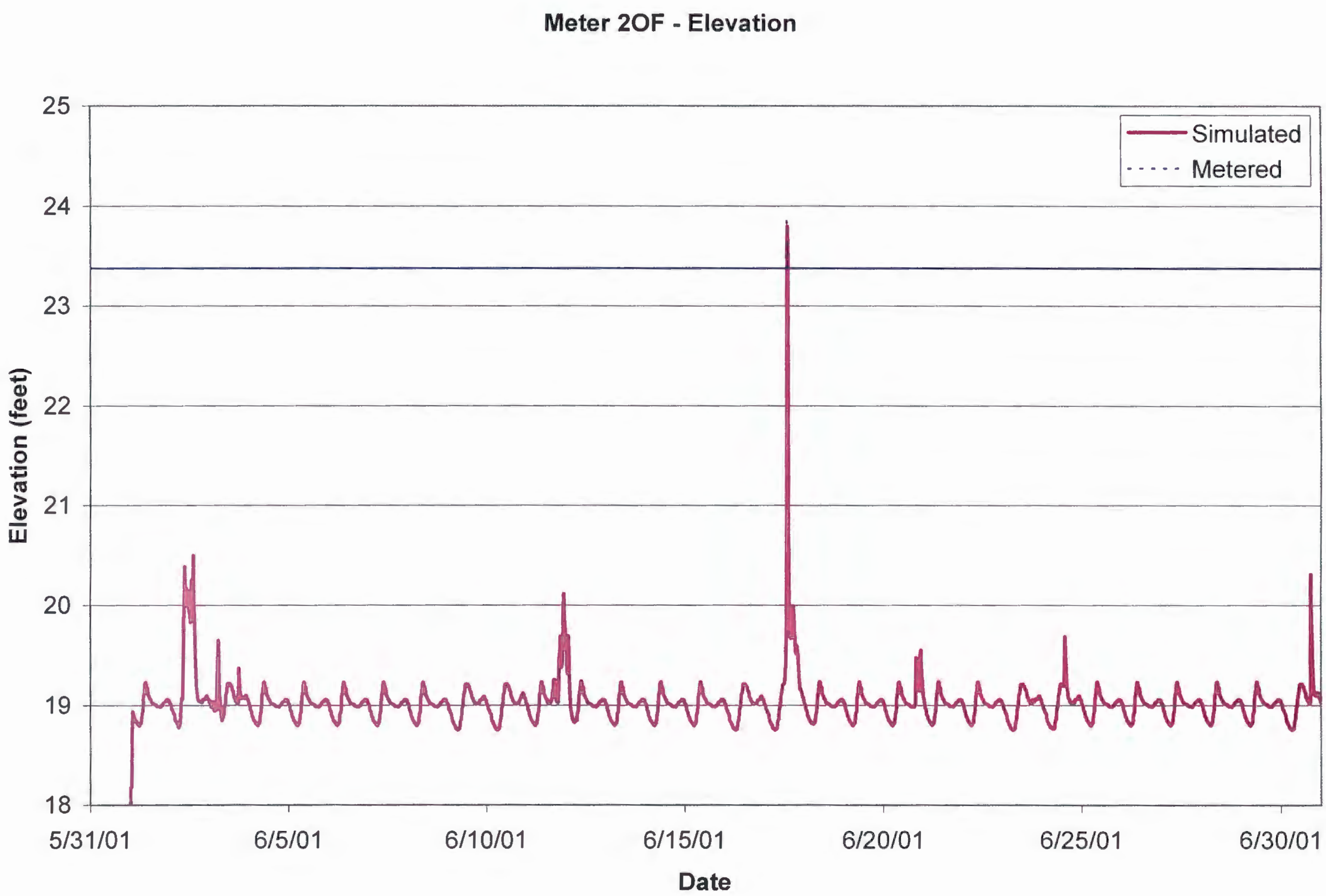

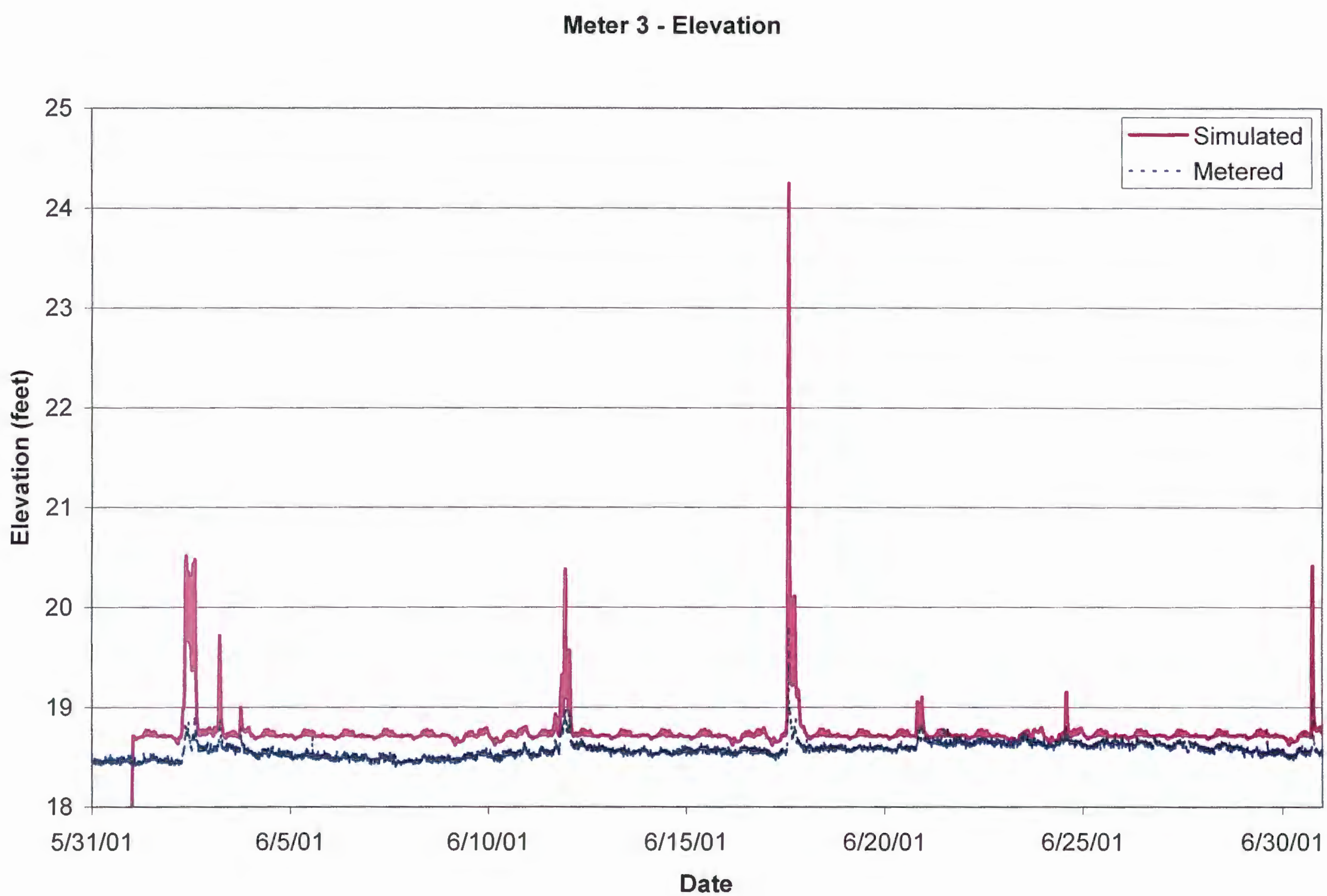
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Date

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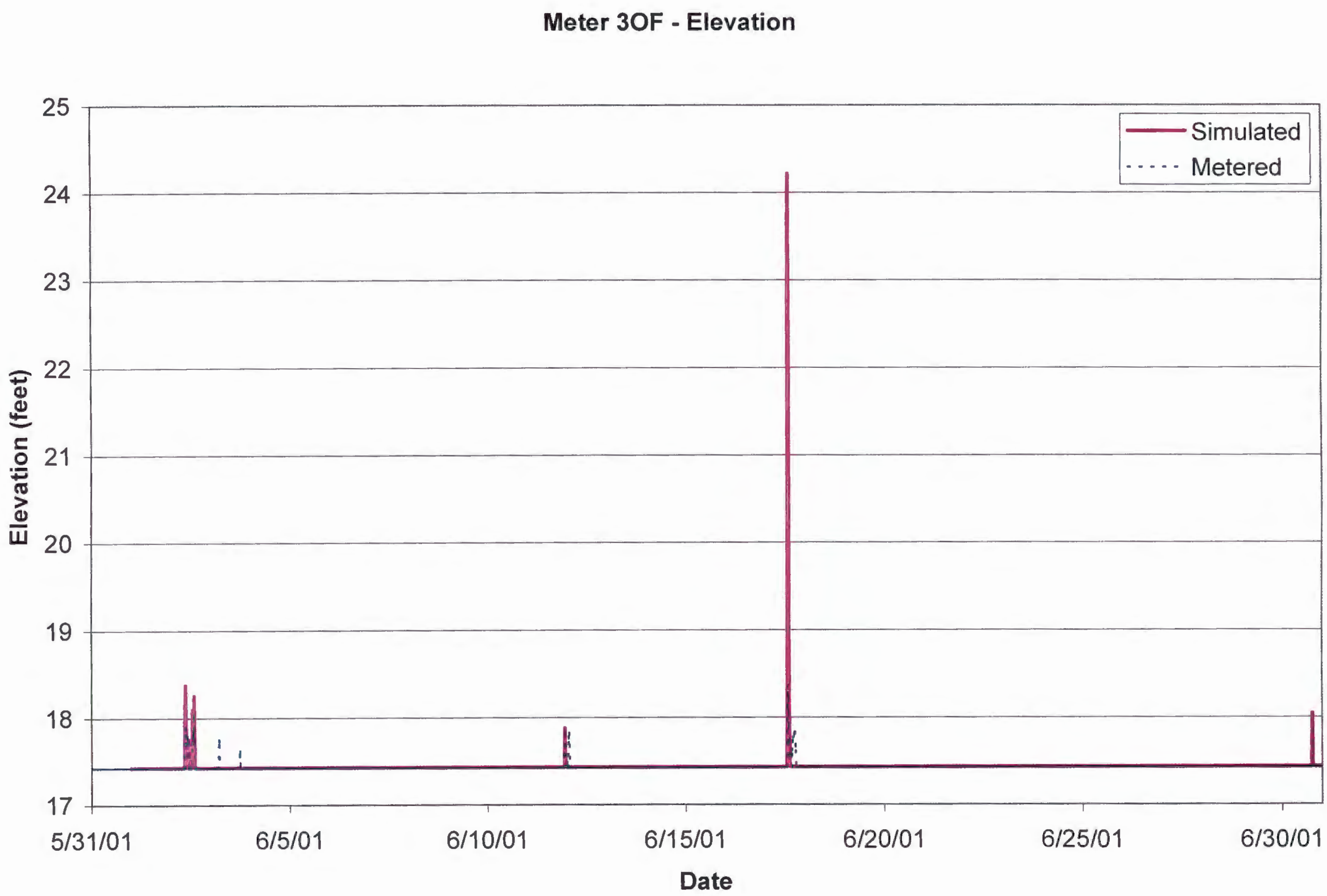

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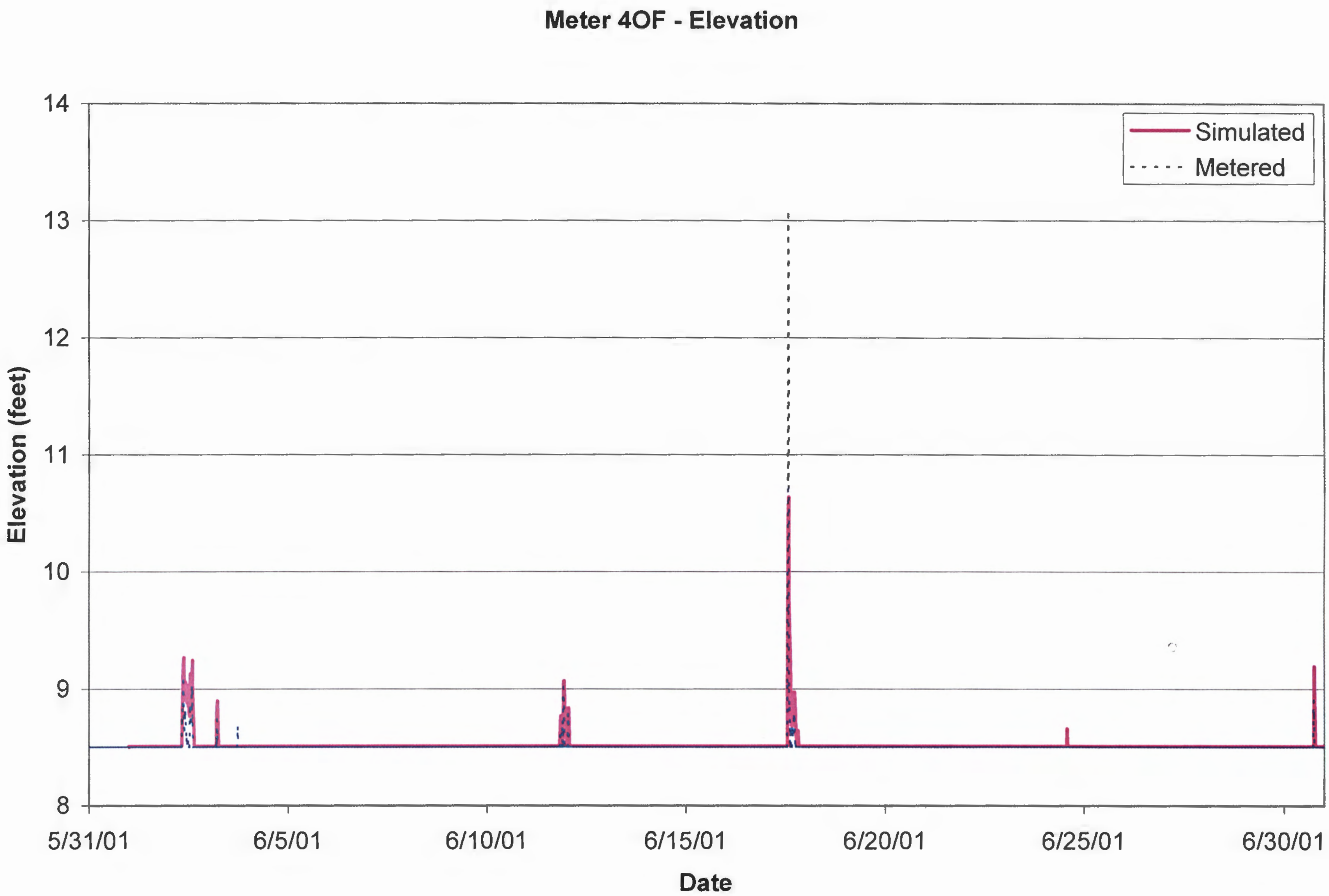

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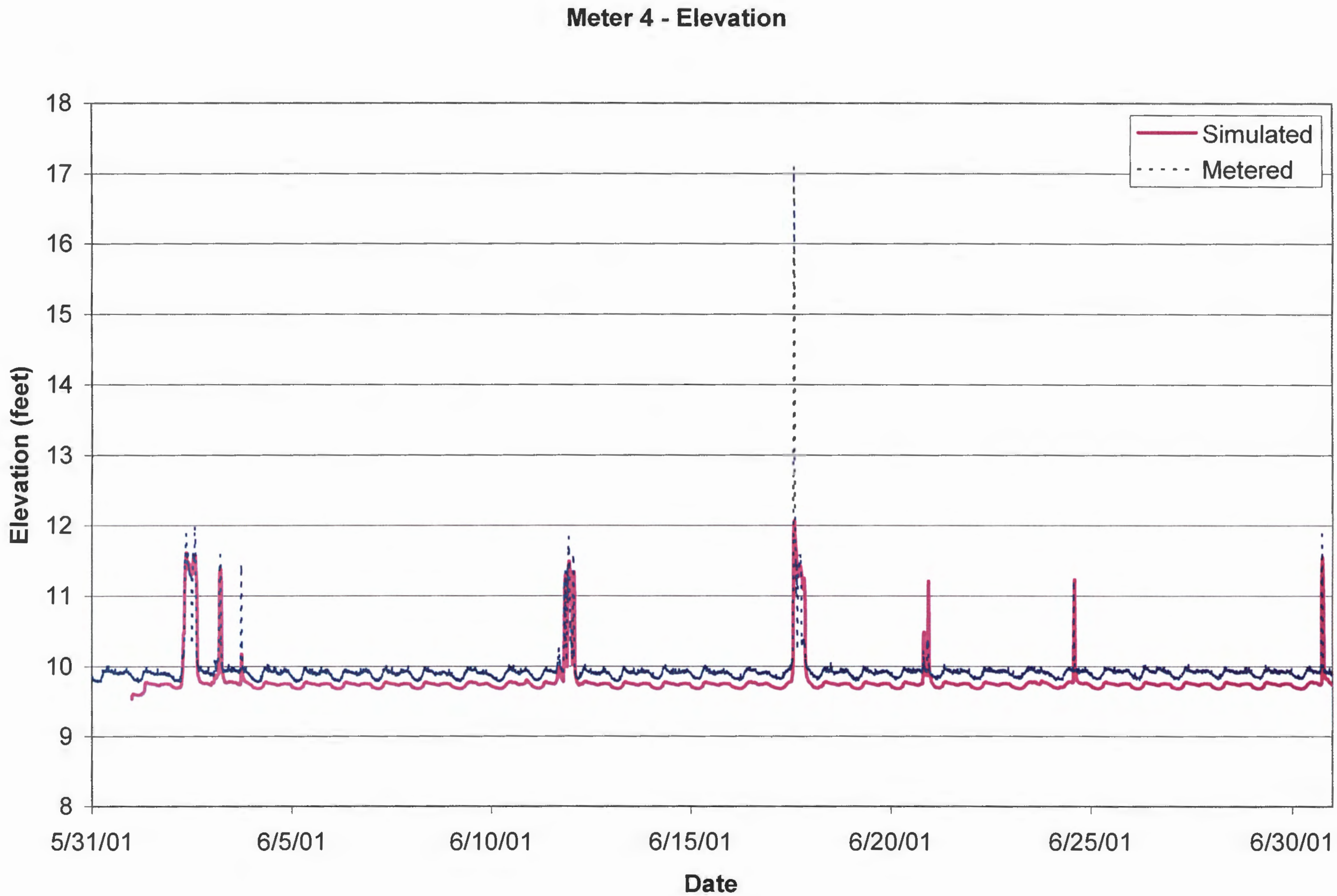

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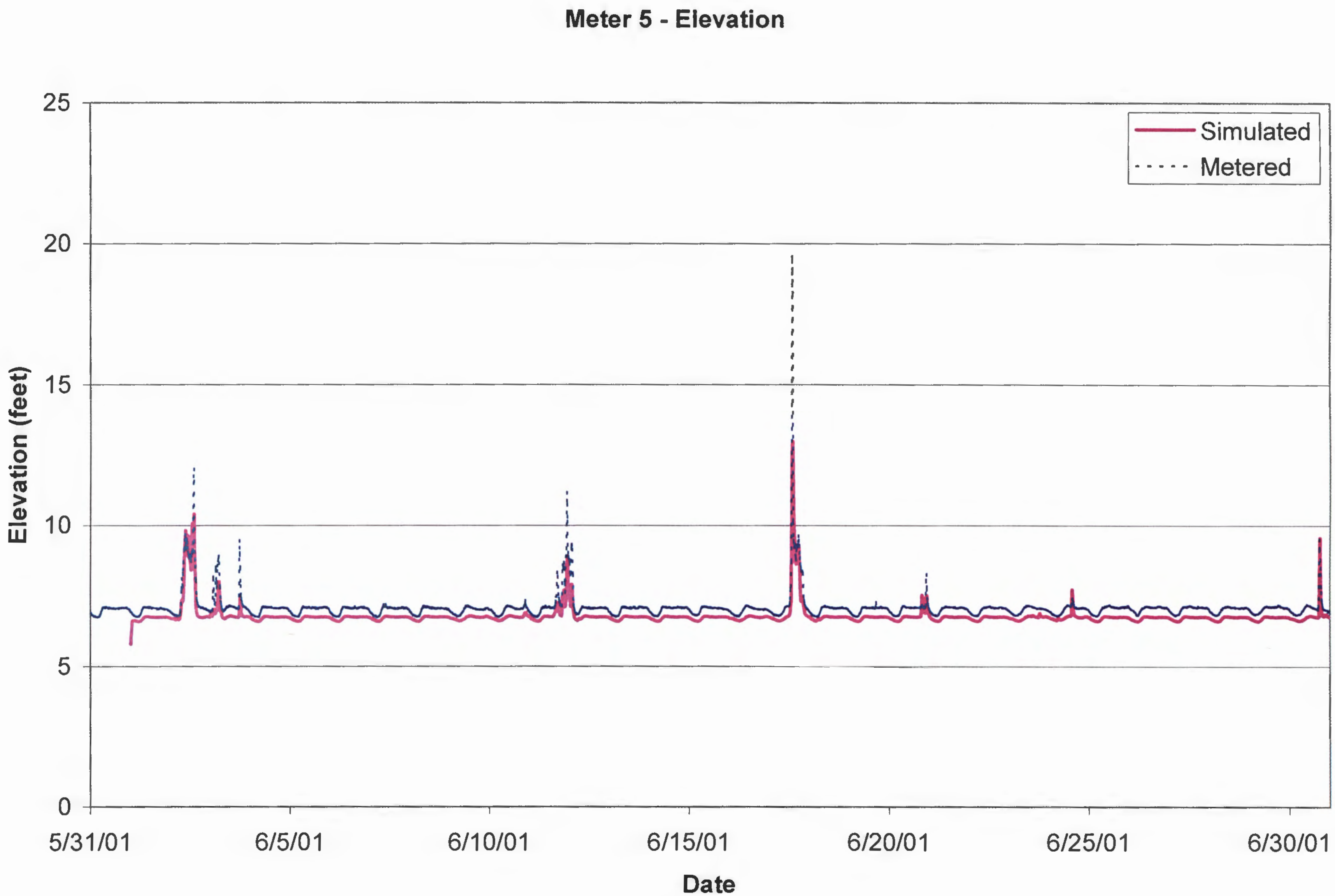

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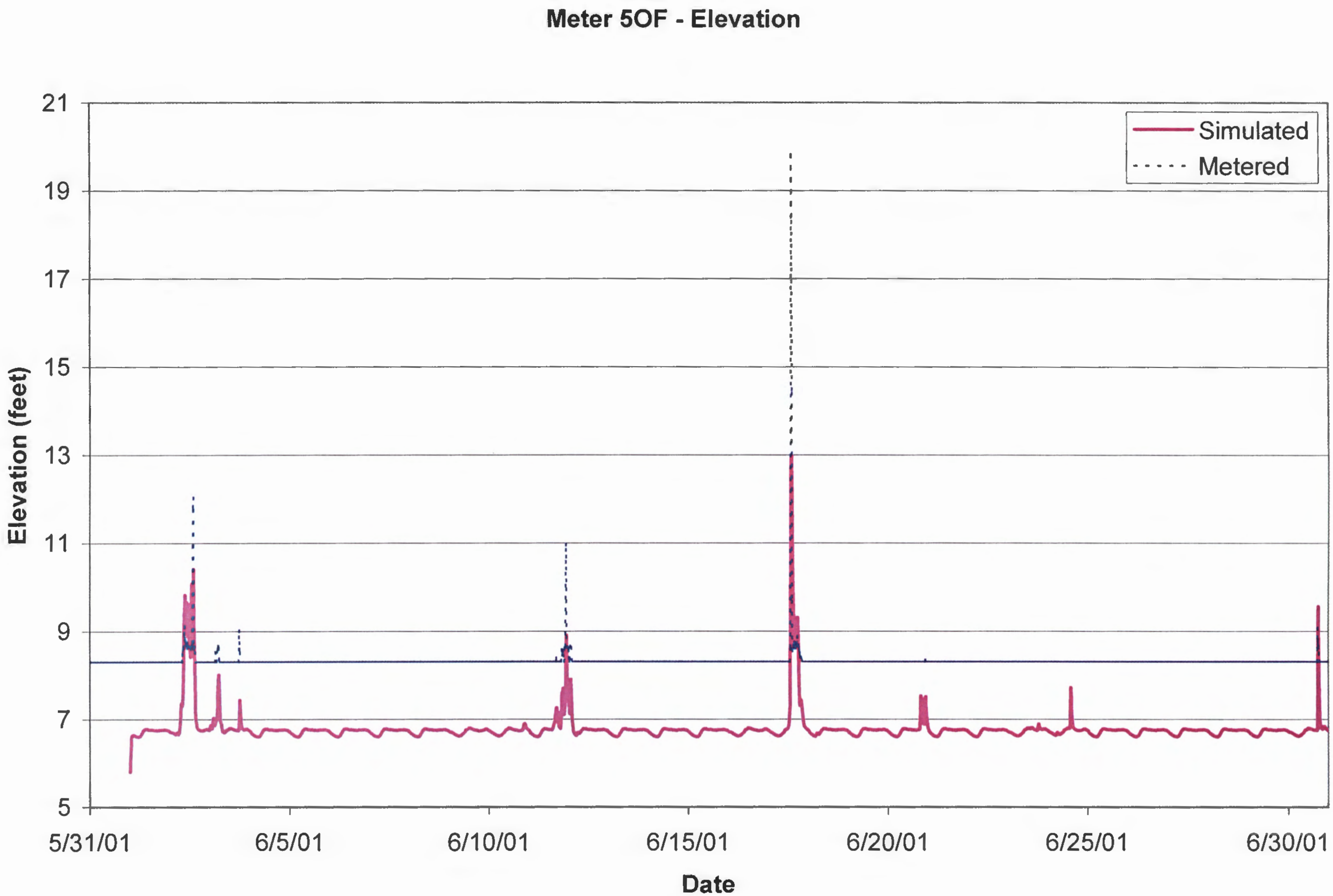

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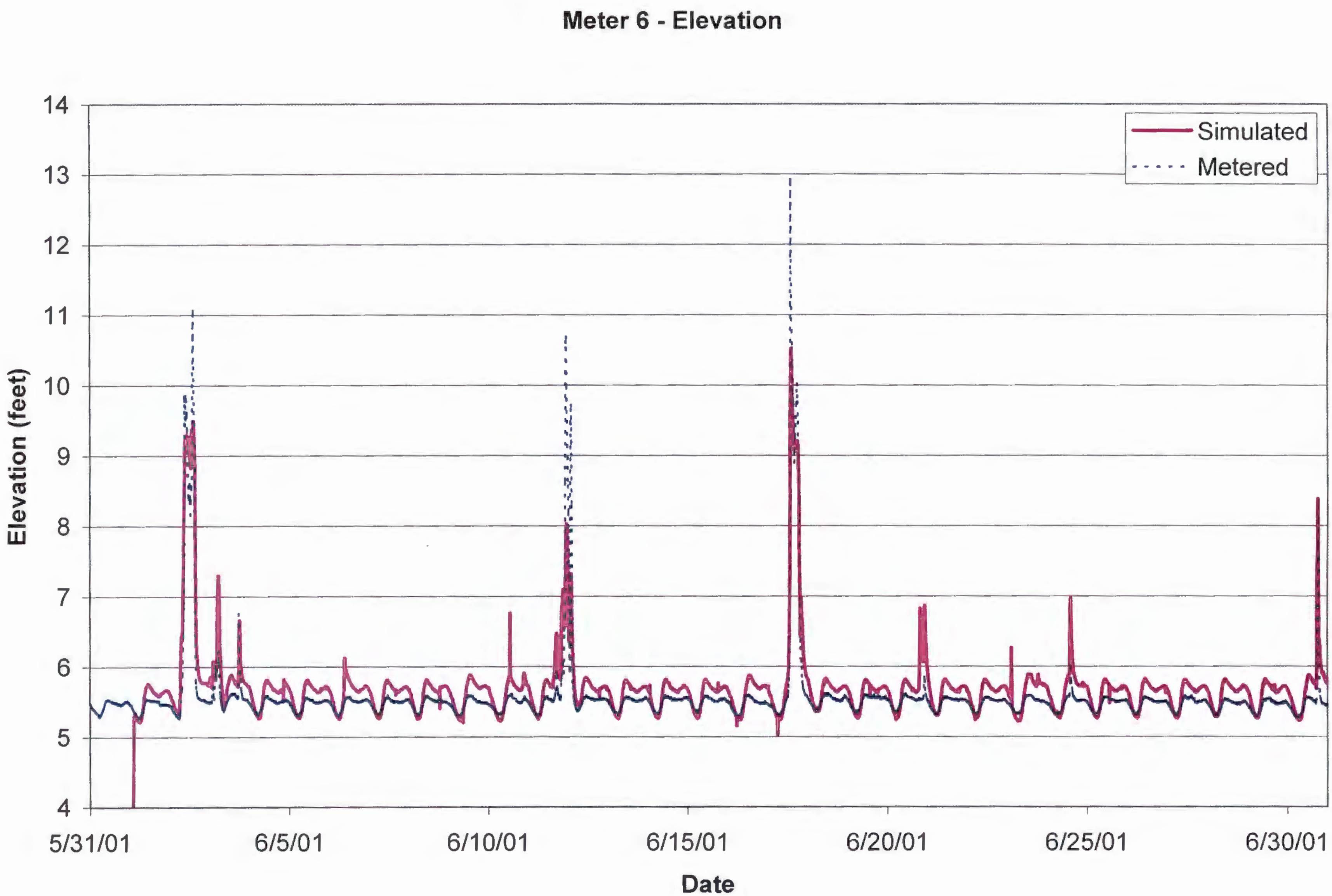

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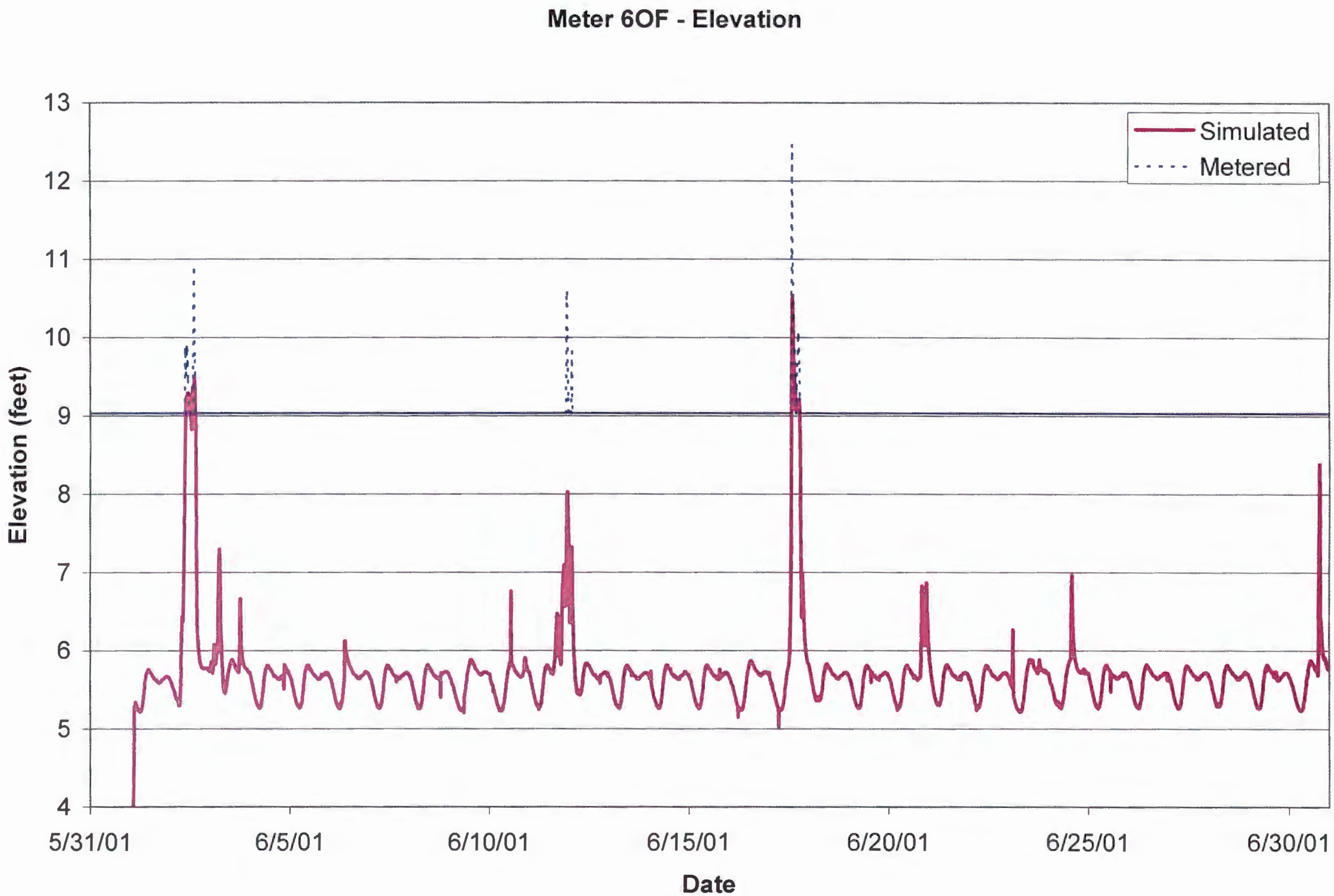

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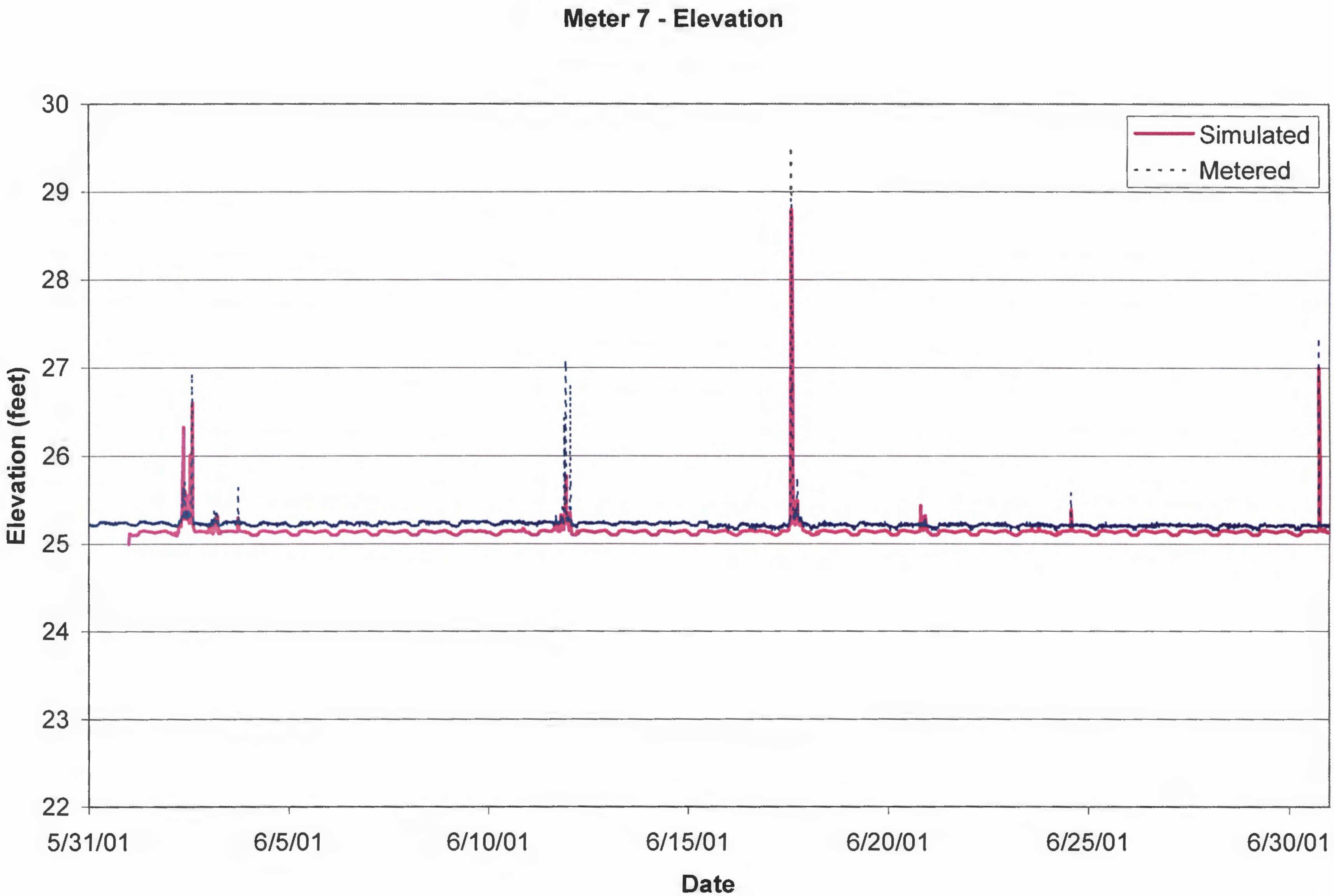

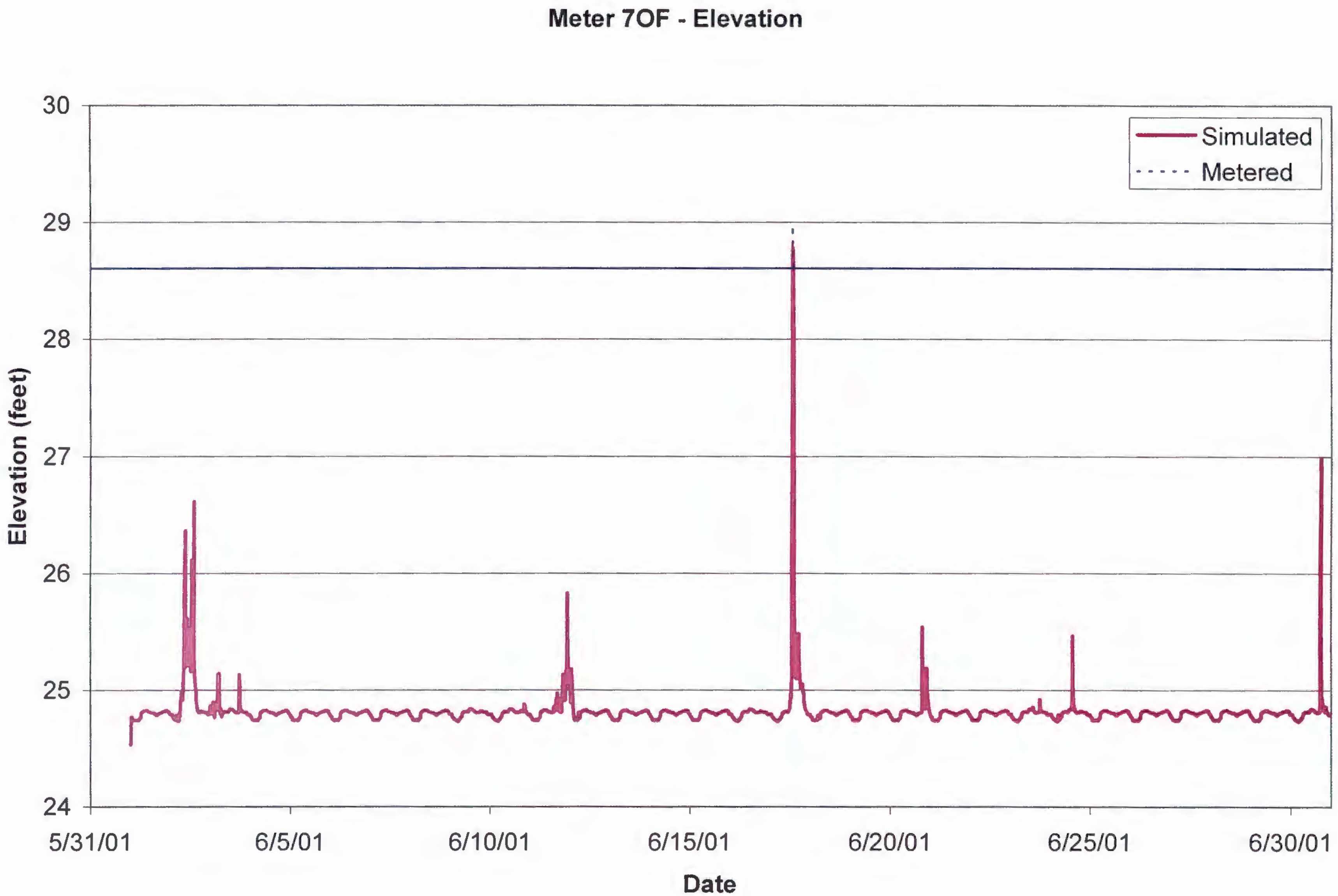
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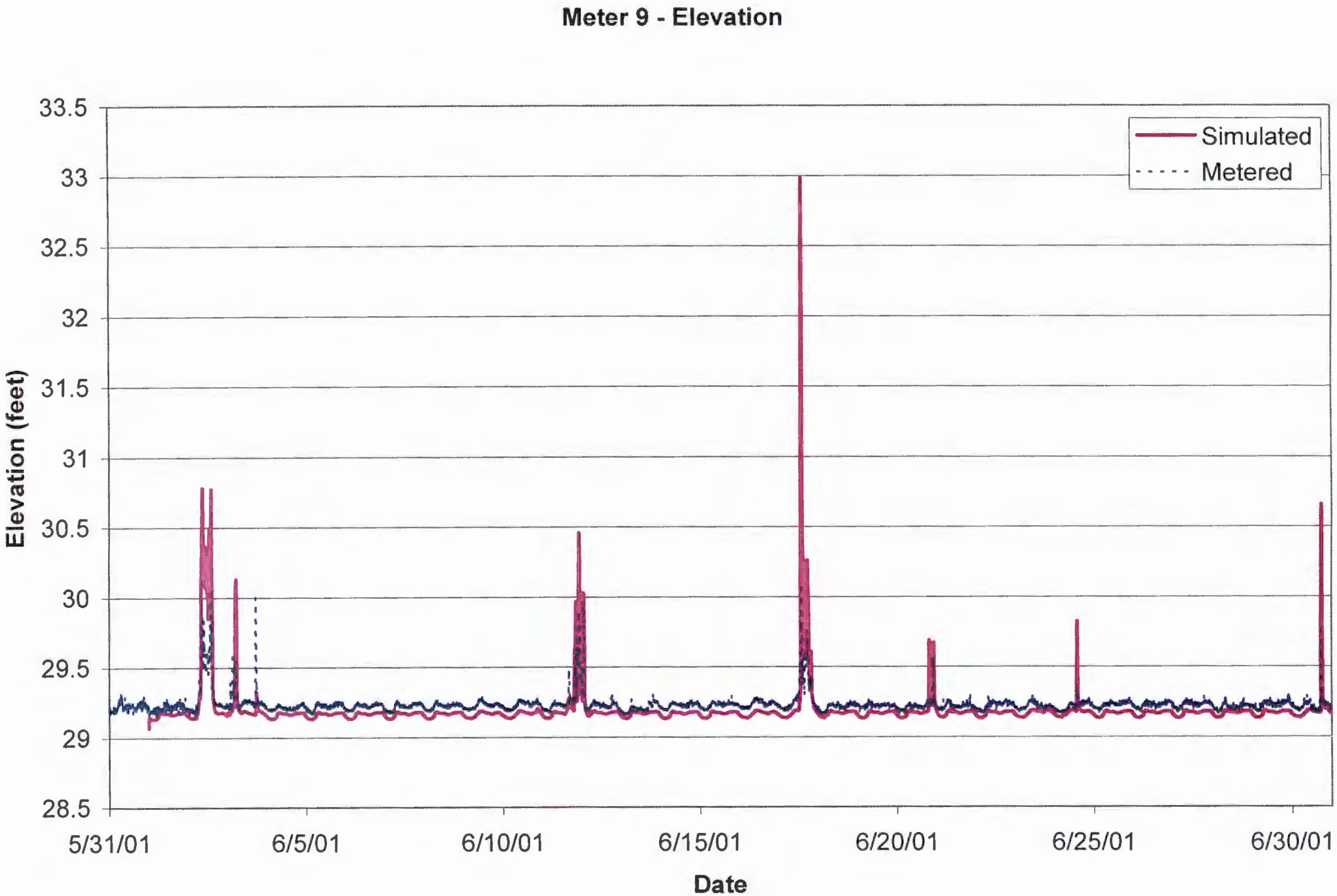

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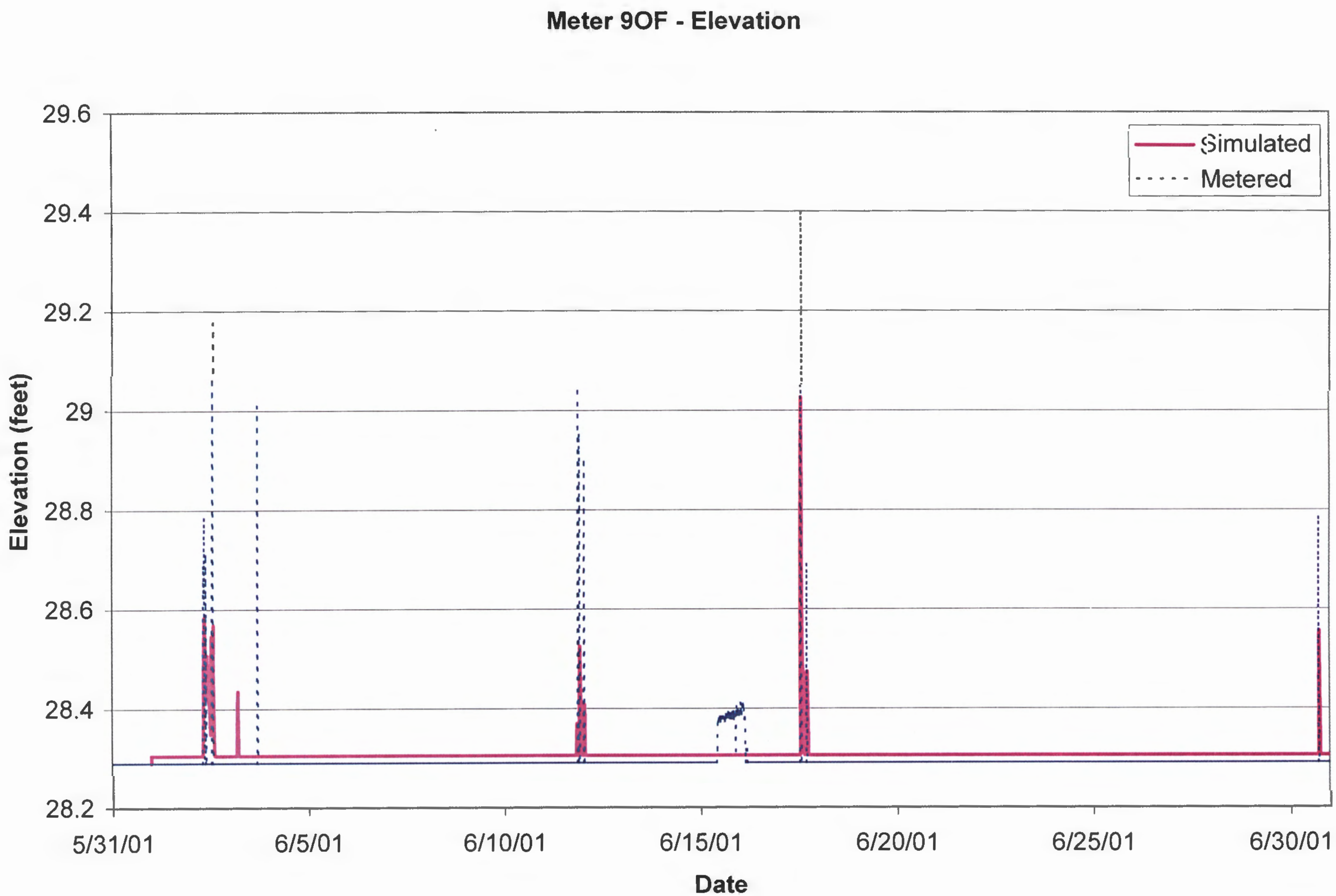

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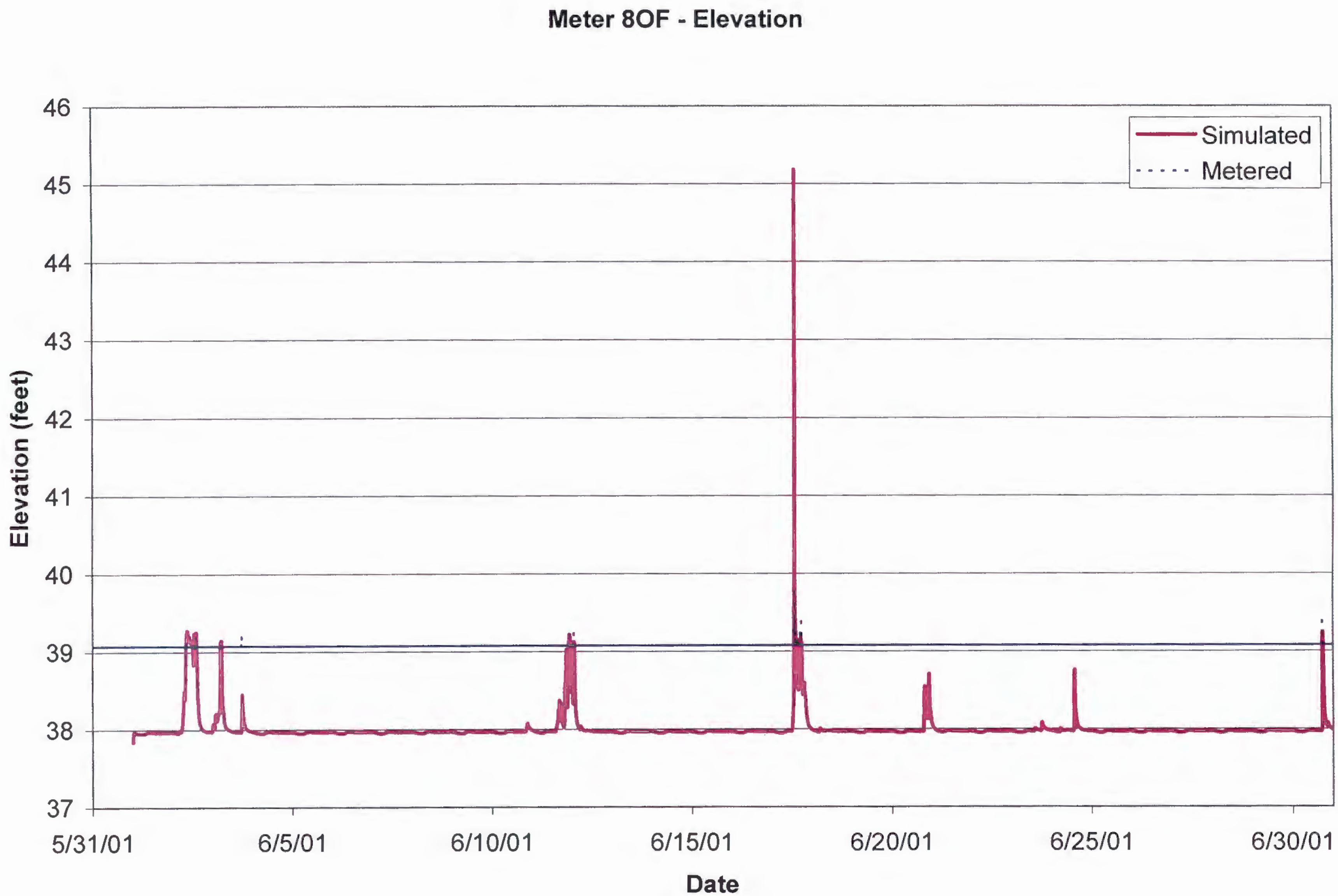

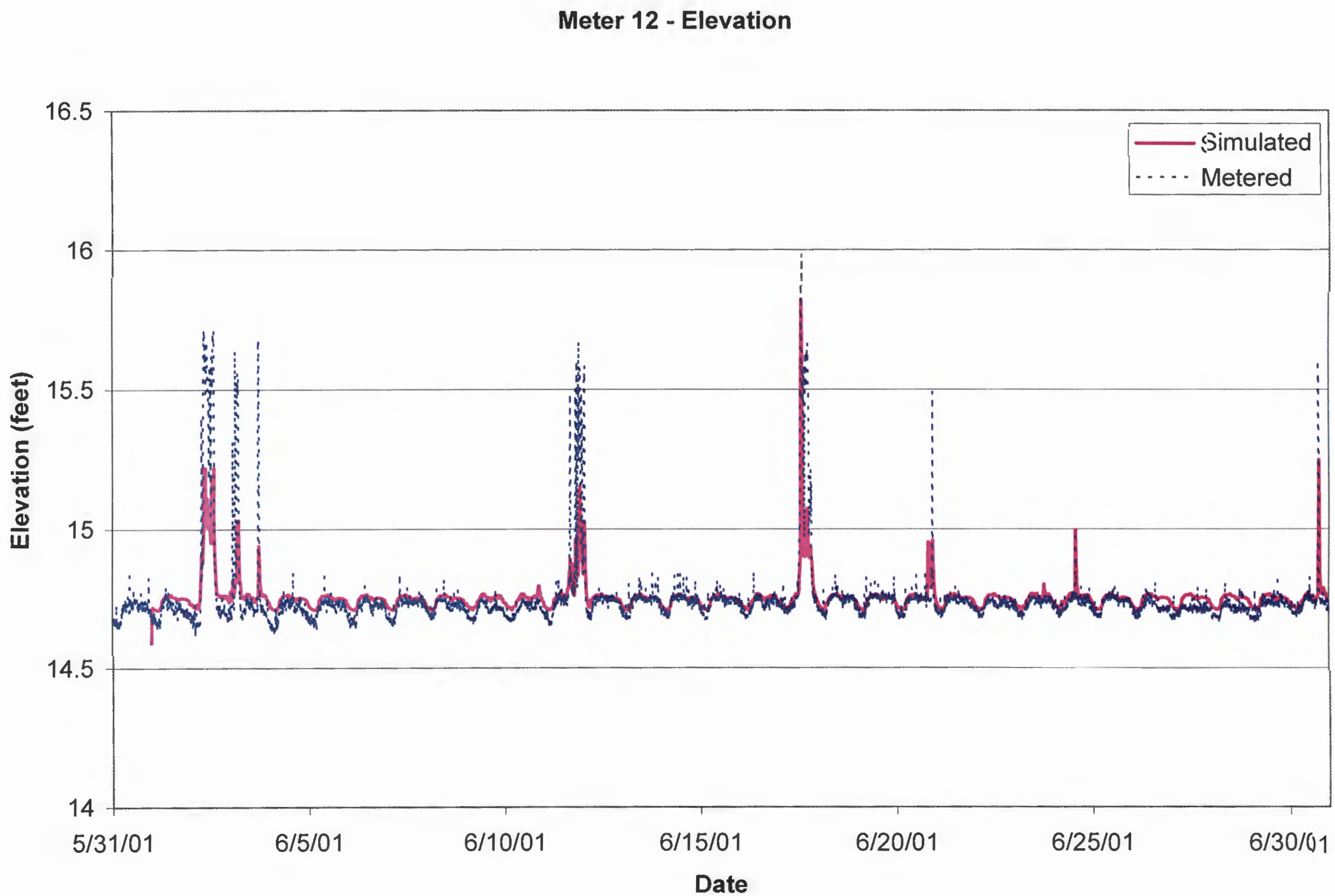
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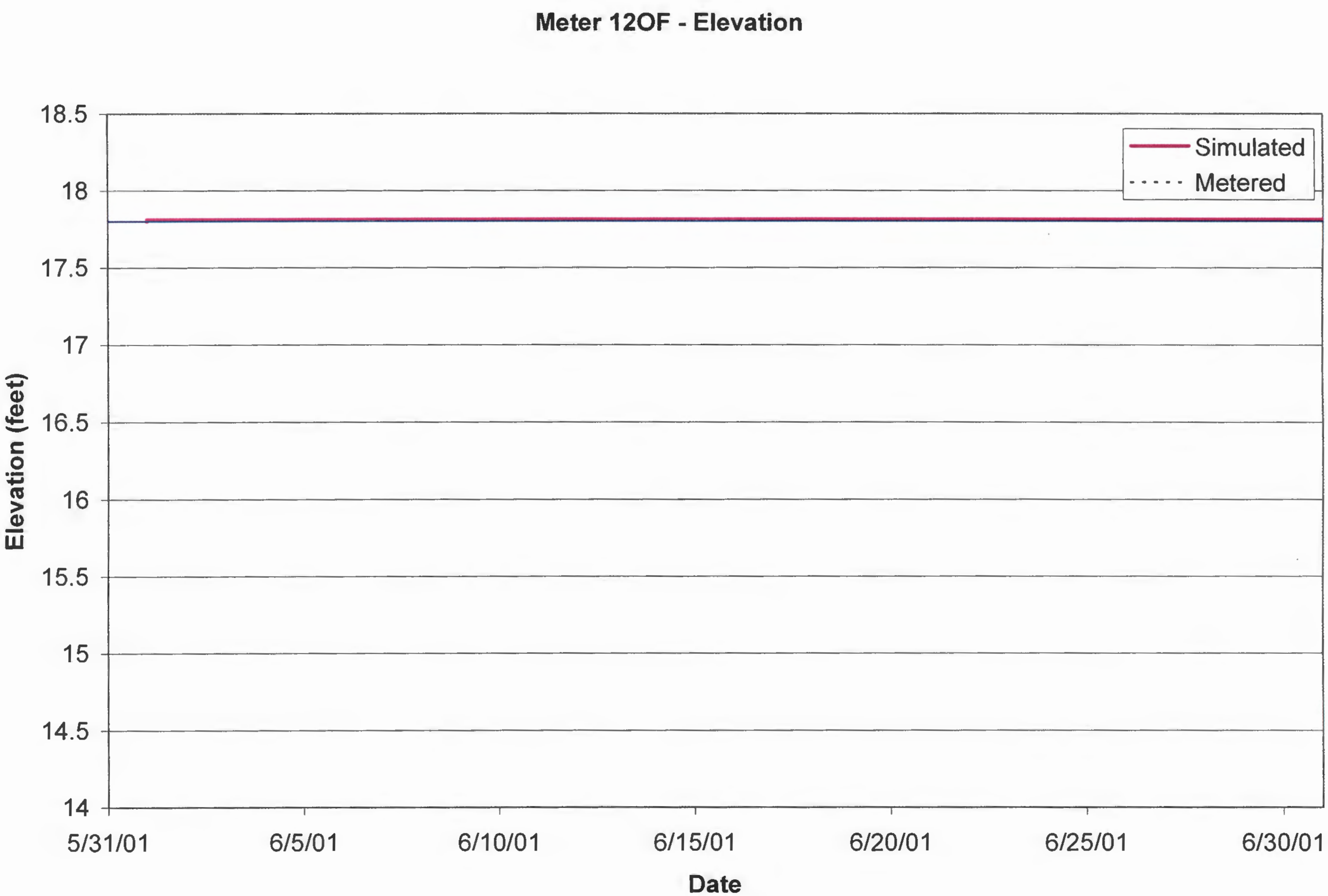
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Elevation (feet)
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Date

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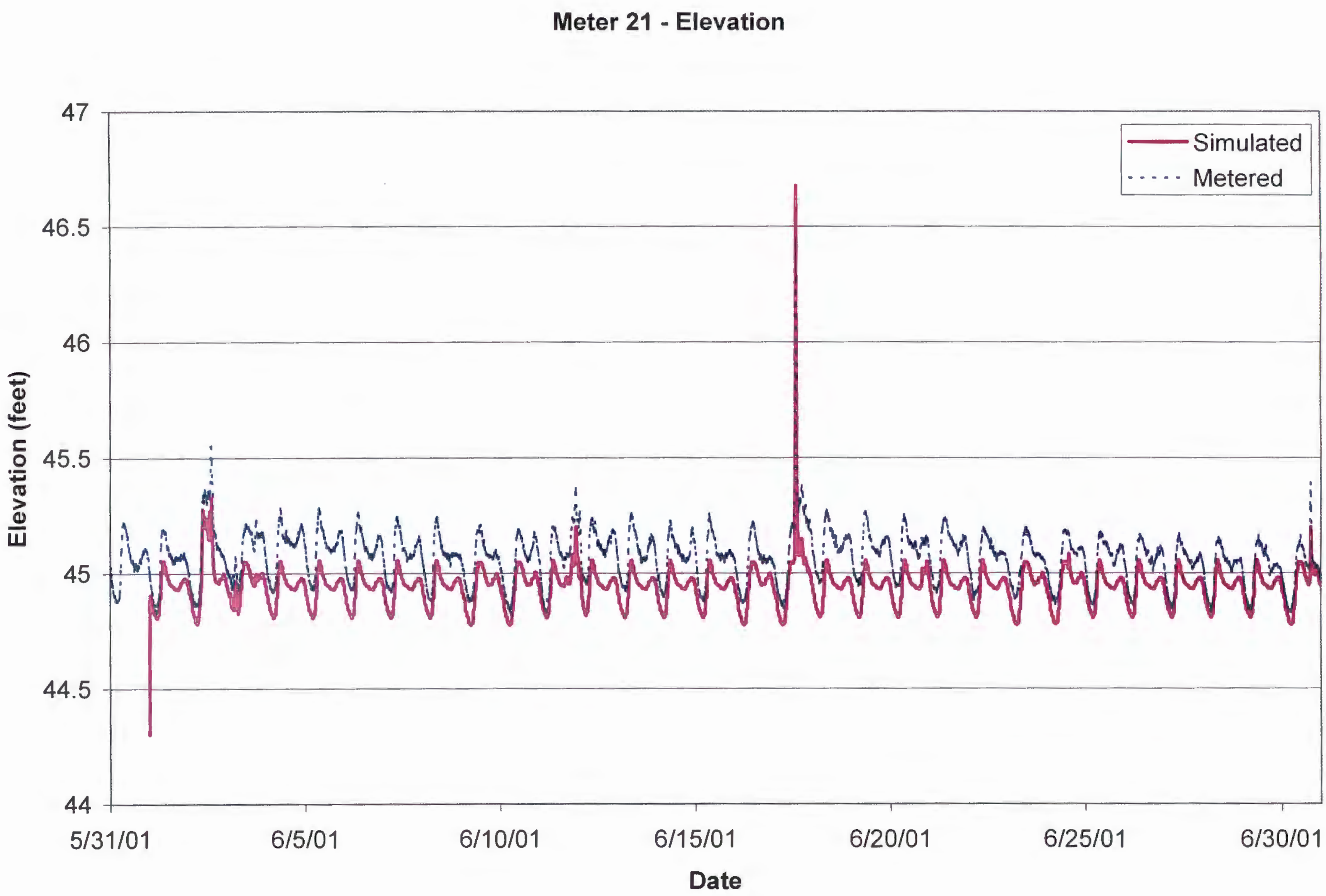

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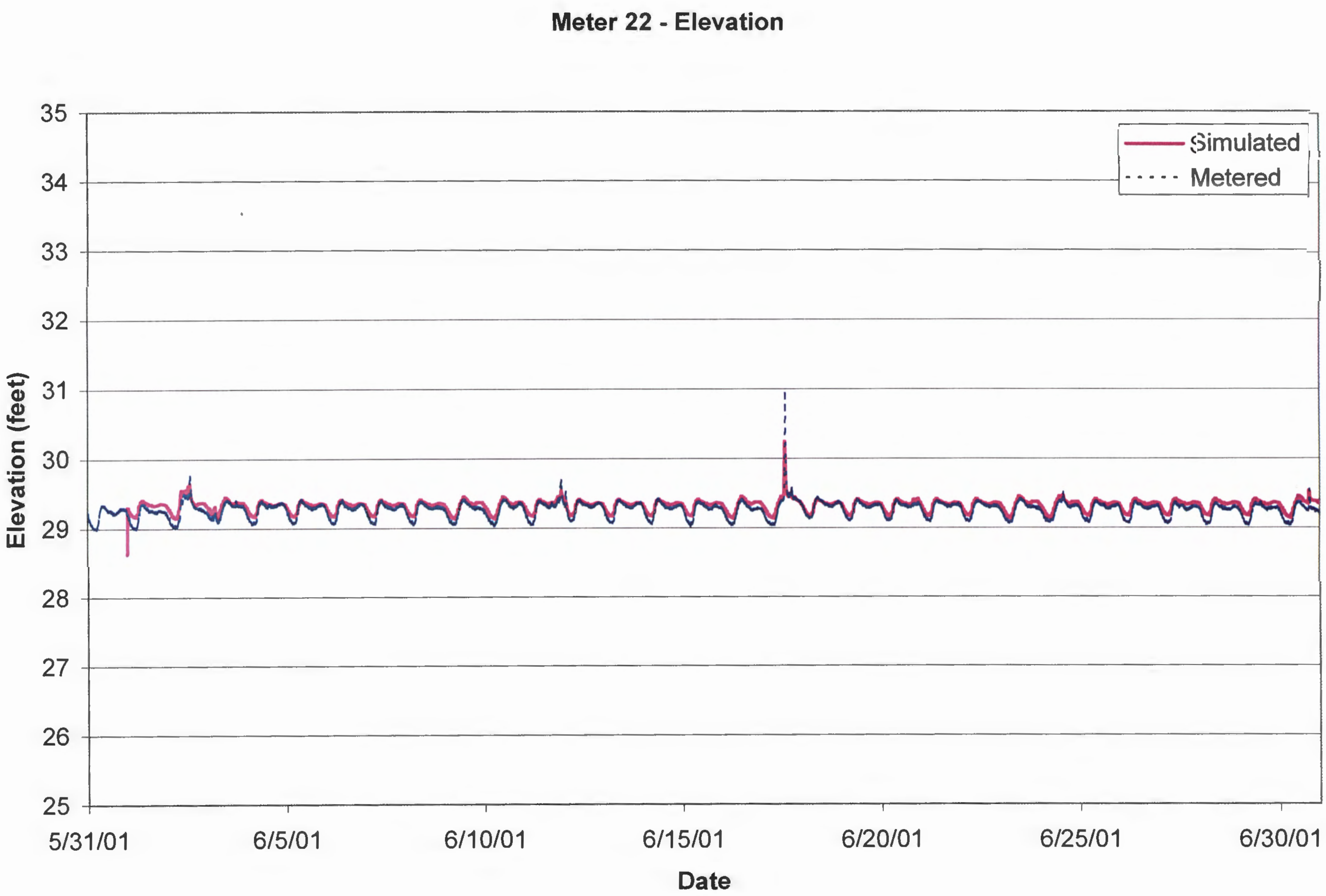

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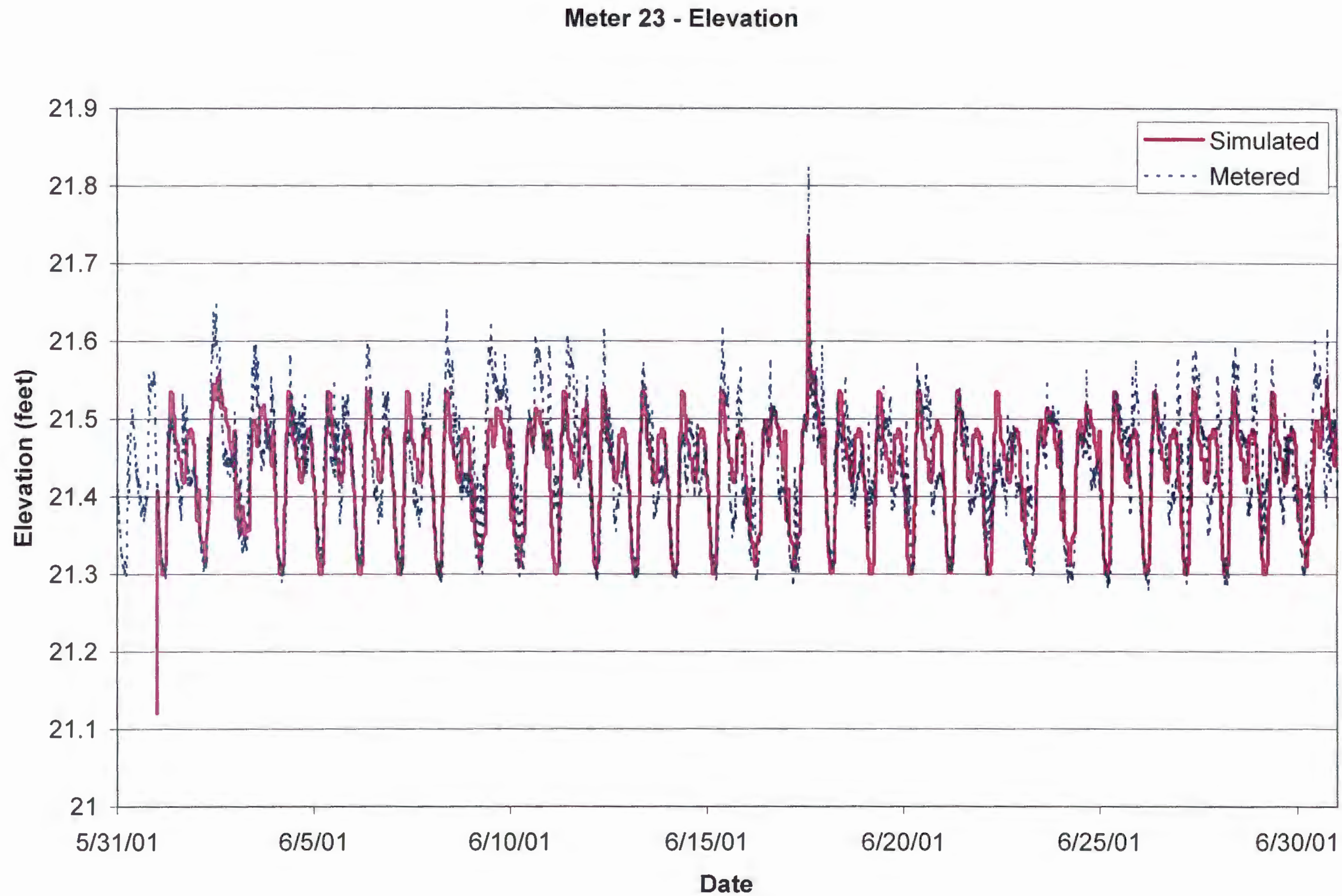

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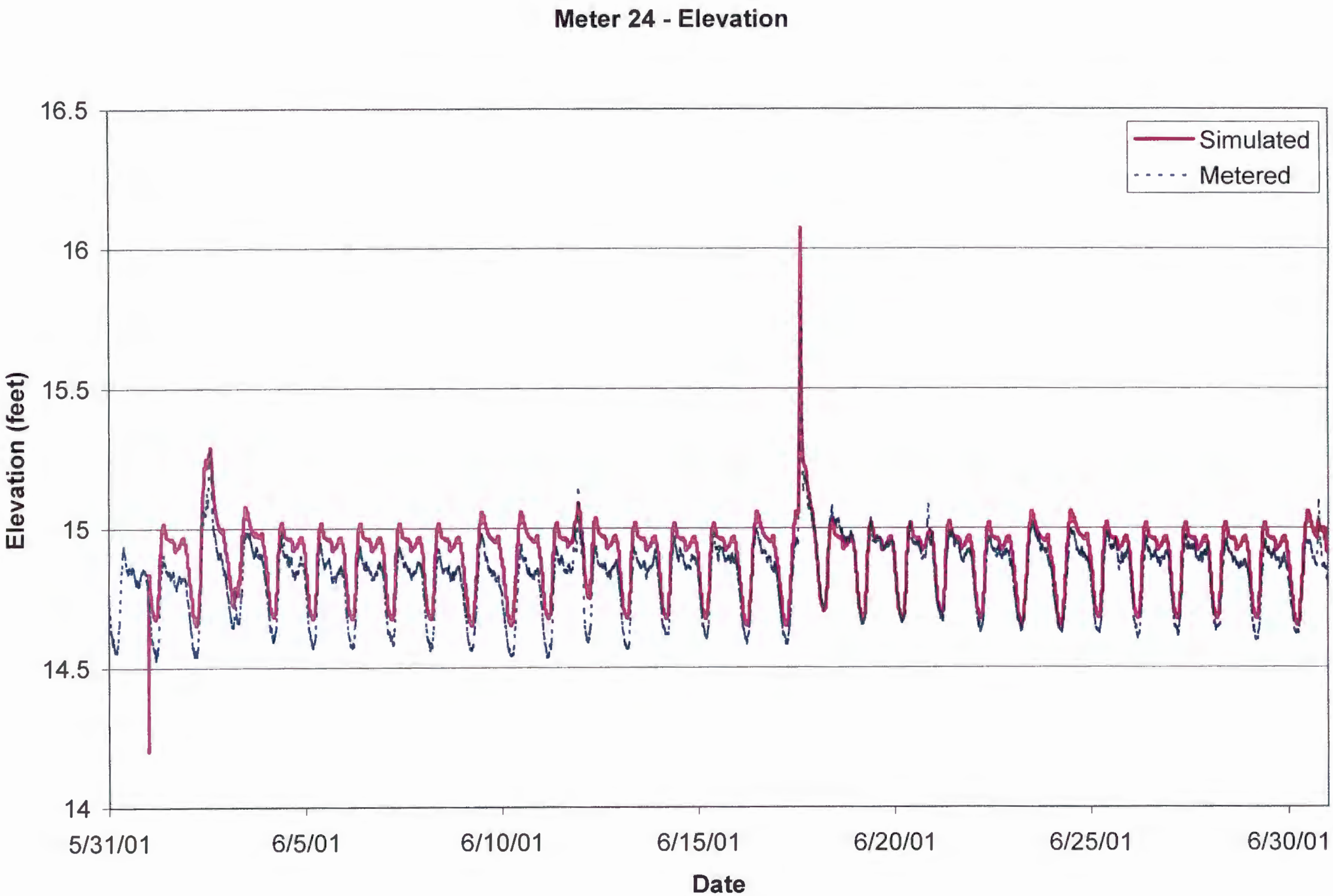

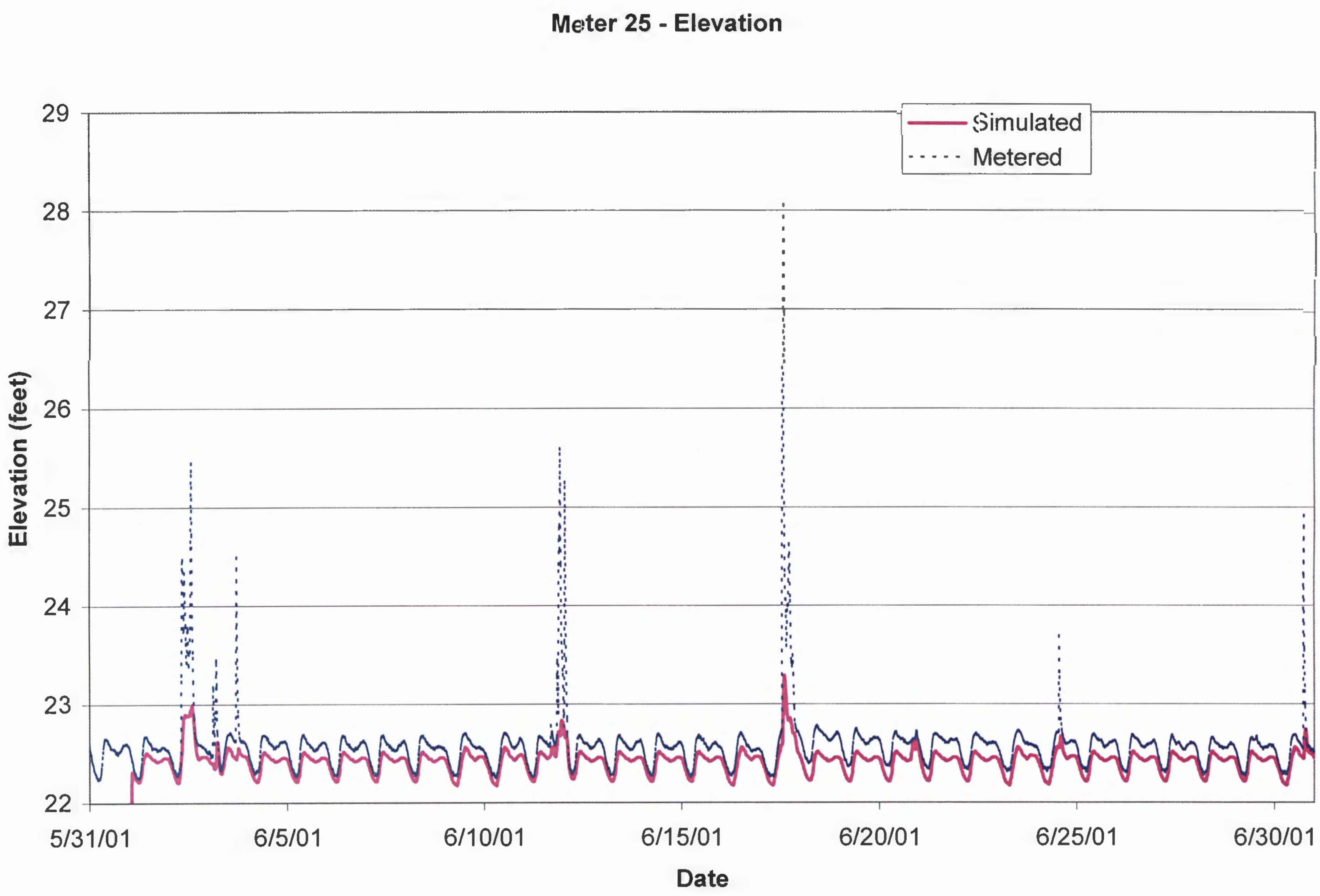
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Date

EXHIBIT G
AR J.1

EXHIBIT G
AR J.1

Metcalf & Eddy

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Wakefield, MA 01880-5371
P.O. Box 4071
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www.m-e.com

June 4, 2003

Ms. Joy Hilton
United States Environmental Protection Agency
Region 1
1 Congress Street
Suite 1100
Boston, MA 02114-2023

Mr. George Berlandi
New Hampshire Department of Environmental Services
6 Hazen Drive
Concord, NH 03302

Subject: Long-Term Water Quality and Infrastructure Control Plan
City of Nashua, NH

Dear Ms. Hilton and Mr. Berlandi:

On behalf of the City of Nashua, we are please to submit the, "Evaluation of Higher Levels of CSO Control Than Presented in The January 2003 Report on Baseline Conditions Update And Development And Evaluation of Alternatives to The City's Current CSO Control Plan". This document has been prepared as requested at our May 28, 2003 meeting with EPA and NHDES.

We look forward to meeting with you to discuss this document and plans for moving ahead with Nashua's revised CSO control plan at our meeting on June 11, 2003. In the meantime, if you have any questions or require additional information regarding this matter, please contact us.

Very truly yours,

Gregory R. Heath
Associate

cc: G. Crombie, w/encl.
R. Seymour, w/encl.

EXHIBIT G
AR J.1

CITY OF NASHUA, NEW HAMPSHIRE
WET WEATHER POLLUTION CONTROL PROGRAM

EVALUATION OF HIGHER LEVELS OF CSO CONTROL THAN PRESENTED IN THE JANUARY 2003 "REPORT ON BASELINE CONDITIONS UPDATE AND DEVELOPMENT AND EVALUATION OF ALTERNATIVES TO THE CITY'S CURRENT CSO CONTROL PLAN"

June 4, 2003

Following is a review of incrementally higher levels of CSO control, beyond the level of CSO control presented in the January 2003, "Report on Baseline Conditions Update and Development and Evaluation of Alternatives to the City's Current CSO Control Plan". This review and presentation of information on higher levels of CSO control was requested at a May 28, 2003 meeting with EPA and NHDES. The purpose of this request was to address the issue of whether incremental increases to components of the CSO control plan recommended in the January 2003 report could achieve significant additional benefits at reasonable cost.

Reference is made herein to "actual" and "TP-40" design storms. As discussed with EPA and NHDES on September 18, 2003, the 2-year and 5-year "actual" design storms were developed as part of Nashua's 1997 CSO study. The 5-year "actual" design storm has its peak relatively early in the event and the 2-year "actual" storm peaks relatively late. It is believed that this is the reason why most CSOs are predicted to experience a greater overflow volume in response to the 2-year "actual" storm as compared to the 5-year "actual" storm. In the 2-year "actual" storm, the ground is saturated by significant precipitation prior to the peak of the storm, so when the peak occurs, there is substantial runoff. In the 5-year "actual" event, the system is better able to absorb the peak because the peak occurs early in the storm. Because of the counter-intuitive CSO response to the 2-year and 5-year "actual" storm events (2-year event produces greater CSO volume at most outfalls than 5-year event), 2-year and 5-year design storms were developed using Technical Paper 40 (TP-40) intensity-duration-frequency (IDF) curves. These synthetic "TP-40" design storms produced greater CSO volumes than either the 2-year or 5-year "actual" storm events. Accordingly, the following sequence of design storm events was generally used to evaluate incrementally higher levels of CSO control: largest storm in typical year; 5-year "actual" storm; 2-year "actual" storm; 2-year "TP-40" storm; 5-year "TP-40" storm.

It is important to note that the evaluation of higher levels of CSO control presented below is based on applying judgement to the incremental cost and incremental performance of the expanded plan component to achieve a higher level of CSO control than presented in the January 2003 report. Due to the high level of CSO control provided by the CSO control components of the January 2003 report (ranging from no untreated CSOs in response to the largest storm in the typical rainfall year to no untreated CSOs in response to the 5-year "actual" storm), it is not possible to evaluate alternatives to provide higher levels of CSO control using more traditional means such as cost per unit load of pollutant removed or in terms of reducing the annual number of CSO discharges (since the annual number of CSO discharges is already zero).

It is also important to recognize that each outfall has unique characteristics and responds somewhat differently to various design storms. For example, most outfalls are predicted to have greater CSO discharge volumes in response to the 2-year "actual" storm event as compared to the 5-year "actual" event. However, at outfall CSO 004 (Burke Street), the 5-year "actual" storm event is predicted to result in a greater CSO volume than the 2-year "actual" event. This example illustrates the importance of considering the unique characteristics and site-specific response of each CSO in evaluating the level of CSO control recommended in the January 2003 report as well as the incrementally higher levels of CSO control presented herein. The CSO controls recommended in the January 2003 report all achieve *at least* zero untreated CSOs in response to the largest storm in the typical rainfall year. In fact, the recommended CSO controls achieve no untreated CSO in response to the 2-year and 5-year "actual" storm events at many of Nashua's CSOs. The need to consider the unique characteristics and site-specific response of each CSO dictates that CSO control cannot be considered on a "one-size-fits-all" basis. Accordingly, in addressing the issue of whether incremental increases to components of the CSO control plan recommended in the January 2003 report could achieve significant additional benefits at reasonable cost, it was not possible to recommend a single design storm as the basis for CSO control at all outfalls.

It is important that the reader keep in mind that this site-specific level of CSO control is due to the site-specific nature of CSOs. To assist the reader, the information that follows is presented on an outfall by outfall basis. For each outfall the level of CSO control recommended in the January 2003 report is summarized and feasible alternatives to achieve higher levels of CSO control are discussed.

CSO 002 (Salmon Brook)

The January 2003 report recommends no CSO control at this outfall.

No overflows are predicted at CSO 002 in the largest storm in the typical year, or in the 2-year or 5-year "actual" design storms.

Activation of CSO 002 is predicted in response to the 2-year "TP-40" design storm.

- Predicted volume = 760,000 gal
- Storage tank cost = $7.7 million

Based on the high cost and infrequent realization of benefit associated with storage at CSO 002, no structural CSO control at CSO 002 remains the recommended level of control at this location.

CSO 003 (Farmington Road)

The January 2003 report recommends:

- system optimization (increasing the size of the DWF connection); $60,000
- 40,000 gallon storage tank; $2.5 million

With these recommendations in place, no overflows are predicted in the largest storm in the typical year, or in the 2-year or 5-year "actual" design storms.

With these recommendations in place, activation of CSO 003 is predicted in response to the 2-year "TP-40" design storm.

- Predicted volume = 1.15 mgal
- Storage tank cost = $11.0 million

Based on the high cost and infrequent realization of benefit associated with increasing the size of storage at CSO 003 to control the 2-year "TP-40" storm, a 40,000 gallon storage tank to control up to the 5-year "actual" event remains the recommended level of control at this location.

CSO 004 (Burke Street)

The January 2003 report recommends:

- system optimization (raising the CSO regulator weir and increasing the size of the DWF connection); $64,000
- 10,000 gallon storage tank; $2.0 million

With these recommendations in place, no overflows are predicted in the largest storm in the typical year, or in the 2-year "actual" design storm.

With these recommendations in place, activation of CSO 004 is predicted in response to the 5-year "actual" design storm as well as the larger 2-year and 5-year "TP-40" design storms.

<u>5-year "actual" design storm</u>

- Predicted volume = 20,000 gal
- Storage tank cost = $2.0 million

2-year "TP40" design storm
- Predicted volume = 170,000 gal
- Storage tank cost = $3.3 million

5-year "TP40" design storm
- Predicted volume = 430,000 gal
- Storage tank cost = $5.4 million

It is clearly justifiable to up-size the tank volume to capture the 5-year "actual" design storm, at essentially no increase in project cost. The incremental cost to increase the size of the storage tank to capture the 2-year "TP-40" storm is $1.3 million over the cost to capture the 5-year "actual" event. While difficult to measure the "cost-benefit" or "cost-performance" of this increase in the level of CSO control, the incremental cost is judged to be a reasonable expenditure at this time. The incremental cost to further increase the size of the storage tank to capture the 5-year "TP-40" storm is $2.1 million over the cost to capture the 2-year "TP-40" storm, and $3.4 million over the cost for the storage tank included in the January 2003 report. This incremental cost is judged to be excessive at this time.

Recommendation: Increase the size of the CSO 004 storage tank to 170,000 gallons at a cost of $3.3 million. This will increase the level of CSO control at this location to the 2-year "TP-40" storm.

CSO 005 (E. Hollis) / 006 (Nashua River)

The January 2003 report recommends:

- system optimization (raising the CSO regulator weirs at both 005 and 006); $17,450

- screening and disinfection facility to treat peak flow from both outfalls in the largest storm in the typical year; $7.9 million
  - peak flow treatment capacity = 76.4 cfs
  - treated volume = 1.38 mgal

With these recommendations in place, no untreated overflows are predicted in the largest storm in the typical year, or in the 5-year "actual" design storm. An untreated discharge is predicted in response to the 2-year "actual" design storm as well as the larger 2-year and 5-year "TP-40" design storms.

It is noted that the January 2003 report presented a cost of $6.0 million for the screening and disinfection facility described above. In reviewing the basis of costs in conjunction with the evaluation presented herein, it was determined that costs associated with effluent pumping were not fully accounted for in the cost estimate. Accordingly, the cost estimating approach was modified to more appropriately account for the cost of effluent pumping for the CSO 005 / 006 screening and disinfection facility recommended in the January 2003 report and for the up-sized facility alternatives presented below.

2-year "actual" design storm
- Peak flow treatment capacity = 103.1 cfs
- treated volume = 2.03 mgal
- Cost = $9.6 million

2-year "TP40" design storm
- Peak flow treatment capacity = 356 cfs
- treated volume = 15.33 mgal
- Cost = $21.0 million

5-year "TP40" design storm
- Peak flow treatment capacity = 482 cfs
- treated volume = 28.03 mgal
- Cost = $26.2 million

It appears justifiable to up-size the screening and disinfection facility to treat the 2-year "actual" design storm, at an increase in project cost of $1.7 million. It does not appear reasonable to up-size the screening and disinfection facility to treat the 2-year "TP-40" storm at a cost more than double the cost for a facility sized to treat the 2-year "actual" storm. It also does not appear reasonable to increase the design basis of this alternative to the 2-year or 5-year "TP-40" storm peak flows due to the impact on the sizing of the chlorine contact tank required. To provide 15 minutes of detention time at peak flow in the 2-year "TP-40" storm would require a CCT volume of 2.4 mgal, which would store the entire 2.03 mgal overflow predicted in response to a 2-year "actual" storm. Furthermore, this degree of up-sizing would unreasonably complicate equipment rotation and maintenance as well as chemical storage, at least until the need for higher levels of CSO control have more conclusively been documented.

CSO 007 (Tampa Street)

The January 2003 report recommends:

- system optimization (raising the weir and installing a flap gate); $100,000

With these recommendations in place, no overflows are predicted in the largest storm in the typical year, or in the 2-year or 5-year "actual" design storms.

With these recommendations in place, activation of CSO 007 is predicted in response to the 2-year "TP-40" design storm.

- Predicted volume = 650,000 gal
- Storage tank cost = $6.9 million

Based on the high cost and infrequent realization of benefit associated with constructing a storage tank at CSO 007 to control the 2-year "TP-40" storm, system optimization, only remains the recommended level of control at this location. Increasing the level of CSO control at this location would necessitate construction of a large underground structure which would impinge on other land uses in the area and would require continual maintenance. It does not appear reasonable to incur these long-term adverse impacts associated with a structure that would have a design life of approximately 20 years but would likely be used between four and ten times in its design life.

CSO 008 (Broad Street)

The January 2003 report recommends:

- system optimization (raising the CSO regulator weir and increasing the size of the DWF connection); $723,700

With these recommendations in place, no overflows are predicted in the largest storm in the typical year.

With these recommendations in place, activation of CSO 008 is predicted in response to the 2-year and 5-year "actual" design storms as well as the larger 2-year and 5-year "TP-40" design storms.

<u>2-year "actual" design storm</u>
- Predicted volume = 30,000 gal
- Storage tank cost = $2.0 million

<u>5-year "actual" design storm</u>
- Predicted volume = 30,000 gal
- Storage tank cost = $2.0 million

<u>2-year "TP40" design storm</u>
- Predicted volume = 270,000 gal
- Storage tank cost = $4.2 million

<u>5-year "TP40" design storm</u>
- Predicted volume = 890,000 gal
- Storage tank cost = $9.4 million

Based on the cost and infrequent realization of benefit associated with constructing a storage tank at

CSO 008 to control overflows in storms larger than the largest storm in the typical year, system optimization, only remains the recommended level of control at this location. Increasing the level of CSO control at this location would necessitate construction of an underground structure which would impinge on other land uses in the area and would require continual maintenance. It does not appear reasonable to incur these long-term adverse impacts associated with a structure that would have a design life of approximately 20 years but would likely be used less than 20 times in its design life.

CSO 009 (Lock Street)

The January 2003 report recommends:

- system optimization (increasing the size of the DWF connection and removing a hanging baffle); $60,000

With these recommendations in place, no overflows are predicted in the largest storm in the typical year, or in the 2-year or 5-year "actual" design storms.

With these recommendations in place, activation of CSO 009 is predicted in response to the 2-year and 5-year "TP-40" design storms.

2-year "TP40" design storm

- Predicted volume = 20,000 gal
- Storage tank cost = $2.0 million

5-year "TP40" design storm

- Predicted volume = 80,000 gal
- Storage tank cost = $2.7 million

Based on the cost and infrequent realization of benefit associated with constructing a storage tank at CSO 009 to control overflows in storms larger than the 2-year and 5-year "actual" storms, system optimization, only remains the recommended level of control at this location. Increasing the level of CSO control at this location would necessitate construction of an underground structure which would impinge on other land uses in the area and would require continual maintenance. It does not appear reasonable to incur these long-term adverse impacts associated with a structure that would have a design life of approximately 20 years but would likely be used between four and ten times in its design life.

NWTF Wet Weather Flow Treatment Facility

The January 2003 report recommends:

- high rate, chemically enhanced sedimentation facility to treat peak flow in excess of the NWTF capacity, from the largest storm in the typical year; $26 million
  - peak flow treatment capacity = 92.1 cfs
  - treated volume = 3.85 mgal

With these recommendations in place, no untreated overflows are predicted in the largest storm in the typical year, or in the 5-year "actual" design storm.

With these recommendations in place, an untreated discharge is predicted in response to the 2-year "actual" design storm as well as the larger 2-year and 5-year "TP-40" design storms.

<u>2-year "actual" design storm</u>
- Peak flow treatment capacity = 94.0 cfs
- treated volume = 6.84 mgal
- Cost = $26 million

<u>2-year "TP40" design storm</u>
- Peak flow treatment capacity = 113 cfs
- treated volume = 9.8 mgal
- Cost = $29 million

<u>5-year "TP40" design storm</u>
- Peak flow treatment capacity = 117 cfs
- treated volume = 14.4 mgal
- Cost = $30 million

It is clearly justifiable to up-size the treatment facility to treat the 2-year "actual" design storm, at no increase in project cost. It does not appear reasonable to increase the design basis of this alternative to the 2-year or 5-year "TP-40" storm peak flows due to the $3 million to $4 million associated cost. Furthermore, it is possible to construct this treatment facility in a modular fashion that would facilitate future increases in capacity if deemed necessary.

Summary

Incrementally higher levels of CSO control, beyond the level of CSO control presented in the January 2003 report, have been reviewed. As presented above, the following is a summary of findings from this evaluation:

- **CSO 002:** The January 2003 report recommends no CSO control at this outfall. This remains the recommendation. No untreated CSOs are predicted in response to the largest storm in the typical year or the 2-year or 5-year "actual" storms.

- **CSO 003:** The January 2003 report recommends system optimization (increasing the size of the DWF connection) at a cost of $60,000 and construction of a 40,000 gallon storage tank at a cost of $2.5 million. This remains the recommendation. No untreated CSOs are predicted in response to the largest storm in the typical year or the 2-year or 5-year "actual" storms.

- **CSO 004:** The January 2003 report recommends system optimization (raising the CSO regulator weir and increasing the size of the DWF connection) at a cost of $64,000 and construction of a 10,000 gallon storage tank at a cost of $2.0 million. Based on the results of the review presented above, this recommendation is revised to include construction of a 170,000 gallon storage tank at a cost of $3.3 million. With this revision, no untreated CSOs are predicted in response to the largest storm in the typical year, the 2-year or 5-year "actual" storms, or the 2-year "TP-40" storm.

- **CSO 005 and 006:** The January 2003 report recommends system optimization (raising the CSO regulator weirs at both 005 and 006) at a cost of $17,450 and a screening and disinfection facility to treat peak flow from both outfalls in the largest storm in the typical year at a cost of $7.9 million. Based on the results of the review presented above, this recommendation is revised to include increasing the size of the screening and disinfection facility to treat the peak flow from both outfalls in the 2-year "actual" storm at a cost of $9.6 million. With this revision, no untreated CSOs are predicted in response to the largest storm in the typical year or the 2-year or 5-year "actual" storms.

- **CSO 007:** The January 2003 report recommends system optimization (raising the weir and installing a flap gate) at a cost of $100,000. This remains the recommendation. No overflows are predicted in the largest storm in the typical year, or in the 2-year or 5-year "actual" design storms.

- **CSO 008:** The January 2003 report recommends system optimization (raising the CSO regulator weir and increasing the size of the DWF connection) at a cost of $723,700. This remains the recommendation. No overflows are predicted in the largest storm in the typical year.

- **CSO 009:** The January 2003 report recommends system optimization (increasing the size of the DWF connection and removing a hanging baffle) at a cost of $60,000. This remains the recommendation. With these recommendations in place, no overflows are predicted in the largest storm in the typical year, or in the 2-year or 5-year "actual" design storms.

- **NWTF Wet Weather Flow Treatment Facility:** The January 2003 report recommends a high rate, chemically enhanced sedimentation facility to treat peak flow in excess of the NWTF capacity, from the largest storm in the typical year. This remains the recommendation. No untreated overflows are predicted in the largest storm in the typical year, or in the 5-year "actual" design storm.

The total cost of the recommended plan presented in the January 2003 report was $37.5 million. Based on an updated cost estimate for the CSO 005 / 006 screening and disinfection facility (see above), the current estimated cost is $39.4 million. With the revisions to recommendations summarized herein, the total cost associated with Nashua's CSO control program recommended for implementation at this time is increased by $3.0 million to $42.4 million. Based on the assessment presented above, it appears that these incremental increases to the CSO 004 storage tank and the CSO 005 and 006 screening and disinfection facility are the only incremental increases to components of the January 2003 recommended plan expected to achieve additional benefits at reasonable cost.