CEE 371 Fall 2009

Homework #4 Water Distribution System Storage

4 points total for entire homework

1. **Given the hourly average demand rates shown below (in gpm), calculate the uniform 24 hour supply (or pumping) rate and the required equalizing storage volume (in million gallons). Prepare both a diurnal demand hydrograph and a "mass diagram" for the problem. Find the equalizing storage using the demand hydrograph, and confirm on the mass diagram.**

12 midnight	**2000**
1 AM	**1900**
2	**1800**
3	**1795**
4	**1700**
5	**1800**
6	**1910**
7	**3200**
8	**5000**
9	**5650**
10	**6000**
11	**6210**

12 noon	**6300**
1 PM	**6500**
2	**6460**
3	**6463**
4	**6500**
5	**6700**
6	**7119**
7	**9000**
8	**8690**
9	**5220**
10	**2200**
11	**2100**
12 midnight	**2000**

1 point for #1

Preliminary calculation for demand graphs:

			24 hr supply	24 hr supply	12 hr supply 6 am-6 pm	24 hr supply
	TIME	DEMAND (GPM)	Cumulative Demand (gal)	Cumulative Supply (gal)	Cumulative Supply (gal)	Eq. Stor Volume (gal)
midnight	12	2000	0	0	0	
a.m.	1	1900	117000	280460	0	
	2	1800	228000	560920	0	
	3	1795	335850	841379	0	
	4	1700	440700	1121839	0	
	5	1800	545700	1402299	0	
	6	1910	657000	1682759	0	
	7	3200	810300	1963219	560920	
	8	5000	1056300	2243678	1121839	1793
	9	5650	1375800	2524138	1682759	39060
	10	6000	1725300	2804598	2243678	69060
	11	6210	2091600	3085058	2804598	85860
noon	12	6300	2466900	3365518	3365518	94860

	1	6500	2850900	3645977	3926437	103560
p.m.	2	6460	3239700	3926437	4487357	108360
	3	6430	3626400	4206897	5048276	106260
	4	6500	4014300	4487357	5609196	107460
	5	6700	4410300	4767817	6170116	115560
	6	7119	4824870	5048276	6731035	134130
	7	9000	5308440	5328736	0	203130
	8	8690	5839140	5609196	0	250260
	9	5220	6256440	5889656	0	136860
	10	2200	6479040	6170116	0	3003
	11	2100	6608040	6450575	0	
	12	2000	6731040	6731035	0	
Avg Q		4674 (or 6.73 MGD)		(avg Qsupply= 4674 gpm)	(avg Qsupply=9349 gpm)	1559216

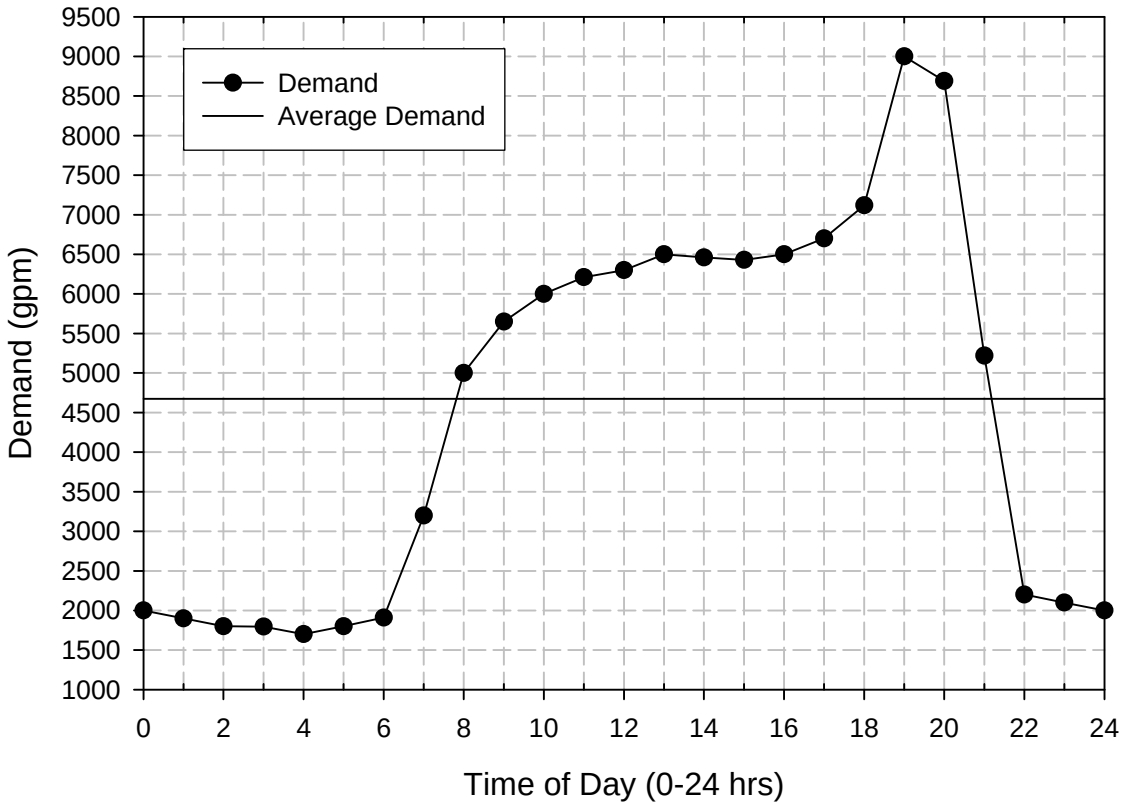

Figure 1. Demand Hydrograph

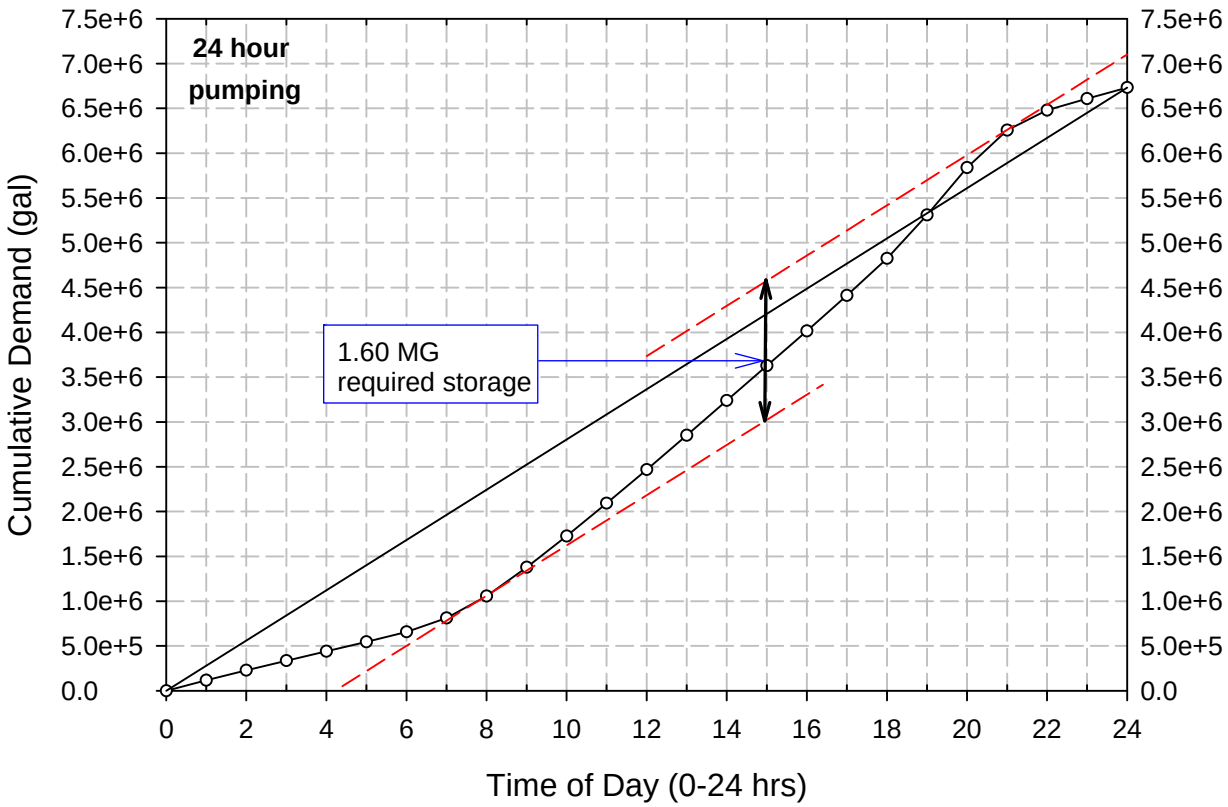

Figure 2. Cumulative Demand with 24 Hour Pumping

2. Suppose that the supply or pumping period is only 12 hours, from 6 a.m. to 6 p.m. Determine the required equalizing storage volume in this case.

0.5 points for #2

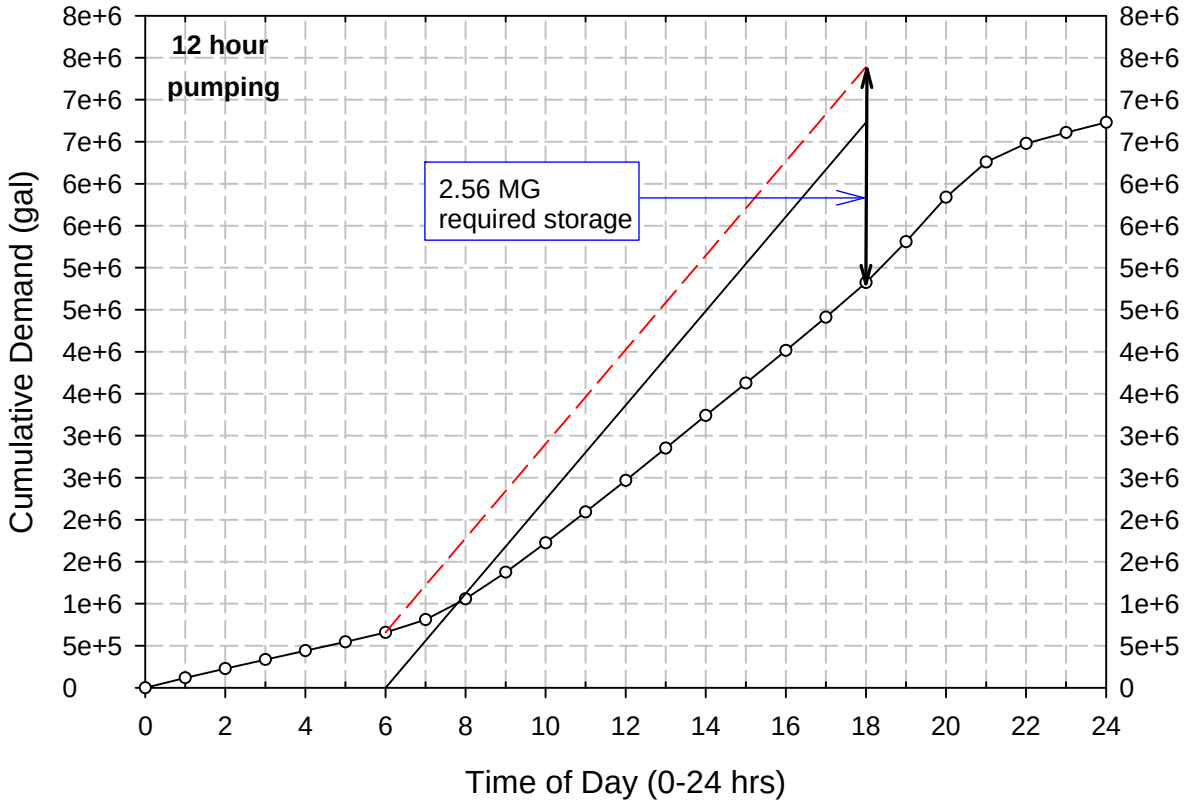

Figure 3. Cumulative Demand with 12 Hour Pumping

Note: Be careful to consider the entire 24 hours of demand, regardless of the pumping duration.

3. Make an estimate of the total required distribution storage volume for this community. Assume that the information for part 1 is for the maximum day flow for a community of 35,000 people and that the ratio of Q max day to Q average day is 1.5 for this community. Use the population method to calculate a design fireflow and assume a fire duration of 10 hours. Clearly state your assumptions and reasoning for estimating the emergency reserve storage volume.

Case #1: Assumptions: use 24 hr pumping; multiple sources so that emergency storage isn't needed.

Fire Flow

0.5 points for #3

$$Q_{fire} = 1020\left(\sqrt{P}\right)\left(1 - 0.01\sqrt{P}\right)$$
$$= 1020\left(\sqrt{35}\right)\left(1 - 0.01\sqrt{35}\right)$$
$$= 5677\,gpm$$
$$= 8.18MGD$$

V_{fire} = Duration * Q_{fire} = (10/24) days * 8.18 MGD = **3.41 MG**

Equalizing storage based on max daily flow (determined in part 1)

V_{equal} = **1.60 MG**

Total Required Storage

V_{tot} = 3.41 + 1.60 = **5.01 MG**

Case #2: Assumptions: use 24 hr pumping; single sources so that emergency storage is needed. Required emergency is for 36 hrs.

Fire Flow

$$Q_{fire} = 1020\left(\sqrt{P}\right)\left(1 - 0.01\sqrt{P}\right)$$
$$= 1020\left(\sqrt{35}\right)\left(1 - 0.01\sqrt{35}\right)$$
$$= 5677\,gpm$$
$$= 8.18MGD$$

V_{fire} = Duration * Q_{fire} = (10/24) days * 8.18 MGD = **3.41 MG**

Equalizing storage based on max daily flow (determined in part 1)

V_{equal} = **1.60 MG**

Emergency Storage (1.5 days at avg flow)

$Q_{avg} = Q_{max}/1.5$ = 6.73 MGD/1.5 = 4.49 MGD

$Q_{emergency}$ = 1.5*4.49 MGD = **6.73 MGD**

Total Required Storage

V_{tot} = 3.41 + 1.60 + 6.73 = **11.74 MG**

Note: sometimes equalization storage isn't added, especially if emergency storage is provided