TECHNICAL MEMORANDUM
Santa Rosa Subregional Long-Term Wastewater Project
Transport Pipeline Flowrate and Pumping Schedule
Present Worth Analysis
(TM-P-6)

TO: Ed Braunner (City of Santa Rosa)
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GENERAL

The purpose of this memorandum is to:

- present the approach used to evaluate the relative economic benefit of alternative pumping rates and time of day pumping periods and the associated construction and present worth energy costs, and
- recommend the appropriate pumping rate and schedule to be used to obtain the least cost.

Transmission systems to two reservoir sites (Tolay A in South County and Carroll Road in West County) and to the Geysers steamfield recharge were evaluated. Note that this evaluation is to provide a *relative* cost comparison, therefore, evaluation of the three systems is proposed sufficient for this purpose. Flows used in this analysis are based on the flows presented in TM-PS-1 for the delivery system to the reservoirs.

PUMPING ECONOMIC ANALYSIS

The information used in the present worth analysis is shown in Table 1. Two reservoir transmission systems were evaluated for two pumping scenarios as indicated above (Tolay A in South County and Carroll Road in West County). These reservoir sites were selected as representative of the reservoir alignments in the southern and western sections of the county. The Geysers alignment was also evaluated for two pumping scenarios. The major components of each scenario are:

- pumping rate, which impacts the pipe size and pump horsepower requirements, and
- pumping schedule, which impacts the energy costs.

Each reservoir system was evaluated at:

1. Pumping rate of 26 mgd for a pumping schedule of 24 hours a day[1] over a period of five months, either December 1 through April 30 or January 1 through May 31, which represents the period during which reclaimed water will be stored for later use during the irrigation period, at an average energy rate of 0.05880 dollars per kilowatt-hour[2] (which includes peak demand period rates) ($/kW-hr) and

2. Pumping rate of 35 mgd for 18 hours a day[1] over the same period at an average energy rate of 0.05668 $/kW-hr[2] (which does not include peak demand period rates).

The Geysers system was evaluated at:

1. Pumping rate of 26 mgd for a pumping schedule of 24 hours a day[3] over a period of a full year at an energy rate of 0.05837 dollars per kilowatt-hour[4] (which includes peak rates) ($/kW-hr) and

2. Pumping rate of 35 mgd for 18 hours a day[1] over the same period at an energy rate of 0.05545 $/kW-hr[2] (which does not include peak rates).

Under each of these scenarios the pipeline and pump station costs and present worth energy costs were determined for a range of pipe diameters (24-inch, 30-inch, 36-inch, 42-inch, 48-inch, and 54-inch). With the change in pipe size the horsepower requirement changes. As the pipe size increases the cost of the pipe[5] and installation[6] increases, while the pump horsepower requirement and pumping energy cost decreases. At some point, the cost benefit incurred by using a larger pipe and smaller pump station is maximized and the total material cost begins to increase. When the cumulative material cost is plotted, the optimum pipe and pump station size is represented by the low point on the curve. As the pump horsepower requirement decreases, the energy cost to run the pumps decreases. When plotted, the energy cost is a continuous diminishing curve. Plotting the total present worth (material costs and present worth energy costs) yields a curve from

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[1] Pump rate based on information in Parsons ES Draft Technical Memorandum PS-1 dated 8 May 1995.

[2] Energy rates based on information presented in Parsons ES memorandum dated 11 April 1995 and Schedule E-20 from PG&E dated 30 June 1993, attached.

[3] Pump rate based on information in Draft Technical Memorandum PS-1 dated 8 May 1995.

[4] Energy rates based on information presented in memorandum dated 11 April 1995 and Schedule E-20 from PG&E dated 30 June 1993, attached.

[5] Pipe cost for pipe sizes 24-inch to 42-inch were provided by a local vendor. 48-inch and 54-inch pipe costs were extrapolated.

[6] Installation costs include trenching (excavation, backfill, compaction and spoil removal) and bedding costs from Means 1994, corrected for San Francisco and January 1995 ENR.

which the optimum pipeline/pump station can be selected. The low point on this curve is the optimal selection based on cost.

CONCLUSIONS AND RECOMMENDATIONS

Pumping at 26 mgd for a 24 hour period requires a smaller diameter pipeline and smaller pump horsepower requirement than pumping at 35 mgd for 18 hours a day. Thus, the material cost is less for the first scenario. However, at the 24 hour a day pumping schedule the energy rate is higher due to the need for pumping during peak rate hours. This additional energy cost slightly diminishes the benefit of a lower capital cost.

Results of the present worth analysis are shown in Table 1. The present worth analysis is based on an interest rate of 8%, a 20 year period and a net energy rate based on an analysis of rate information provided by PG&E.

Graphical results are shown on Charts 1 through 6. The charts illustrate that material costs are the major factor in the total cost for larger pipelines. Pumping at a higher rate, 35 mgd, significantly increases the capital costs over pumping at a rate of 26 mgd. This higher capital cost is not significantly offset by the reduction in energy cost per hour incurred over the 18 hour pumping schedule. Pumping at 35 mgd for 18 hours a day, 5 months a year, for 20 years results in an energy savings of approximately $170,000, much less than the additional costs incurred by the larger pumps and piping this pumping rate requires. Therefore, the 26 mgd, 24 hour a day pumping scenario will be used for design purposes.

Comparing Chart 1 and 2 for transmission to the Tolay A reservoir, it is seen that the lowest present worth occurs with a 48-inch pipeline and pumping at 26 mgd 24 hours a day (versus pumping at 35 mgd for 18 hours per day). The net savings is $1,924,000.

Likewise, comparing Charts 3 and 4 for transmission to the Carroll Road reservoir, a 48-inch pipeline and pumping at 26 mgd 24 hours per day represents the lowest present worth cost. The net savings for this case is $1,537,000.

Finally, comparing Charts 5 and 6 for transmission to the Geysers steamfield recharge, a 48-inch pipeline and pumping at 26 mgd 24 hours per day represents the lowest present worth cost. The net savings for this case is $4,000,000.

TABLE 1

SELECT ROUTES FOR TRANSMISSION LINES (TL) TO STORAGE

EVALUATION OF PUMPING ALTERNATIVES

												Met'l & Installation Cost						
												Pipe Dia. (in)	Pipe Cost ($/LF)		PW Factor	9.82		
												24	67		I (%)	8		
												30	117		n (years)	20		
												36	121		Pump. Period (yr)	1		
								Pump n	0.8			42	141		Energy ($/kW-hr)	0.0588	with Peak-5 Mo. Period	
			5		120			Motor n	0.92			48	146		Energy ($/kW-hr)	0.05666	without Peak-5 Mo. Period	
			Est.[1]		C = 120							54	161		Energy ($/kW-hr)	0.05837	with Peak-Annual	
															Energy ($/kW-hr)	0.05545	without Peak-Annual	
	Length	Flow	Flow	Flow	Pipe Dia.	Pipe[2]	Unit Loss	Hf	Static Head	TDH	Total Pump	Pipe Cost	Pump Sta.[1,2]	Construction	Energy Use	Energy Cost	PW Energy	Total PW Cost
Reservoir	(Feet)	(MGD)	(GPM)	(CFS)	@ V = 5fps	Diameter	(ft/100ft)	(ft)	(ft)	(ft)	HP	($)	($)	($)	(kW-h/yr)	($/yr)	($)	($)
Alternative 2A																		
Toley A	92,000	26	18,056	36.94	37	24	2.145	1974	195	2169	13,436	6,181,306	15,700,000	21,881,306	36,323,294	2,135,810	20,969,694	42,851,001
(Alt. Align.)						30	0.724	666	195	861	5,337	10,740,224	8,200,000	18,940,224	14,428,164	848,376	8,329,481	27,269,706
						36	0.298	274	195	469	2,908	11,134,580	5,800,000	16,934,580	7,863,112	462,351	4,539,430	21,474,010
						42	0.141	130	195	325	2,011	12,950,454	4,600,000	17,550,454	5,437,412	319,720	3,139,056	20,689,510
						48	0.074	68	195	263	1,627	13,410,454	4,025,000	17,435,454	4,399,860	258,712	2,540,070	19,975,524
						54	0.041	38	195	233	1,444	16,666,688	3,800,000	20,466,688	3,905,204	229,626	2,254,502	22,721,190
Alternative 2A																		
Toley A	92,000	35	24,306	49.72	43	24	3.718	3421	195	3616	30,154	6,181,306	25,000,000	31,181,306	61,140,182	3,465,426	34,024,059	65,205,365
(Alt. Align.)						30	1.256	1155	195	1350	11,259	10,740,224	14,300,000	25,040,224	22,828,725	1,293,932	12,704,016	37,744,241
						36	0.517	476	195	671	5,593	11,134,580	8,400,000	19,534,580	11,341,389	642,830	6,311,399	25,845,979
						42	0.244	225	195	420	3,500	12,950,454	6,600,000	19,550,454	7,096,970	402,256	3,949,411	23,499,865
						48	0.128	117	195	312	2,605	13,410,454	5,550,000	18,960,454	5,261,492	299,355	2,939,111	21,899,565
						54	0.072	66	195	261	2,178	16,666,688	5,075,000	21,741,688	4,415,958	250,296	2,457,448	24,199,136
Alternative 4C																		
Carroll Road	64,500	26	18,056	36.94	37	24	2.145	1384	260	1644	10,183	4,333,633	13,900,000	18,233,633	27,530,625	1,618,801	15,893,624	34,127,258
(Alt. Align.)						30	0.724	467	260	727	4,505	7,529,831	7,200,000	14,729,831	12,180,235	716,198	7,031,736	21,761,567
						36	0.298	192	260	452	2,803	7,806,309	5,800,000	13,606,309	7,577,562	445,561	4,374,580	17,980,889
						42	0.141	91	260	351	2,174	9,079,394	5,075,000	14,154,394	5,876,936	345,564	3,392,797	17,547,191
						48	0.074	47	260	307	1,905	9,401,894	4,510,000	13,911,894	5,149,522	302,792	2,972,855	16,884,749
						54	0.041	27	260	287	1,776	11,684,798	4,250,000	15,934,798	4,902,725	282,400	2,772,647	18,707,445
Alternative 4C																		
Carroll Road	64,500	35	24,306	49.72	43	24	3.718	2398	260	2658	22,168	4,333,633	21,250,000	25,583,633	44,949,276	2,647,725	25,013,939	50,597,572
(Alt. Align.)						30	1.256	810	260	1070	8,922	7,529,831	13,200,000	20,729,831	18,089,613	1,025,319	10,066,735	30,796,567
						36	0.517	334	260	594	4,950	7,806,309	7,700,000	15,506,309	10,035,991	569,840	5,584,955	21,091,263
						42	0.244	158	260	418	3,482	9,079,394	6,525,000	15,604,394	7,060,294	400,177	3,928,996	19,533,390
						48	0.128	82	260	342	2,854	9,401,894	5,800,000	15,201,894	5,787,476	328,034	3,220,688	18,422,582
						54	0.072	46	260	306	2,555	11,684,798	5,500,000	17,184,798	5,180,662	293,640	2,883,000	20,067,798

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EVALUATION OF PUMPING ALTERNATIVES

												Mat'l & Installation Cost					
												Pipe Dia. (in)	Ipe Cost ($/LF)		PW Factor	9.82	
												24	67		i (%)	6	
												30	117		n (years)	20	
												36	121		Pump. Period (yr)	1	
												42	141		Energy ($/kW-hr)	0.0588	with Peak-6 Mo. Period
								Pump n	0.8			48	146		Energy ($/kW-hr)	0.05668	without Peak-6 Mo. Period
				5		120		Motor n	0.92			54	181		Energy ($/kW-hr)	0.05837	with Peak-Annual
				Est.[1]		C = 120									Energy ($/kW-hr)	0.05545	without Peak-Annual
Reservoir	Length (Feet)	Flow (MGD)	Flow (GPM)	Flow (CFS)	Pipe Dia. @ V = 5fps	Pipe[2] Diameter	Unit Loss (ft/100ft)	Hf (ft)	Static Head (ft)	TDH (ft)	Total Pump HP	Pipe Cost ($)	Pump Sta.[1,2] ($)	Construction ($)	Energy Use (kW-h/yr)	Energy Cost ($/yr)	PW Energy ($)	Total PW Cost ($)
The Geysers	179,520	26	18,056	36.94	37	24	2.145	3851	3220	7071	43,808	12,061,610	32,000,000	44,061,610	286,280,583	16,710,198	164,063,184	208,124,793
						30	0.724	1301	3220	4521	28,004	20,957,447	25,000,000	45,957,447	183,007,187	10,682,129	104,878,722	150,836,169
						36	0.298	536	3220	3756	23,260	21,726,954	22,500,000	44,226,954	152,041,615	8,874,669	87,132,809	131,359,763
						42	0.141	253	3220	3473	21,515	25,270,276	21,500,000	46,770,276	140,600,245	8,206,836	80,575,929	127,346,205
						48	0.074	132	3220	3352	20,766	26,167,876	21,000,000	47,167,876	135,706,394	7,921,182	77,771,335	124,939,211
						54	0.041	74	3220	3294	20,409	32,521,781	20,500,000	53,021,781	133,373,237	7,784,996	76,434,237	129,456,018
The Geysers	179,520	35	24,306	49.72	43	24	3.718	6675	3220	9895	82,518	12,061,610	49,000,000	61,061,610	404,440,443	22,426,223	220,183,659	281,245,569
						30	1.256	2254	3220	5474	45,649	20,957,447	34,000,000	54,957,447	223,735,677	12,406,143	121,805,343	176,762,790
						36	0.517	928	3220	4148	34,594	21,726,954	29,500,000	51,226,954	169,553,025	9,401,715	92,307,426	143,534,380
						42	0.244	438	3220	3658	30,509	25,270,276	27,000,000	52,270,276	149,533,252	8,291,619	81,408,336	133,678,612
						48	0.128	229	3220	3449	28,762	26,167,876	26,000,000	52,167,876	140,970,134	7,816,794	76,746,435	128,914,311
						54	0.072	129	3220	3349	27,929	32,521,781	25,000,000	57,521,781	136,887,644	7,590,420	74,523,861	132,045,642

Chart 1
Material vs Energy Costs - Tolay 26 mgd

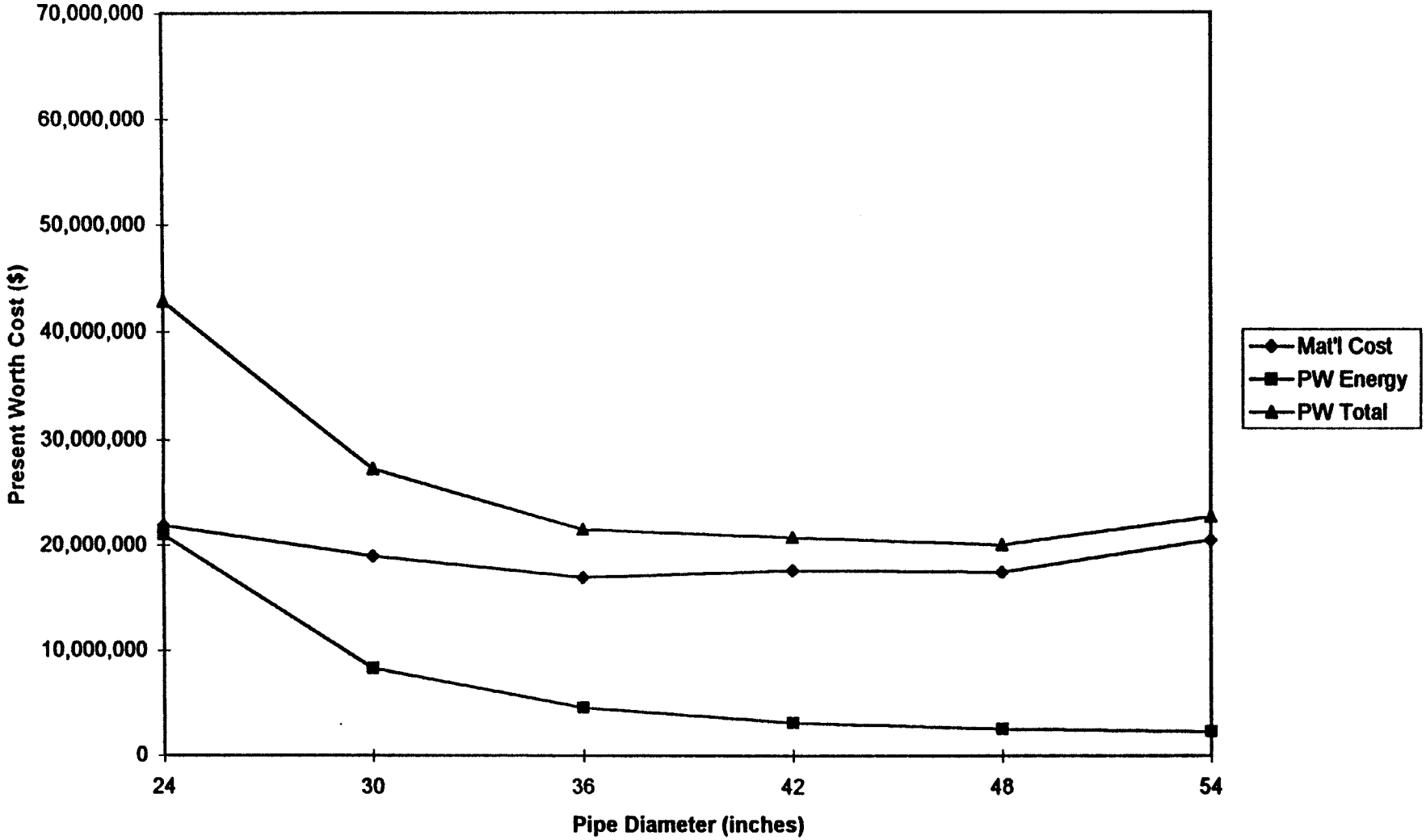

Chart 2
Material vs Energy Costs - Tolay 35 mgd

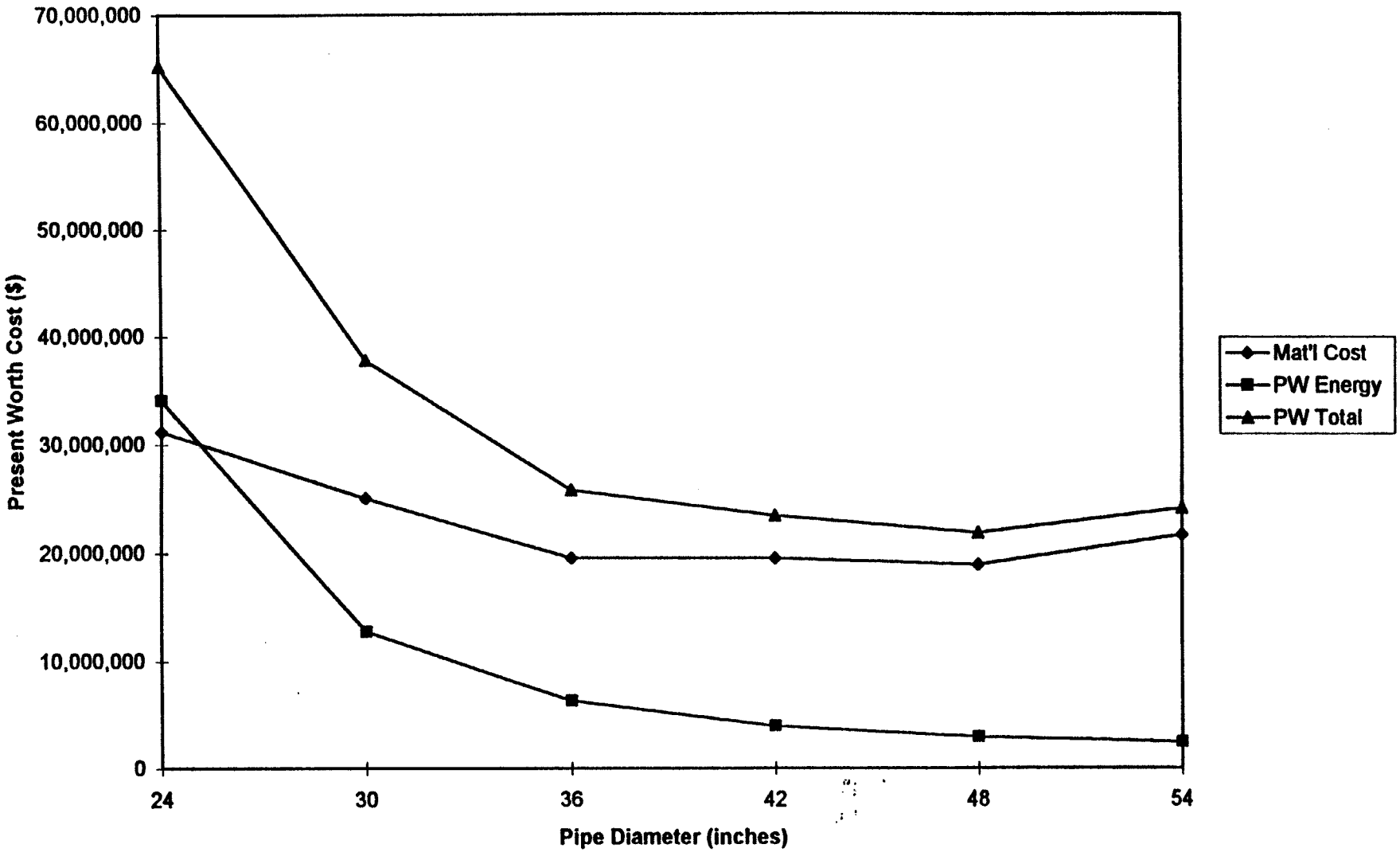

Chart 3
Material vs Energy Costs - Carroll Road 26 mgd

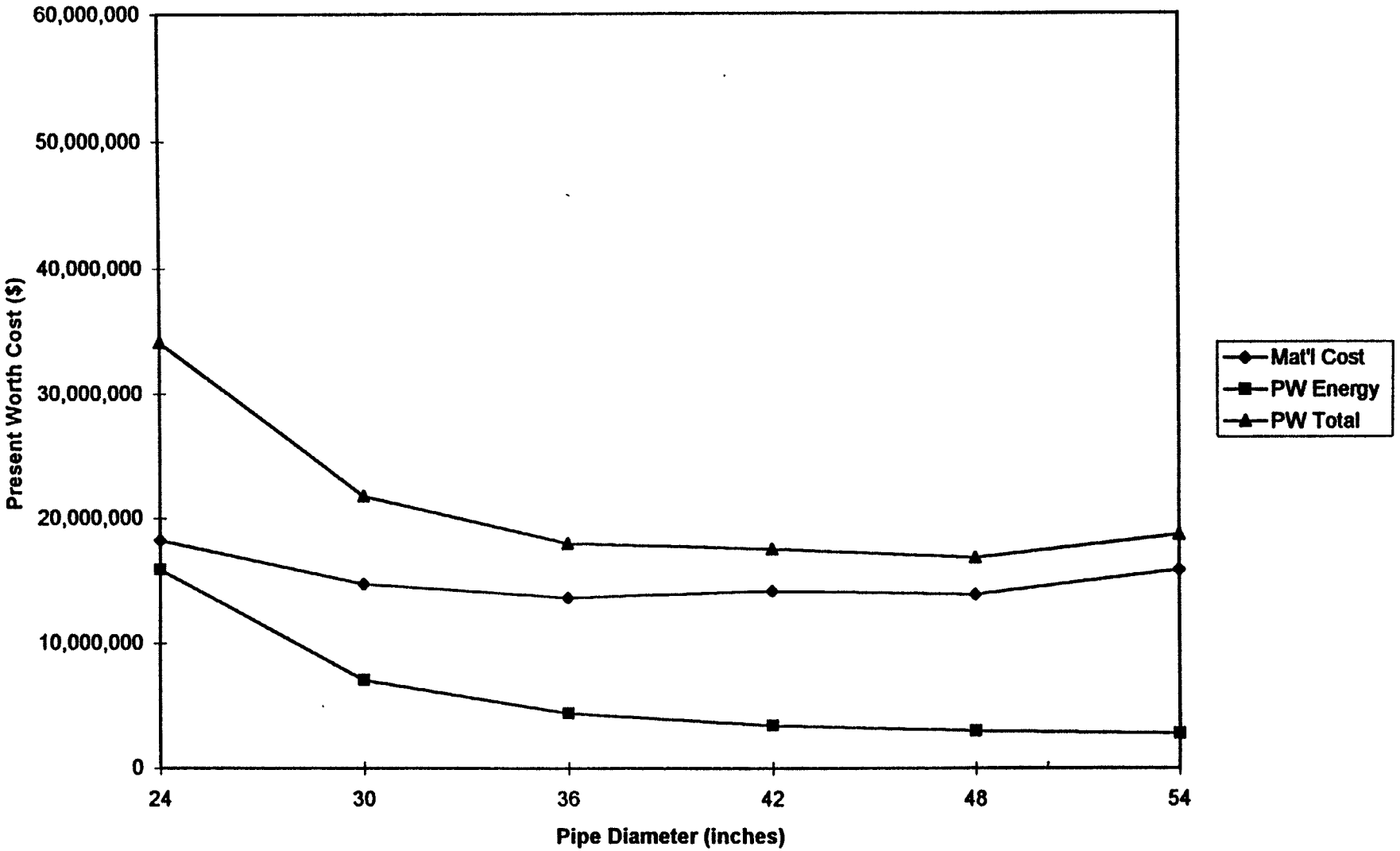

Chart 4
Material vs Energy Costs - Carroll Road 35 mgd

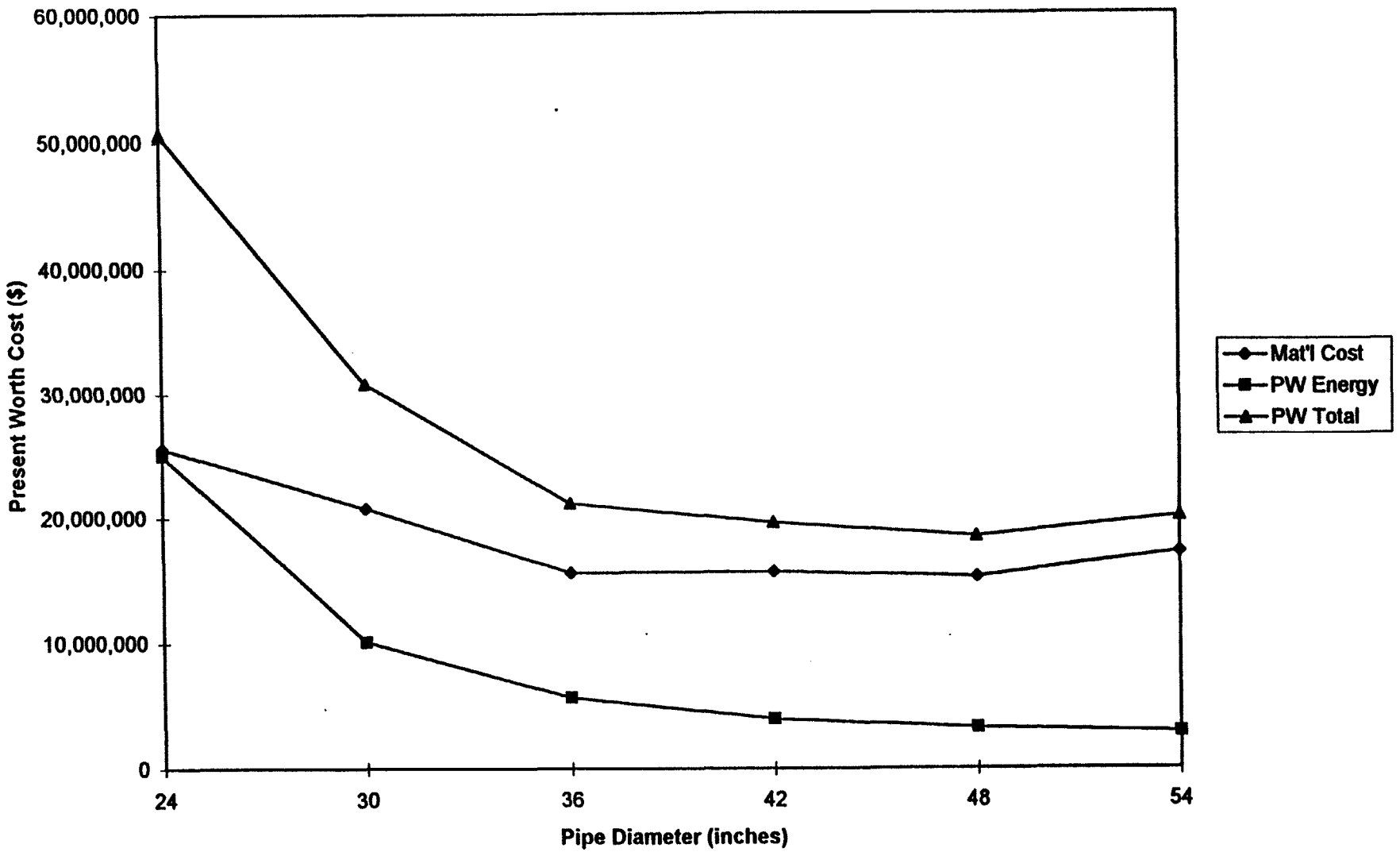

Chart 5
Material vs Energy Costs - The Geysers 26 mgd

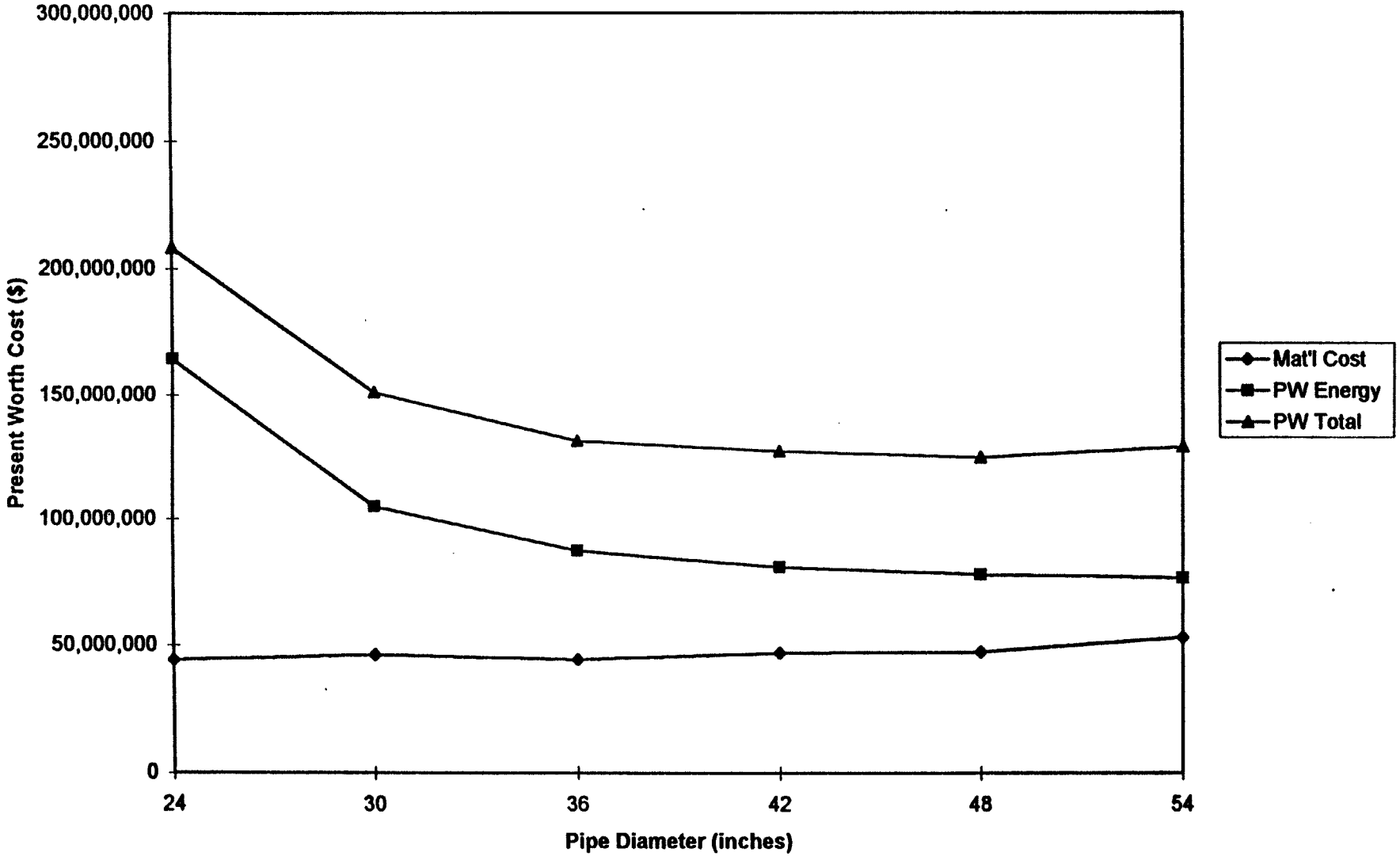

Chart 6
Material vs Energy Costs - The Geysers 35 mgd