Alum is received in bulk granular form by rail car, unloaded by a rubber-tired front end loader and stored in concrete bins. The front end loader or a wheelbarrow is used to haul the granular material from storage to the bucket elevator which transports the alum to two small storage hoppers located above the dissolver type feed system. The Duriron pumps deliver the solution from the dissolver tank through a 4-inch feed line about 680 feet in length to the flash mixing compartment ahead of Basin No. 2. Alum is fed only at times of high raw water turbidity when polymer alone is not adequate.

Cationic polymer is delivered by tank truck and stored in a 7,000 gallon fiberglass tank located in the chemical feed building adjacent to Basins 1 and 2. Polymer is fed primarily at the raw water suction well as a coagulant aid. Because of the distance between the polymer storage tank and the raw water suction well, polymer is loaded into drums from the storage tank and transported to the suction well to supply the metering pumps installed there.

The lime storage and feed system is located in the chemical building next to Basins 1 and 2. Bulk lime is blown into a 60,000 lb. storage bin from delivery trucks. An air transfer system is used to supply the feeders from the storage bins. W&T Gravimetric feeders dissolve the lime and the solution is applied to the inlet of Basin 2 or the inlet to Basin 3. A roller-type hose pump is available to assist in delivering the lime solution and to reduce problems in clogging of the solution hoses. Lime is applied for pH adjustment which is only required during times of high alum usage as dictated by high turbidity in the raw water.

Carbon is received in bags and stored in the chemical feed building adjacent to basins 1 and 2. Bags are loaded manually into the hopper for the bucket elevator which charges the feeder bin. Carbon slurry is delivered by gravity from the feeder to the inlet of basin 1 or basin 2. Carbon is used infrequently, wherever taste and odor problems develop in the raw water. The volume of flow in the Missouri River plus the high velocity of the River rapidly mixes and dissipates most taste and odor problems and few are detectable at the St. Joseph plant intake.

Chlorine is stored and fed at two locations. Ton cylinders are truck delivered to one chlorine room which is situated in part of the filter building. The chlorine scales will handle three ton containers. An evaporator provides gaseous chlorine for five chlorinators at this location. Two 2,000 ppd units supply about one-half of the pre-chlorine need to the inlet of basin no. 3. Two 500 ppd and one 400 ppd units supply post chlorine needs which can be applied either directly after filtration or directly after the clearwater storage tank.

The second chlorinator facility is located in the chemical building adjacent to basins 1 and 2. The chlorine scale room has a triple one-ton cylinder scale. An evaporator feeds two chlorinators, a 1,000 ppd unit and a 2,000 ppd unit which supply about one-half of the pre-chlorine demand to the inlet of basin no. 3. Either of the two chlorination setups can feed the entire pre-chlorine needs in the event of a malfunction at one location.

APPENDIX B

MISSOURI-AMERICAN WATER COMPANY
ST. JOSEPH DISTRICT

TURBIDITY DATA 11/90 - 10/91

MISSOURI-AMERICAN WATER COMPANY
ST. JOSEPH DISTRICT
TURBIDITY DATA 11/90 - 10/91

Date	Low Service Flow 1000 gal	Raw Turbidity JTU	Effluent Turbidities Clarifier NTU	Basin 1 NTU	Basin 2 NTU	Basin 3 NTU
04-Nov-90	13495	89	10	4	3	2
05-Nov-90	17800	93	10	5	3	2
06-Nov-90	18143	100	13	5	3	3
07-Nov-90	15065	100	11	5	3	3
08-Nov-90	18051	103	10	5	3	3
09-Nov-90	18137	96	11	5	3	3
10-Nov-90	13917	88	10	6	2	2
11-Nov-90	15960	96	10	5	3	3
12-Nov-90	14975	92	10	4	3	2
13-Nov-90	18127	103	10	5	3	3
14-Nov-90	18107	105	10	5	3	3
15-Nov-90	18293	94	10	5	3	3
16-Nov-90	15780	88	10	5	3	2
17-Nov-90	16215	84	10	4	3	2
18-Nov-90	13735	79	10	4	3	2
19-Nov-90	17230	74	10	4	3	2
20-Nov-90	17200	78	10	4	3	2
21-Nov-90	17325	79	10	4	2	2
22-Nov-90	12145	84	10	4	2	2
23-Nov-90	14912	86	10	4	2	2
24-Nov-90	16102	83	10	4	3	2
25-Nov-90	13166	80	10	4	2	2
26-Nov-90	18014	72	10	5	3	2
27-Nov-90	16975	165	12	6	3	3
28-Nov-90	15826	124	12	6	4	4
29-Nov-90	17770	403	10	5	3	3
30-Nov-90	15721	78	10	4	3	2

	Low Service	Raw	Effluent Turbidities			
	Flow	Turbidity	Clarifier	Basin 1	Basin 2	Basin 3
Date	1000 gal	JTU	NTU	NTU	NTU	NTU
01-Dec-90	16790	65	11	5	3	3
02-Dec-90	13331	68	10	4	3	2
03-Dec-90	16927	73	10	5	3	3
04-Dec-90	16707	69	10	6	4	3
05-Dec-90	16672	68	10	5	3	3
06-Dec-90	16266	82	10	6	4	3
07-Dec-90	16112	77	10	6	3	3
08-Dec-90	16482	57	10	5	4	3
09-Dec-90	13948	63	10	5	3	3
10-Dec-90	17292	63	10	5	3	3
11-Dec-90	19205	73	10	5	3	3
12-Dec-90	16861	92	10	5	3	3
13-Dec-90	17189	94	10	5	4	3
14-Dec-90	16139	83	10	5	4	3
15-Dec-90	15260	78	10	5	3	3
16-Dec-90	12671	73	10	4	4	3
17-Dec-90	19269	68	10	5	3	3
18-Dec-90	16155	67	10	5	3	3
19-Dec-90	15860	60	10	5	3	3
20-Dec-90	15446	63	10	5	3	3
21-Dec-90	16945	63	10	5	4	3
22-Dec-90	15266	54	12	6	4	3
23-Dec-90	16068	43	10	6	4	3
24-Dec-90	17416	30	10	6	3	3
25-Dec-90	15376	28	10	5	4	3
26-Dec-90	17759	29	10	6	4	3
27-Dec-90	17311	27	10	6	4	4
28-Dec-90	16462	28	10	5	4	4
29-Dec-90	16881	51	14	7	5	4
30-Dec-90	16961	26	10	5	4	4
31-Dec-90	15954	21	10	4	3	3

Date	Low Service Flow 1000 gal	Raw Turbidity JTU	Effluent Turbidities Clarifier NTU	Basin 1 NTU	Basin 2 NTU	Basin 3 NTU
01-Jan-91	15767	17	10	5	4	4
02-Jan-91	16033	15	10	4	3	3
03-Jan-91	17678	15	10	4	3	3
04-Jan-91	17974	17	10	4	3	3
05-Jan-91	16647	15	10	4	3	3
06-Jan-91	15714	15	10	4	3	3
07-Jan-91	15932	15	10	4	3	3
08-Jan-91	17954	15	10	4	3	3
09-Jan-91	17908	14	10	4	3	3
10-Jan-91	18159	9	9	4	3	3
11-Jan-91	18081	9	8	4	3	3
12-Jan-91	15464	9	7	4	3	3
13-Jan-91	14920	10	8	4	3	2
14-Jan-91	18240	9	7	4	3	3
15-Jan-91	15605	10	8	4	3	3
16-Jan-91	18320	10	8	4	3	2
17-Jan-91	18183	10	8	4	3	3
18-Jan-91	17856	10	7	4	3	3
19-Jan-91	14537	10	7	4	3	2
20-Jan-91	14878	16	10	5	4	3
21-Jan-91	17953	29	12	6	5	5
22-Jan-91	15584	18	10	5	4	4
23-Jan-91	18213	16	10	5	3	3
24-Jan-91	18127	17	10	5	3	3
25-Jan-91	15312	15	10	4	3	3
26-Jan-91	18086	15	10	4	3	3
27-Jan-91	12936	15	10	4	3	3
28-Jan-91	18325	15	10	5	4	3
29-Jan-91	17550	17	10	5	3	3
30-Jan-91	16022	17	10	5	3	3
31-Jan-91	18032	15	10	5	4	3

Date	Low Service Flow 1000 gal	Raw Turbidity JTU	Effluent Turbidities Clarifier NTU	Basin 1 NTU	Basin 2 NTU	Basin 3 NTU
01-Feb-91	18216	13	10	4	3	3
02-Feb-91	17436	17	12	4	3	3
03-Feb-91	13958	182	55	29	5	4
04-Feb-91	18054	228	57	49	5	5
05-Feb-91	18024	283	57	53	4	4
06-Feb-91	15503	303	40	37	3	3
07-Feb-91	18350	267	42	38	3	3
08-Feb-91	17992	272	42	39	3	3
09-Feb-91	14628	177	41	33	3	3
10-Feb-91	14205	162	40	32	3	3
11-Feb-91	17976	173	44	34	3	3
12-Feb-91	15099	180	45	38	3	3
13-Feb-91	18350	185	40	36	3	3
14-Feb-91	17925	150	32	32	3	3
15-Feb-91	15693	133	24	20	2	2
16-Feb-91	14193	102	18	13	2	2
17-Feb-91	13133	83	14	9	2	2
18-Feb-91	15374	76	14	9	3	2
19-Feb-91	17415	68	13	8	3	2
20-Feb-91	14899	82	11	7	2	2
21-Feb-91	18162	124	12	7	4	4
22-Feb-91	17008	138	11	7	3	2
23-Feb-91	13339	125	11	7	2	2
24-Feb-91	12975	106	11	8	3	2
25-Feb-91	14944	150	13	7	2	2
26-Feb-91	16655	157	15	9	3	2
27-Feb-91	14054	163	15	11	3	2
28-Feb-91	17645	137	13	11	3	3

Date	Low Service Flow 1000 gal	Raw Turbidity JTU	Effluent Turbidities Clarifier NTU	Basin 1 NTU	Basin 2 NTU	Basin 3 NTU
01-Mar-91	13827	127	11	7	3	2
02-Mar-91	15788	171	10	7	2	2
03-Mar-91	11843	213	10	6	2	2
04-Mar-91	14712	1225	22	16	3	3
05-Mar-91	16942	1742	45	36	4	3
06-Mar-91	13955	1042	47	47	4	4
07-Mar-91	17431	329	27	28	3	3
08-Mar-91	14701	192	14	10	2	2
09-Mar-91	12671	206	11	9	2	2
10-Mar-91	12280	145	10	6	2	1
11-Mar-91	16622	184	11	6	3	3
12-Mar-91	16039	132	11	6	3	3
13-Mar-91	16291	103	10	6	3	3
14-Mar-91	15116	112	10	5	3	2
15-Mar-91	16681	125	10	5	3	2
16-Mar-91	13295	127	10	6	3	2
17-Mar-91	13567	303	15	8	4	3
18-Mar-91	14990	386	15	10	4	4
19-Mar-91	17889	247	12	7	4	3
20-Mar-91	15357	333	13	8	4	3
21-Mar-91	17866	299	19	9	4	4
22-Mar-91	14967	282	14	7	3	2
23-Mar-91	13809	203	10	6	3	2
24-Mar-91	12854	178	10	6	3	2
25-Mar-91	15165	633	12	6	3	2
26-Mar-91	17141	375	15	7	3	2
27-Mar-91	14178	517	12	7	3	2
28-Mar-91	16269	1258	16	11	4	3
29-Mar-91	12381	588	13	9	4	3
30-Mar-91	13600	242	10	6	3	2
31-Mar-91	13564	275	10	6	3	2

Date	Low Service Flow 1000 gal	Raw Turbidity JTU	Effluent Turbidities Clarifier NTU	Basin 1 NTU	Basin 2 NTU	Basin 3 NTU
01-Apr-91	14193	250	10	6	3	2
02-Apr-91	17700	183	10		3	3
03-Apr-91	17129	147	12	5	3	2
04-Apr-91	19896	143	10	5		3
05-Apr-91	17260	127	10	4	2	3
06-Apr-91	18100	119	10	4	2	2
07-Apr-91	12890	117	10	5	2	2
08-Apr-91	17786	115	10	4	2	2
09-Apr-91	17713	99	10	4	3	
10-Apr-91	16790	108	10	4	2	2
11-Apr-91	16183	113	10	4	2	2
12-Apr-91	15027	103	10	4	2	2
13-Apr-91	13325	130	10	5	2	2
14-Apr-91	12259	783	12	6	3	2
15-Apr-91	15971	1950	17	10	4	3
16-Apr-91	17300	2200	24	21	3	3
17-Apr-91	14863	1558	22	18	3	3
18-Apr-91	15391	1200	17	15	3	3
19-Apr-91	17112	1317	13	9	3	2
20-Apr-91	12352	1142	11	9	2	2
21-Apr-91	12300	733	10	6	1	1
22-Apr-91	15843	393	10	5	2	1
23-Apr-91	17962	278	10	5	2	2
24-Apr-91	15083	255	10	5	2	2
25-Apr-91	16159	215	10	5	2	2
26-Apr-91	13895	182	10	5	2	2
27-Apr-91	14539	3833	69	45	4	3
28-Apr-91	13159	892	15	27	3	3
29-Apr-91	15167	1642	22	18	3	2
30-Apr-91	15239	2416	25	20	2	2

Date	Low Service Flow 1000 gal	Raw Turbidity JTU	Effluent Turbidities Clarifier NTU	Basin 1 NTU	Basin 2 NTU	Basin 3 NTU
01-May-91	17962	1233	18	10	3	2
02-May-91	14714	588	11	7	2	2
03-May-91	15863	383	10	5	3	2
04-May-91	11980	350	10	5	3	2
05-May-91	12230	900	14	7	3	2
06-May-91	15161	575	10	7	4	3
07-May-91	17594	460	11	6	3	3
08-May-91	14145	305	10	6	3	2
09-May-91	17762	267	10	6	3	3
10-May-91	14648	312	10	5	2	2
11-May-91	16804	158	10	6	3	2
12-May-91	12053	145	10	4	2	2
13-May-91	15663	150	10	5	2	2
14-May-91	17969	270	10	5	3	2
15-May-91	16665	222	10	6	3	2
16-May-91	14231	156	9	6	3	2
17-May-91	17635	1745	31	14	3	2
18-May-91	14389	2967	64	73	3	3
19-May-91	14013	1304	18	18	3	3
20-May-91	14815	1225	13	8	2	2
21-May-91	17624	1350	14	7	2	2
22-May-91	14535	3167	25	21	3	2
23-May-91	15536	1967	15	15	3	3
24-May-91	14385	983	13	11	2	2
25-May-91	13257	1017	15	9	3	2
26-May-91	14647	2000	26	22	3	2
27-May-91	13727	1125	11	9	2	2
28-May-91	17915	538	10	5	3	2
29-May-91	17911	393	12	5	2	2
30-May-91	15006	700	12	5	2	2
31-May-91	17825	2550	22	16	3	3

Date	Low Service Flow 1000 gal	Raw Turbidity JTU	Effluent Turbidities			
			Clarifier NTU	Basin 1 NTU	Basin 2 NTU	Basin 3 NTU
01-Jun-91	17980	2583	18	13	3	3
02-Jun-91	17534	1650	11	9	3	2
03-Jun-91	15207	3400	32	14	3	2
04-Jun-91	18287	3958	35	37	4	3
05-Jun-91	18183	3317	25	23	2	2
06-Jun-91	18163	1933	15	10	2	2
07-Jun-91	18364	4150	33	24	4	3
08-Jun-91	18013	4642	84	94	4	4
09-Jun-91	14089	3200	55	65	3	3
10-Jun-91	16110	1741	21	25	3	2
11-Jun-91	15012	767	13	10	2	2
12-Jun-91	18090	517	10	7	2	2
13-Jun-91	18319	675	13	8	2	2
14-Jun-91	17858	495	12	7	2	2
15-Jun-91	19975	2983	38	18	3	2
16-Jun-91	19271	6167	193	187	4	4
17-Jun-91	19007	4500	123	137	3	4
18-Jun-91	22196	5417	64	92	3	3
19-Jun-91	22780	3917	32	42	2	2
20-Jun-91	21429	1633	11	8	2	2
21-Jun-91	22239	817	10	6	2	2
22-Jun-91	14854	2100	17	6	2	2
23-Jun-91	15655	1533	24	14	3	3
24-Jun-91	15920	663	10	6	2	2
25-Jun-91	21169	508	11	5	2	2
26-Jun-91	21197	429	12	8	3	2
27-Jun-91	22173	296	11	5	3	2
28-Jun-91	23230	295	11	5	3	2
29-Jun-91	22269	205	10	4	2	2
30-Jun-91	19192	180	10	4	3	2

	Low Service	Raw	Effluent Turbidities			
	Flow	Turbidity	Clarifier	Basin 1	Basin 2	Basin 3
Date	1000 gal	JTU	NTU	NTU	NTU	NTU
01-Jul-91	22186	149	10	4	3	3
02-Jul-91	23220	152	10	4	3	3
03-Jul-91	21006	148	10	4	3	2
04-Jul-91	21631	147	10	4	3	3
05-Jul-91	19703	192	10	5	3	3
06-Jul-91	22642	468	15	7	4	3
07-Jul-91	21641	390	15	6	3	3
08-Jul-91	23191	262	10	5	4	3
09-Jul-91	22368	175	10	4	3	3
10-Jul-91	19999	1517	14	7	3	3
11-Jul-91	16906	1683	14	8	4	3
12-Jul-91	18311	1458	17	10	3	3
13-Jul-91	18356	522	10	6	2	2
14-Jul-91	17528	265	10	4	2	1
15-Jul-91	18765	182	10	5	3	2
16-Jul-91	21778	167	10	5	2	2
17-Jul-91	23225	126	10	4	4	3
18-Jul-91	22893	110	10	5	3	3
19-Jul-91	23377	113	10	5	4	3
20-Jul-91	25618	106	10	4	3	3
21-Jul-91	19421	92	10	4	3	3
22-Jul-91	23133	131	11	4	3	3
23-Jul-91	23184	177	10	5	3	3
24-Jul-91	21540	233	10	5	3	3
25-Jul-91	22436	113	10	5	3	3
26-Jul-91	25460	94	10	4	3	3
27-Jul-91	19873	92	10	4	3	3
28-Jul-91	18498	95	10	4	3	3
29-Jul-91	21872	93	8	4	3	3
30-Jul-91	23220	83	7	4	3	3
31-Jul-91	20345	82	8	4	3	3

Date	Low Service Flow 1000 gal	Raw Turbidity JTU	Effluent Turbidities Clarifier NTU	Basin 1 NTU	Basin 2 NTU	Basin 3 NTU
01-Aug-91	22194	83	7	4	3	3
02-Aug-91	23301	88	6	4	3	3
03-Aug-91	22309	81	6	4	3	3
04-Aug-91	16435	75	5	4	2	2
05-Aug-91	19594	76	6	4	3	2
06-Aug-91	21510	79	6	4	3	3
07-Aug-91	21986	73	6	4	3	3
08-Aug-91	21660	77	6	4	3	3
09-Aug-91	17985	82	6	5	3	3
10-Aug-91	18137	95	6	4	3	2
11-Aug-91	14560	110	7	5	2	2
12-Aug-91	19341	123	7	5	3	3
13-Aug-91	21355	113	7	5	3	3
14-Aug-91	21569	100	8	5	3	3
15-Aug-91	21247	96	6	5	3	3
16-Aug-91	21584	87	7	5	3	3
17-Aug-91	21131	78	6	4	3	3
18-Aug-91	21253	77	6	4	3	3
19-Aug-91	19151	172	7	5	3	3
20-Aug-91	21477	125	7	5	3	3
21-Aug-91	22130	93	7	5	3	3
22-Aug-91	23454	79	7	4	4	3
23-Aug-91	23120	75	6	4	4	3
24-Aug-91	21466	68	5	3	3	3
25-Aug-91	21270	63	5	3	3	3
26-Aug-91	20726	64	5	3	3	3
27-Aug-91	23120	62	4	3	2	3
28-Aug-91	23260	58	5	3	2	2
29-Aug-91	21833	63	5	4	3	2
30-Aug-91	21788	65	5	3	3	3
31-Aug-91	21680	56	5	3	3	3

Date	Low Service Flow 1000 gal	Raw Turbidity JTU	Effluent Turbidities Clarifier NTU	Basin 1 NTU	Basin 2 NTU	Basin 3 NTU
01-Sep-91	18429	59	5	3	3	3
02-Sep-91	17921	65	5	4	3	3
03-Sep-91	19837	90	7	4	3	2
04-Sep-91	21371	72	7	4	3	2
05-Sep-91	21451	62	6	4	3	2
06-Sep-91	21785	58	5	4	2	2
07-Sep-91	21360	56	5	4	2	2
08-Sep-91	20177	58	6	4	2	2
09-Sep-91	18390	108	6	4	3	2
10-Sep-91	21055	123	7	4	2	2
11-Sep-91	21128	90	7	4	2	2
12-Sep-91	21430	69	7	4	3	2
13-Sep-91	23075	96	7	4	3	3
14-Sep-91	18988	106	7	5	2	2
15-Sep-91	15539	81	6	4	3	2
16-Sep-91	18103	78	7	5	3	3
17-Sep-91	18038	81	7	5	3	3
18-Sep-91	18231	67	7	5	3	2
19-Sep-91	18048	68	7	5	3	3
20-Sep-91	21468	75	7	5	3	3
21-Sep-91	18341	80	7	5	3	3
22-Sep-91	15085	81	8	5	3	3
23-Sep-91	18770	89	8	5	3	3
24-Sep-91	20834	87	8	5	3	3
25-Sep-91	18161	82	8	5	3	3
26-Sep-91	21271	78	7	5	3	3
27-Sep-91	21582	77	7	5	3	3
28-Sep-91	18604	81	7	5	3	3
29-Sep-91	20672	68	7	5	3	3
30-Sep-91	19638	71	8	5	3	3

Date	Low Service Flow 1000 gal	Raw Turbidity JTU	Effluent Turbidities Clarifier NTU	Basin 1 NTU	Basin 2 NTU	Basin 3 NTU
01–Oct–91	21598	72	7	5	3	3
02–Oct–91	21548	75	7	5	3	3
03–Oct–91	20154	83	7	5	3	3
04–Oct–91	16461	94	7	5	3	3
05–Oct–91	17738	71	8	5	3	3
06–Oct–91	13911	68	6	5	2	2
07–Oct–91	17912	70	7	5	3	2
08–Oct–91	18068	73	7	5	3	2
09–Oct–91	18671	66	7	5	3	3
10–Oct–91	21341	61	6	4	3	3
11–Oct–91	19217	64	7	5	3	2
12–Oct–91	19384	69	7	5	3	3
13–Oct–91	14642	74	6	4	2	2
14–Oct–91	18555	71	7	5	3	3
15–Oct–91	20161	63	7	5	3	3
16–Oct–91	18093	61	8	6	3	3
17–Oct–91	19900	60	7	5	3	3
18–Oct–91	20856	57	7	5	3	3
19–Oct–91	17605	58	7	5	3	3
20–Oct–91	13785	61	7	4	3	2
21–Oct–91	20204	71	7	5	3	3
22–Oct–91	17869	67	7	4	3	2
23–Oct–91	21512	64	7	5	3	2
24–Oct–91	18194	68	7	5	3	2
25–Oct–91	15904	70	7	5	3	2
26–Oct–91	17386	72	7	5	3	2
27–Oct–91	15413	67	7	4	3	2
28–Oct–91	16164	65	7	4	2	2
29–Oct–91	18322	68	8	5	3	2
30–Oct–91	17988	69	8	5	3	2
31–Oct–91	17894	68	8	5	3	3
01–Nov–91	15983	103	9	5	3	3
02–Nov–91	18019	150	14	7	4	3

APPENDIX C

CORRESPONDENCE FROM MISSOURI DNR
dated February 11, 1991

JOHN ASHCROFT
Governor

G. TRACY MEHAN III
Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Divisionof Parks, Recreation,
and Historic Preservation

P.O. Box 176
Jefferson City, MO 65102

MO-American Water Co.
St. Joseph, MO
Review No. 1897-91

February 11, 1991

Mr. H. W. Cole
American Water Works Service Company
St. Joseph Water Company
2707 Pembroke Lane
St. Joseph, MO 64506

Dear Mr. Cole:

An engineering report for a multi-phase water treatment plant improvements for the American Water Company in St. Joseph, Missouri, has been reviewed. The proposed phases of improvements are: Phase-1, replacing filter media of the existing filters, installing filter effluent turbidimeters, and using a streaming monitor to assist in coagulation control; Phase-2, replacing the existing secondary stage sedimentation basins with superpulsator solids contact clarifiers and improving pretreatment chemical applications; Phase-3, adding four filters with combined capacity of 12 MGD (million gallons per day), a clearwell, transfer pump station, and laboratory/support building and; Phase-4, adding six more filters with a combined capacity of 18 MGD to improve the reliability and performance of the treatment plant. The report was examined as to sanitary features which may affect the operation of the project, including size, capacities of units, and factors which may affect efficiency and ease of operation.

Our experience with solids contact units used as secondary stage treatment has not been favorable. Tentative approval of the engineering report is hereby given pending completion of the proposed pilot test using superpulsator solids contact units as second stage treatment to the existing primary clarifiers.

Should results of the pilot test are favorable, you may proceed to arrange for financing of the proposed improvements and have your engineer prepare detailed plans and specifications for our review and approval. An addendum to this engineering report evaluating the data gathered from the pilot test must be submitted with the detailed plans and specifications.

Regulations require written approval of detailed plans and specifications prior to initiating construction of the proposed improvements. Upon receipt of the detailed plans and specifications, we will proceed with our review and advise you by written report of our approval. An updated engineering report must be submitted before final plans and specifications will be reviewed if the original report is more than two years old.

Sincerely,

PUBLIC DRINKING WATER PROGRAM

Rolando A. Bernabe

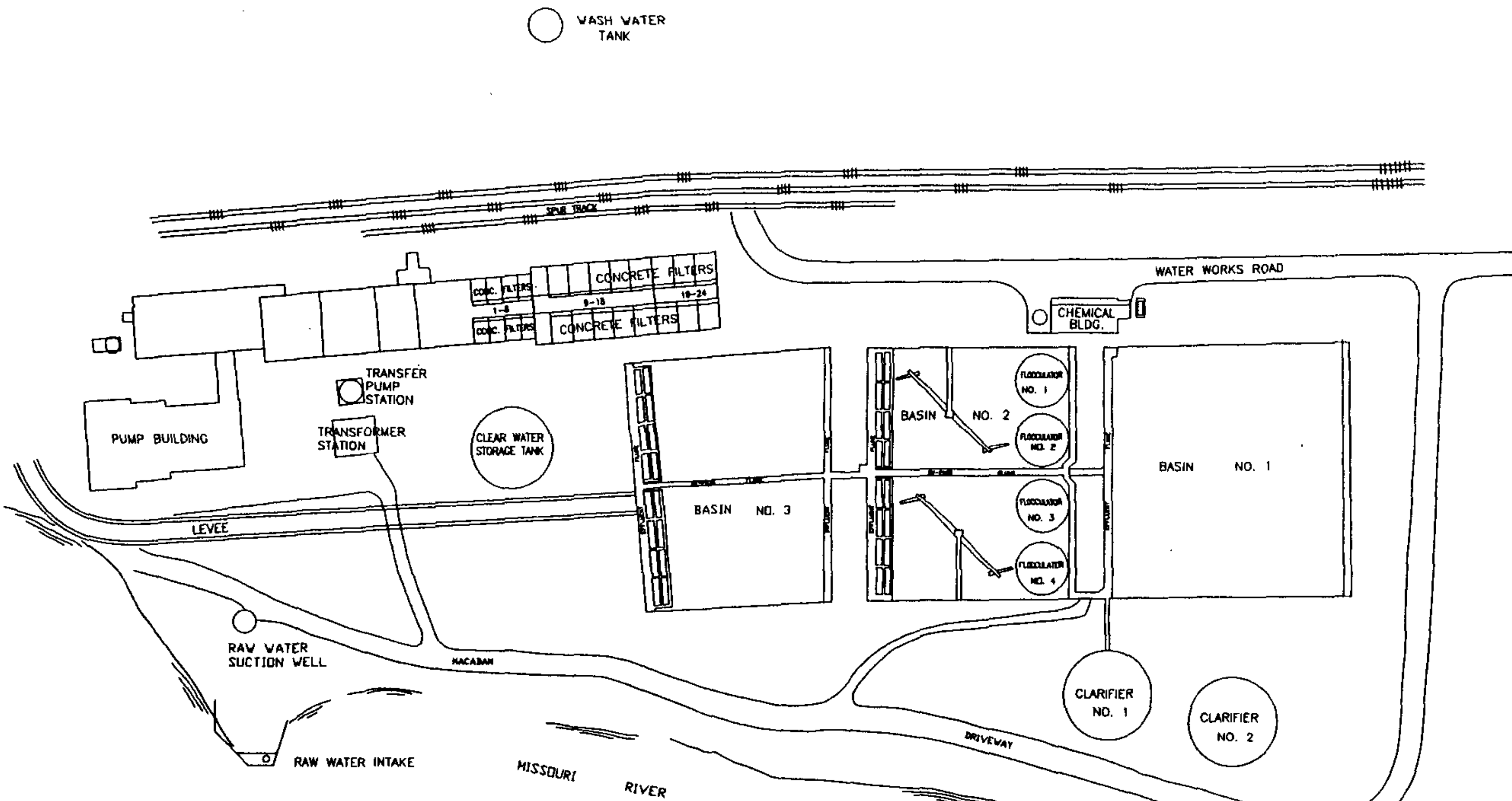
Rolando A. Bernabe
Environmental Engineer

RAB:be

cc: Mr. Steven E. Creel
Kansas City Regional Office
Public Service Commission
Water Pollution Control Program

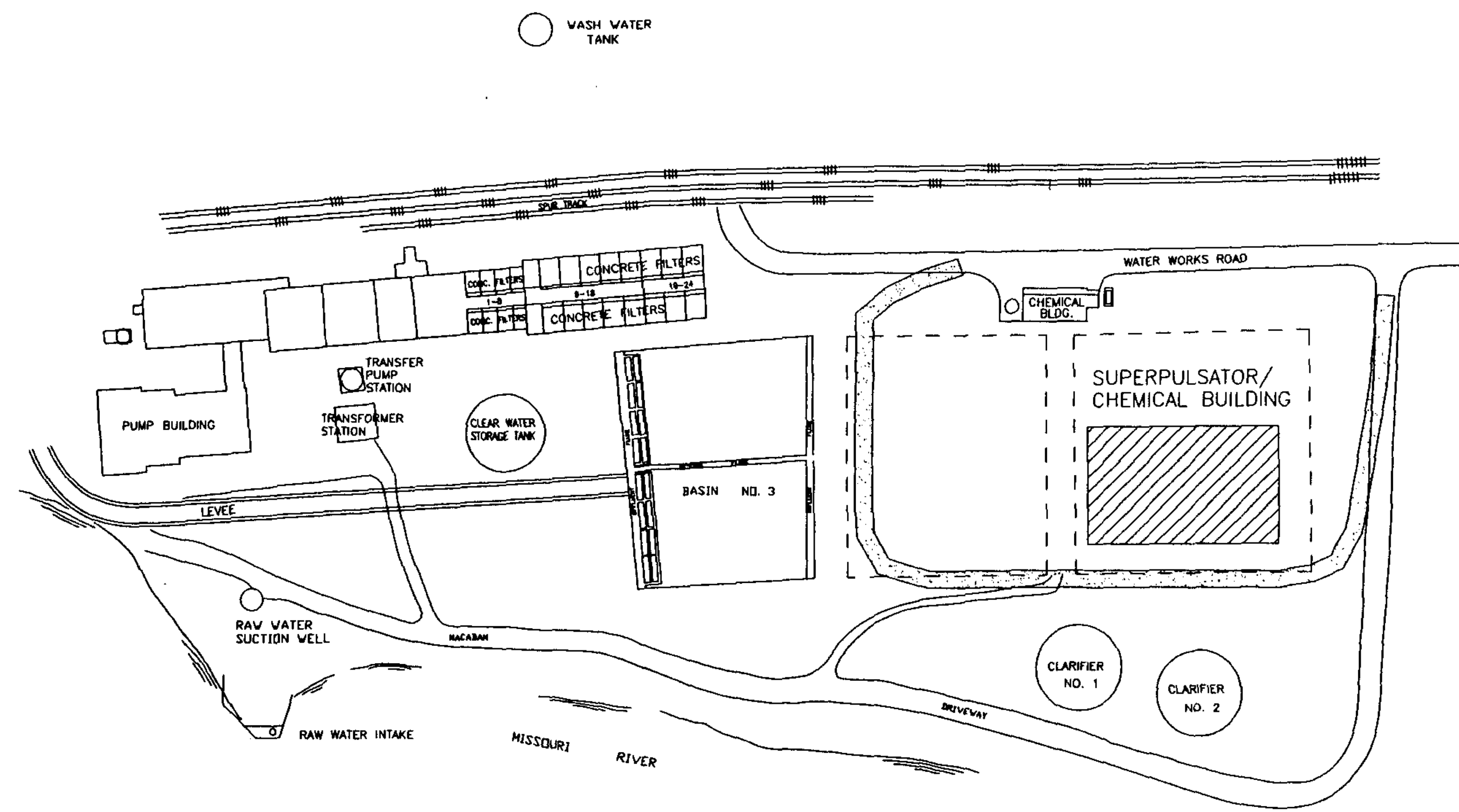
APPENDIX D

CONCEPTUAL SITE PLANS



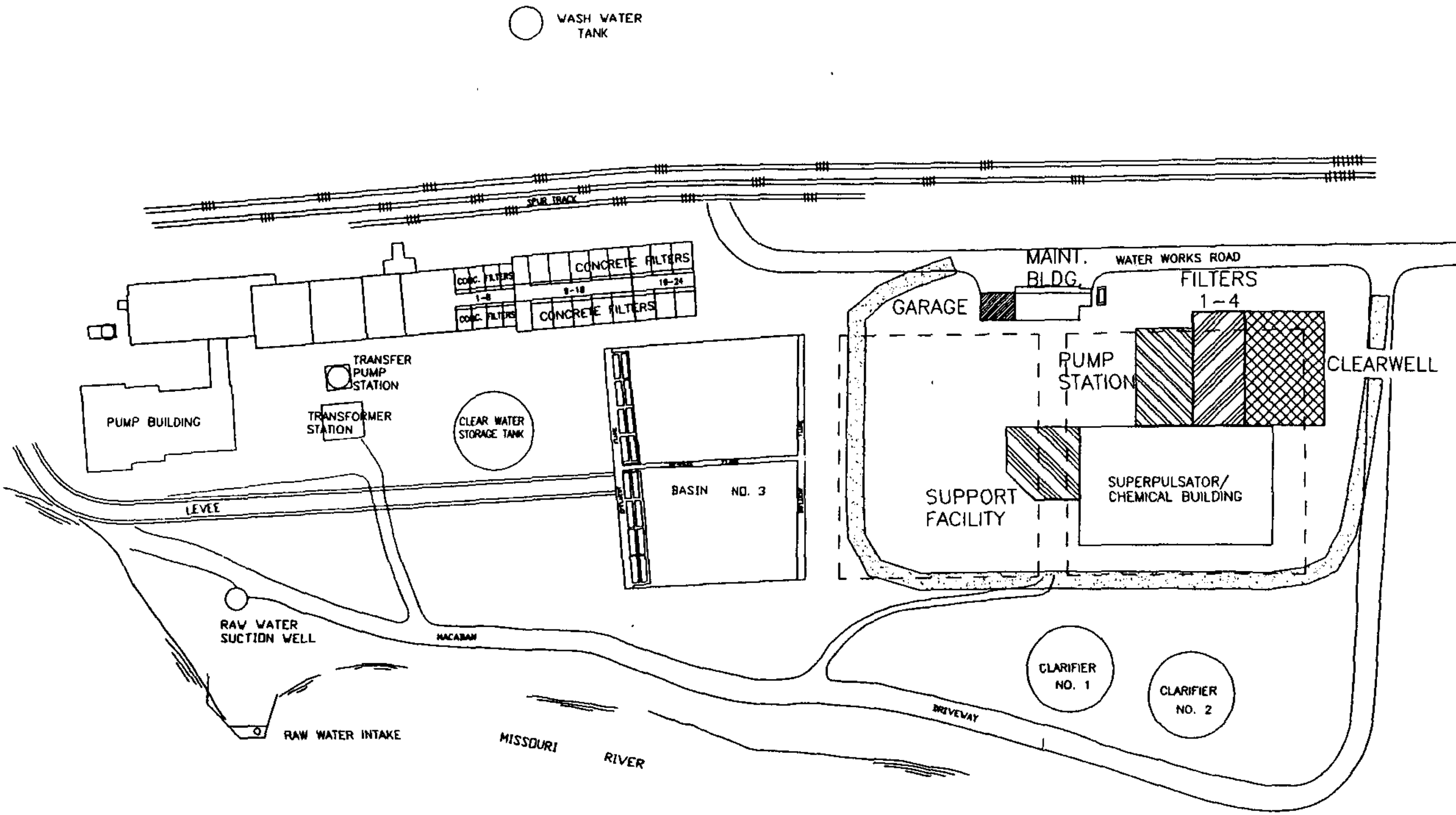
MISSOURI-AMERICAN WATER COMPANY
ST. JOSEPH DISTRICT
TREATMENT PLANT IMPROVEMENTS

EXISTING SITE PLAN



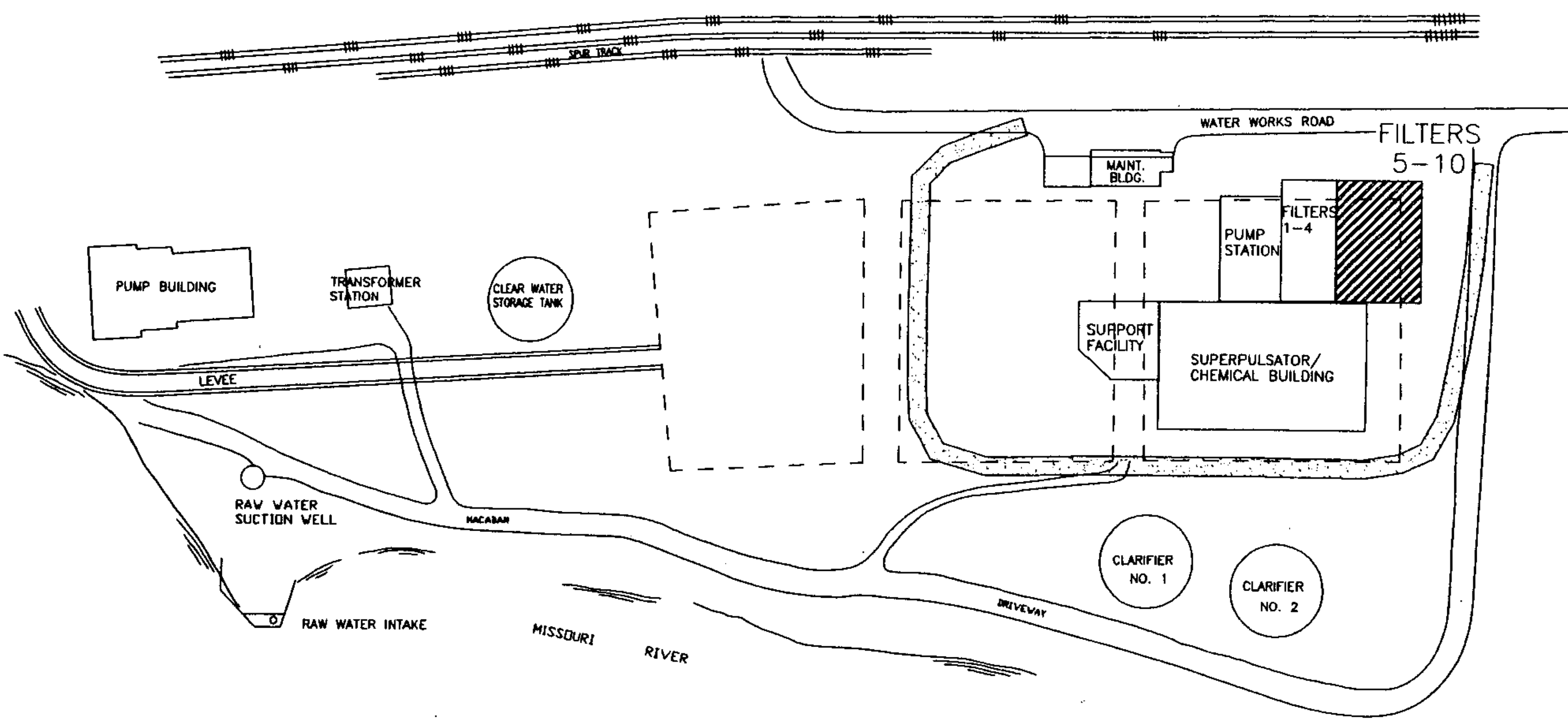
MISSOURI-AMERICAN WATER COMPANY
ST. JOSEPH DISTRICT
TREATMENT PLANT IMPROVEMENTS

PHASE 1 - CONCEPTUAL SITE PLAN



MISSOURI-AMERICAN WATER COMPANY
ST. JOSEPH DISTRICT
TREATMENT PLANT IMPROVEMENTS

PHASE 2 - CONCEPTUAL SITE PLAN



MISSOURI-AMERICAN WATER COMPANY
ST. JOSEPH DISTRICT
TREATMENT PLANT IMPROVEMENTS

PHASE 3 - CONCEPTUAL SITE PLAN

APPENDIX E

PROPOSED PILOT TESTING PROTOCOL

SUPERPULSATOR PILOT PROTOCOL

PURPOSE

The pilot testing program is intended to demonstrate the effectiveness of the Superpulsator in treating water from the Missouri River at St. Joseph. The study will:

A. Evaluate alum and iron based coagulants

B. Evaluate polymer coagulants

C. Evaluate sludge blanket control polymers

D. Evaluate treatment results with a range of influent turbidities

E. Evaluate the impact of start-ups and shut-downs on the process

F. Evaluate the impact of hydraulic flow changes on effluent quality

G. Compare treatment results to existing plant results

H. Evaluate the impact of maintaining powdered activated carbon in the sludge blanket for taste and odor control and pesticide removal

I. Evaluate filtered water quality using pilot filters with media configurations matching those of the existing plant and the proposed GAC filters

J. Determine the characteristics of the sludge blowdown, including it's dewaterability.

EQUIPMENT

A steel pilot unit with dimensions of 16 feet deep with 16 square feet surface area at the water line will be used. Individual chemical feed facilities will be provided for the pilot unit. The unit will be installed on a concrete pad, and enclosed within a temporary structure to prevent freezing of sample lines, etc.

OPERATION

A three-month pilot operation is planned for April through June, 1992. The study period will target cool water conditions in early spring and the high turbidities that are common in June. The pilot plant will be operated 24 hours per day, 5 days per week. A dedicated operator will be provided to operate the pilot plant during the day. The plant filtermen will make spot checks on the unit when the operator is not present.

The unit will be operated at a rate of 64 gpm which produces a surface loading rate of 4 gpm/sf. The pilot unit will be fed with the effluent of the first stage clarifiers. Special trials will use the unclarified raw water as influent to evaluate operation with high turbidities.

The following parameters will be monitored in the influent water: turbidity, pH, alkalinity and temperature. Clarifier effluent will be monitored by continuous turbidimeter, and by hourly grab sample also. Flow and effluent pH will be monitored on a two-hour frequency. Additional special testing will be performed on an as-needed basis to monitor pesticides, and trihalomethane formation potential. Filter effluent turbidity will be monitored with continuous turbidimeters and grab samples.

APPENDIX G

AWWS ENGINEERING STANDARD FOR LIQUID CHEMICAL FEED SYSTEMS

AMERICAN WATER SYSTEM

ENGINEERING STANDARDS

T-2 LIQUID CHEMICAL STORAGE, FEED AND CONTAINMENT

Prepared by: S.E. Cruel

Director:

Vice-President: John J. Young

Date: 4.10.92

Liquid Chemical Storage, Feed and Containment

INTRODUCTION

Background

Water treatment chemicals are generally stored and fed in a concentrated form with many being strong acids or bases. While these chemicals are necessary to provide a safe potable water, mismanagement of the chemicals can have injurious consequences to the water consumer, company personnel, and the environment. In addition, many of these chemicals can damage company facilities if the proper equipment and safeguards are not provided.

Scope

This Standard covers the design of liquid chemical storage, feed, and containment facilities. The standard is meant to be used by engineers and other experienced personnel in the basic design and modification of liquid chemical systems. Selecting materials of construction and sizing of components are two examples where technical expertise is required.

The contents of the Standard go beyond the minimum requirements of Ten State Standards by providing increased protection to consumers, company personnel, water company facilities, and the environment.

Purpose

An engineering standard is necessary to accurately demonstrate the required features of liquid chemical systems to consultants and water company staff involved in maintaining, modifying, and installing such systems. The Standard's goal is to minimize risk to consumers, workers, and the environment by presenting a standardized, proven method of storing, feeding, and containing liquid chemicals. Alternative designs must be carefully evaluated against the Standard before implementation and must not increase the risk of accidental chemical release, or increase the likelihood of human or environmental exposure to the chemical.

REFERENCE

1. Recommended Standards for Water Works (Ten State Standards)

TECHNICAL CONTENTS

Liquid Chemical System Elements

Description of Liquid Chemical System Elements

1. Materials of Construction

Materials used in chemical systems for tanks, piping, fittings, gaskets, hoses, protective coatings, in-situ instrumentation, etc. must be appropriately selected for each chemical. Material selection charts, chemical suppliers, and equipment vendors are a good source of chemical resistance information. Some water treatment chemicals may be mixtures, or may contain impurities that can increase corrosivity.

2. Identification

Identification of tanks, piping, and other equipment is necessary to make operators, maintenance personnel, and other workers aware of the chemicals being handled. Identification of chemicals and availability of material safety data sheets (MSDS) is an Occupational Safety and Health Act (OSHA) requirement as well as a state requirement in many cases.

Storage tanks and tank fill lines must be identified with signage identifying the useable capacity of the tank, contents of the tank, chemical hazards, and recommended safety gear.

Access to the fill connection for bulk tanks be must be restricted to prevent unintentional filling. Suggested hardware includes uniquely keyed locks through the fill connection flange or locked covers over the connection.

Piping is to be color coded according to Ten State Standards and identified with labels indicating the chemical with arrows pointing in the normal direction of flow. Pumps are to be identified to avoid possible confusion during operation or maintenance.

3. Bulk Storage Tanks

Bulk storage tanks are provided where the chemical consumption justifies bulk storage over drum storage, or where the chemical being handled is particularly corrosive and handling of drums would be a safety hazard. Bulk storage tanks are generally sized for 31 days of storage at a maximum dose and average treated water flow, or average dose and maximum treated water flow, whichever is larger. Alternatively, sizing is to be 125 - 150 % of a bulk shipment of chemical. Federal, state, and local regulations governing chemical storage may also be a factor in sizing bulk storage tank capacities.

Bulk storage tanks shall be constructed of high density cross linked polyethylene (HDXLPE) or be an appropriately lined steel tank. Fittings for HDXLPE tanks shall be bolted through the wall style with appropriate bolt and gasket materials. Storage tanks are to be equipped with a fill line, vent line, overflow, and discharge connection. Other accessories include nozzles for continuous level measurement, high level indication, and gasketed hatch. The function of the hatch is primarily for tank inspection, rather than tank entry. A means of access to the hatch, such as a ladder, should be provided.

Continuous tank level indication is to be provided. It is recommended that low level and high level alarms should also be provided which operate off the continuous tank level indicator. An independent high level switch indicating imminent tank overflow is required with local audible alarms that can be heard at the filling station. The high level switch, independent of the continuous level monitor, is required because of concern for the potential for miscalibration of the continuous level system resulting in a chemical overflow.

Tank overflow must be directed to secondary containment. In cases where the chemical has suspected corrosive or injurious vapors or mists, the overflow pipe must be fitted with a low headloss, vaportight check valve (contract System Engineering for recommendation) to allow overflow while preventing the discharge of vapors.

All chemicals with the potential for corrosive or injurious vapors or mists are to be vented to the exterior. In general, this includes all chemicals except polymers. The vent line shall not function as the overflow.

It is recommended a remotely actuated valve be installed on or near the tank outlet to allow the bulk tank to be safely isolated in the event of a leak. Without such a valve, personnel would be required to enter the containment area to operate a manual isolation valve which could expose personnel to considerable safety hazards.

4. Transfer Pumps

Transfer pumps are to be provided to deliver chemical from bulk tanks to day tanks or batch tanks. Transfer pumps provide control and safety in the transfer process as flow can be halted eclectically from outside of the containment area. Transfer pumps may be of several types; centrifugal, positive displacement, drum pumps for small systems, etc. Redundant installed pumps are recommended. Where only one transfer pump is installed, a second pump is to be held in inventory as a spare. A bypass around the transfer pump is not allowed, as it defeats the purpose of the transfer pumps.

Continuous local operator supervision of the transfer process is required. Typically, this is accomplished with a hold-to-run (momentary contact) pushbutton switch. Any deviation from this approach must be reviewed with System Engineering. Transfer pumps are typically sized to fill the day tank within five minutes to avoid operator fatigue.

Discharge piping from the transfer pumps is to be configured to prevent gravity flow or siphonage from the bulk tank. See the schematic in Appendix A for the recommended piping configuration.

5. Day Tanks

A day tank is a refillable storage vessel smaller than a bulk storage tank, which directly supplies metering pumps. Day tanks serve two purposes; (1) To allow accurate determinations of chemical use, and (2) to minimize the volume of chemical which can be accidently discharged into the treated water.

Day tanks are required when bulk storage is provided.

Day tank sizing is to be based on 125 % (including freeboard) of the daily volumetric requirements of the maximum dose for the average daily treated water volume, or the average dose for the maximum treated water volume.

Day tanks are to be equipped with a vented fill line, vent line, overflow, drain, and discharge connection. Other accessories include continuous measurement of level or weight, and an independent high level switch or probe. With many chemicals it is beneficial to provide a sight glass which can be cleaned to indicate liquid level.

All chemicals with the potential for corrosive or injurious vapors or mists are to be vented to the exterior. In general, this includes all chemicals except polymers. In cases where the chemical has suspected corrosive or injurious vapors or mists, the overflow is to be fitted with a low headloss, vaportight check valve (see System Engineering for recommendation) to allow overflow while preventing the discharge of vapors.

Continuous level or weight monitoring is recommended with alarms for high and low level in the day tank. An independent high level switch indicating imminent tank overflow is required, with local audible alarm.

The day tank fill line is to be piped and vented to prevent the possibility of gravity flow or siphonage from the bulk tank to the day tank. See the schematic in the Appendix A for recommended piping configuration.

6. Metering Pumps

Redundant metering pumps are recommended. Where only one pump is installed, a second pump is to be held in inventory as a spare.

A calibration cylinder is to be provided on the suction side of the metering pumps to permit accurate determination of the pump's delivery rate.

Metering pumps that have the ability to produce pressures higher than the piping system can withstand, such as motor driven positive displacement metering pumps, must have a pressure relief valve on the discharge of each pump head. No valve may be located between the pump and the pressure relief valve.

Where pumps are feeding against low pressure, a backpressure/anti-siphon valve must be provided to help the pump deliver accurately, and prevent siphoning or gravity flow through the metering pump.

7. Special Valves

Special valves are needed to prevent siphonage, maintain backpressure, and provide pressure relief.

Backpressure Valve

A backpressure valve maintains a steady backpressure against a metering pump to ensure accurate delivery. A second function is to help prevent siphonage or gravity flow of chemicals from the day tank through the metering pump.

The backpressure valve consists of an adjustable spring loaded diaphragm and seat. The anti-siphon action is lost if the seat becomes fouled. Therefore the backpressure valve requires preventive maintenance and periodic testing.

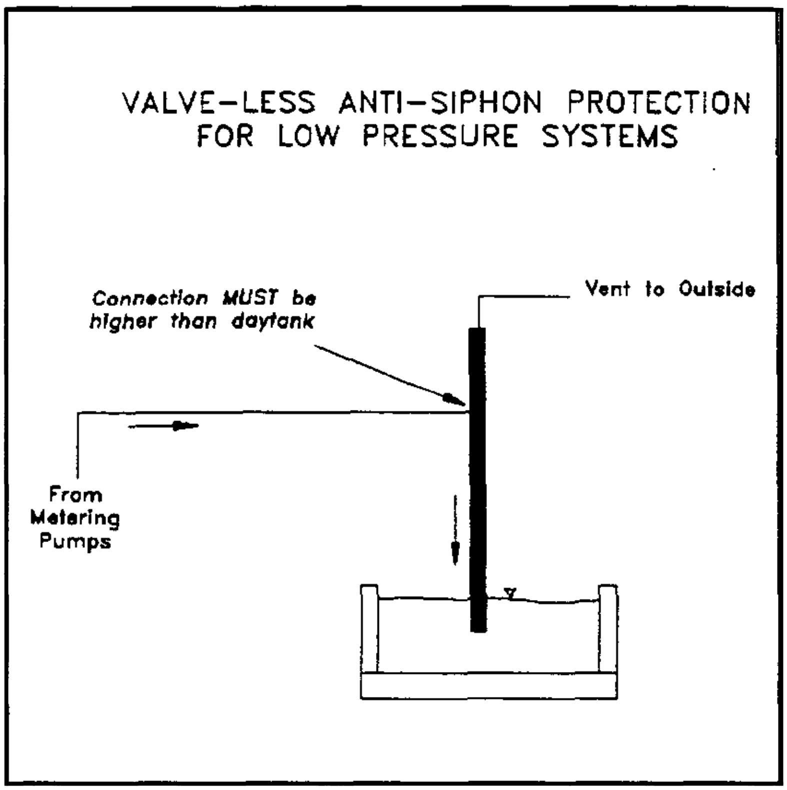
Pressure Relief Valve

Where positive displacement metering pumps capable of pipe bursting pressure are used, a pressure relief valve is to be used upstream of the first valve on the metering pump discharge. The discharge of the pressure relief valve is to be directed to the day tank or drum. Some pressure relief valves also have a bypass feature to assist in priming the pump.

Anti-siphon Valve

Anti-siphon protection is required for all liquid chemical discharge lines, regardless of normal operating pressure. Negative pressures can be produced in normally pressurized lines due to power failures, draining of lines, inadvertent valve operation, etc. and anti-siphon protection is particularly vital during upset conditions.

The surest means of providing anti-siphon protection is a physical siphon break as shown below. However, this arragement is practical only for negative head or low head conditions. This arrangement is not suitable for chemicals that may plug feed lines.



Where the physical siphon break cannot be used because of discharge pressure, an anti-siphon valve is necessary. The anti-siphon valve consists of a spring loaded diaphragm and seat. The anti-siphon action is lost if the seat becomes fouled. Therefore, the valve requires preventive maintenance including periodic testing.

For low pressure conditions where the physical siphon break cannot be used, the anti-siphon valve will be used in series with a backpressure valve which also provides anti-siphon action. The intent is to use these devices to provide at least two barriers to siphoning or gravity flow of chemical from the day tank through the metering pump.

Four-Way Valve

Several vendors manufacture a four function valve which provides anti-siphon, backpressure, priming, and pressure relief action. The valve can replace separate pressure relief and backpressure valves. This valve is limited to low capacity metering pumps.

8. Feeding From Drums

In low capacity systems where both bulk tanks and day tanks are not used, the chemical may be fed directly from a non-refillable drum. A weighing scale shall be used to monitor the quantity of material remaining in the drum. It is recommended the system be equipped with a low weight alarm.

Adequate ventilation must be provided for drum feed areas. Separate rooms may be necessary for fuming chemicals such as hydrofluosilic acid because drum systems cannot be sealed and vented as well as bulk and day tank systems.

The weight of drums typically presents safety concerns in handling. Where drums are used, it is recommended drum handling equipment be provided to minimize the risks associated with moving drums. Such equipment includes hoists, pallet trucks, and dollies. It is recommended that training be provided on the proper operation of this equipment.

See the secondary containment requirements for drums in Item 10.

9. Inventory Monitoring

A reliable and accurate means of monitoring inventory is required for bulk tanks, day tanks, and drums. Typically, a continuous level probe is used for this purpose in tanks. However, in a manned station, a sight glass may be sufficient for this purpose. In all cases, a means of physically verifying liquid level is required to perform physical inventory, and calibrate level instrumentation.

Weighing scales may be used for monitoring inventory. States may require day tanks for fluoride be placed on scales. Some disadvantages of scales are that scale platforms are typically placed within the containment area and are susceptible to chemical spills. The use of weighing scales also requires flexible connections for all piping connections. Additionally, a tare weight for the tank must be used to show net weight.

10. Secondary Containment

Primary containment is defined as the container holding the chemical. Secondary containment is the structure designated to hold spillage or leakage.

Secondary containment is to be provided for all bulk tanks, day tanks, batch tanks, metering pumps, and transfer pumps. Experience has shown that pipe connections to tanks and equipment are most prone to leakage. The function of secondary containment is to keep the spilled chemical within a confined area isolated from other processes and chemicals where it can be cleaned up. Therefore, a common or directly interconnected containment area is recommended for all components of a chemical feed system.

Minimum secondary containment volume is to be determined based on 110 percent of the largest storage tank capacity within the containment area. Freeboard should be added to the calculated minimum containment volume.

The secondary containment structure must be protected with a coating or liner if the chemical is corrosive to the containment structure.

Secondary containment is to be provided for all drums. The containment volume must hold 110 percent of the contents of the largest drum.

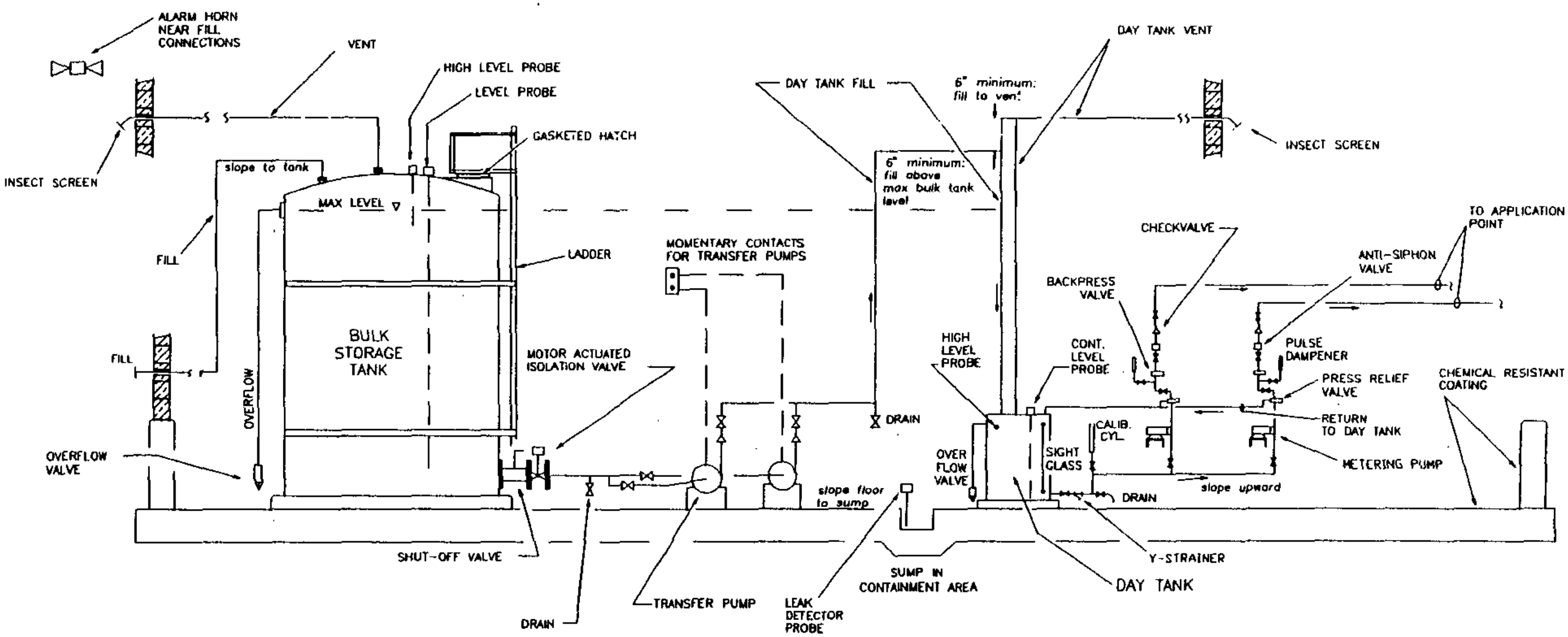
11. Dilution Water

Any water supply connected to a chemical system must have proper backflow protection. For filling of batch tanks, an air gap may be used. For direct connection to batch tanks or chemical piping, reduced pressure zone type backflow preventers must be used.

Continuous dilution water is sometimes recommended to improve dispersion at the feed point, to dilute the concentrated chemical to a more practical concentration, or where the chemical output is very low. Dilution water flow must be controlled as variations in flow will cause variations in feed rate. Also, the flow of dilution water must be known to enable setting a desired dilution rate. It is recommended that a solenoid valve be placed on the water supply line that would close if a leak was detected to prevent filling a containment area with dilution water.

12. Leak Detection

It is recommended that both manned and unmanned chemical feed systems be equipped with a sump equipped with a level switch to signal the occurrence of a leak. It is important that personnel be alerted of a leak as soon as possible. Further, it is recommended the leak sensor be electrically interlocked with the isolation valve on the bulk storage tank, the transfer pumps, metering pumps, and solenoid valves on the chemical feed water supply. Upon detection of a leak the valves should close and pumps should stop, until the leak condition is locally acknowledged.



NOTES:

1. This schematic diagram is an appendix to AMERICAN WATER SYSTEM ENGINEERING STANDARD B-2 for LIQUID CHEMICAL STORAGE, FEED, AND CONTAINMENT. Refer to the Standard for specific requirements.

REVISIONS

APPENDIX A
BULK LIQUID CHEMICAL SYSTEM STANDARD SCHEMATIC

ENGINEERING STANDARD T-2

AMERICAN WATER WORKS SERVICE COMPANY, INC.
SYSTEM ENGINEERING

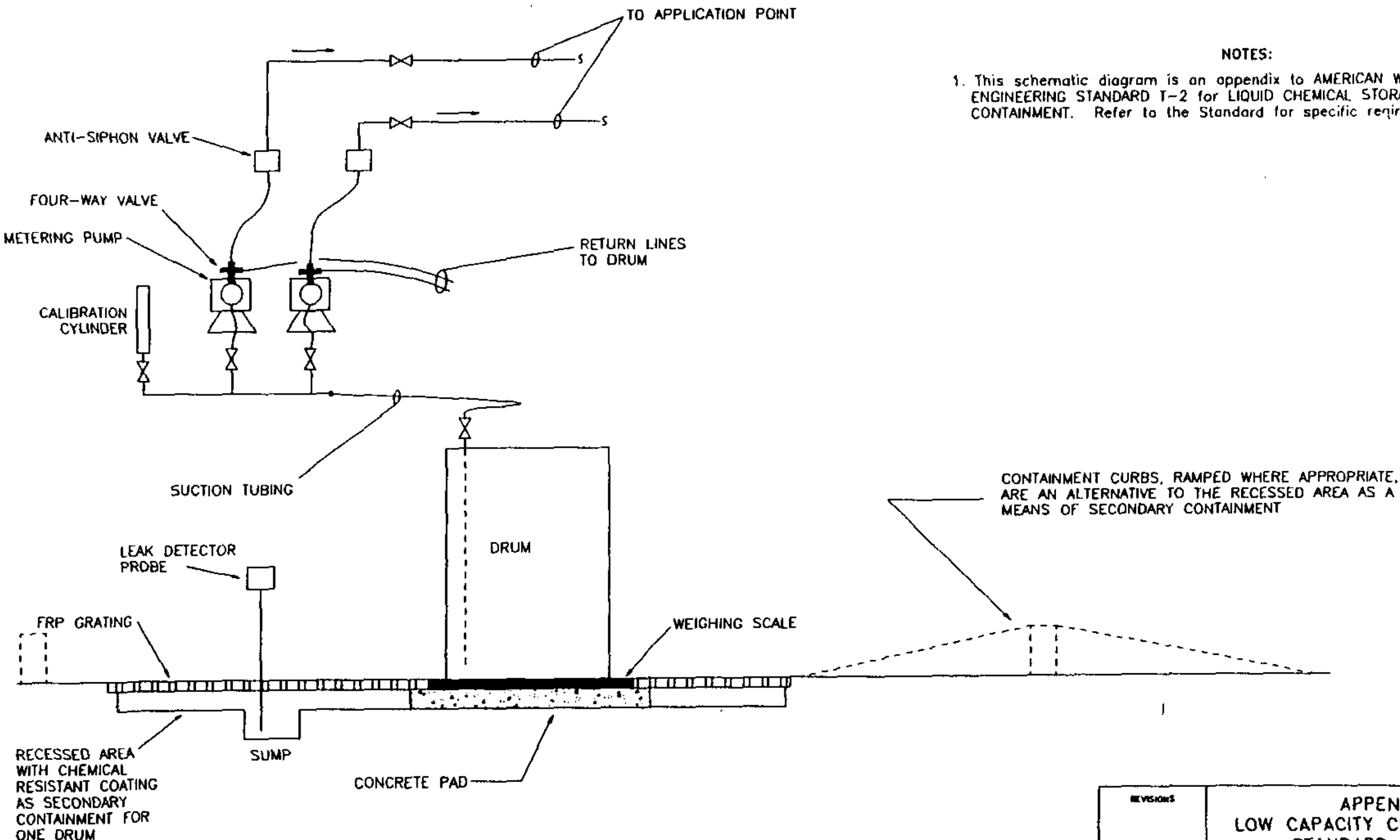
1025 LAUREL OAK RD. VOORHEES, N.J. 08043

DRAWN BY
PROJECT ENG'R
APPROVED

DATE 4-10-92
PROJECT

USE DIMENSIONS ONLY
SCALE NONE

USE APPROVED DRAWINGS ONLY FOR CONSTRUCTION PURPOSES



NOTES:

1. This schematic diagram is an appendix to AMERICAN WATER SYSTEM ENGINEERING STANDARD T-2 for LIQUID CHEMICAL STORAGE, FEED, AND CONTAINMENT. Refer to the Standard for specific reqirements.

REVISIONS

APPENDIX B
LOW CAPACITY CHEMICAL SYSTEM STANDARD SCHEMATIC

ENGINEERING STANDARD T-2

AMERICAN WATER WORKS SERVICE COMPANY, INC.
SYSTEM ENGINEERING

1025 LAUREL OAK RD. VOORHEES, N.J. 08043

DRAWN BY
PROJECT ENG'R
APPROVED

DATE 4-10-92
PROJECT

USE DIMENSIONS ONLY
SCALE NONE

USE APPROVED DRAWINGS ONLY FOR CONSTRUCTION PURPOSES

APPENDIX H

SOIL BORING REPORT
CHEMICAL BUILDING - 1967

FOUNDATION BORINGS AND TESTING
ENGINEERING ANALYSES AND REPORTS
CONSTRUCTION QUALITY CONTROL
INSPECTION DESIGN

Cable: SOILENG – NORTHBROOK

Chicago Phone: 273-5440
Northbrook Phone: 272-6520

SOIL TESTING SERVICES, INC.

111 PFINGSTEN ROAD NORTHBROOK, ILL. 60062

ADDRESS REPLY TO: P.O. BOX 266 NORTHBROOK, ILL. 60062

January 5, 1967

American Water Works Company
310 Penn Center Plaza
Philadelphia, Pennsylvania 19102

Attention: Mr. Lino Gomes

STS Job No. 8908-D

Reference: Final Report for Subsurface Investigation for the proposed Chemical Building at the St. Joseph Water Company Plant at St. Joseph, Missouri

Gentlemen:

We are submitting, herewith, the results of the subsurface investigation and the final soil report for the above project.

If there are any questions with regard to the report, or if we can be of further service to you in any way, please do not hesitate to contact us.

Very truly yours,

SOIL TESTING SERVICES, INC.

Clyde N. Baker, Jr.
Registered Professional Engineer
Illinois

John P. Gnaedinger
Registered Professional Engineer
Missouri

CNB:em

INTRODUCTION

The subsurface investigation for the proposed chemical building at the St. Joseph Water Company Plant site in St. Joseph, Missouri, has been completed. Three (3) soil borings out of an initially proposed five soil borings were performed and the boring logs, along with a location diagram, are included in this report. A rearrangement of the borings, including elimination of two borings, was made because of accessibility problems. The inaccessible borings were the ones located closest to the existing basin and up on the berm for the basin.

It is our understanding that the proposed structure will be two stories in height without a basement. Maximum column load is anticipated to be on the order of 200 kips.

The purpose of this report is to describe the soil conditions encountered, to analyze the results obtained, and to make recommendations regarding feasible foundation design and construction.

SUBSURFACE INVESTIGATION PROCEDURES

The soil borings were performed with a CME truck-mounted power auger rig using continuous flight augers to advance the holes. Both split-barrel and shelby tube sampling procedures were used in the borings in accordance with ASTM Specifications D 1586-64T and D 1587-63T, respectively. The standard penetration resistance values (blows per foot of a 140 lb. hammer falling 30" on a 2" o.d. split-barrel sampler) obtained during split-barrel sampling are noted on the boring logs and may be taken as an indication of the relative density of the soil in place.

In the shelby tube sampling procedure, thin wall steel seamless tubes with sharp cutting edges were pushed hydraulically into the soil and relatively undisturbed samples obtained. All soil samples were sealed in the field and returned to the laboratory for further examination, testing, and reclassification where necessary. The samples were classified in accordance with the Unified Soil Classification system and the Unified Soil Classification symbols are noted in parentheses at the end of the soil description on the boring logs. Copies of the Unified Soil Classification system are included in the appendix of this report.

TESTING PROGRAM

The testing program consisted of performing unconfined compression, water content, penetrometer and density tests on representative samples taken from the shelby tubes and water content and penetrometer tests on representative cohesive split-barrel samples. The penetrometer test is a test in which the unconfined compressive strength of cohesive material can be estimated by the sample's resistance to penetration of a small spring-calibrated cylinder. All these test results are noted on the boring logs in the appendix.

In addition, two consolidation tests were performed on representative samples taken from 3" diameter shelby tubes. The samples were selected in an attempt to be representative of the average material located in the probable zone of stress influence beneath possible footing foundations. Liquid and plastic limit tests were also performed on these samples. The results of these tests are noted on separate figures in the appendix. One consolidation test was performed on material in the depth range of 8' to 10' at the boring #1 location. Unfortunately, it was not possible to carry this consolidation test to as high a loading condition as initially planned because of squeezing of the sample noted around the porous stone when the loading increment from 2½ to 5 kilograms per square centimeter was made. This sample was particularly plastic as noted by the very high liquid limit of 63%, although the initial moisture content was only 38%. Fortunately, the test was carried far enough to get a good indication of the preconsolidation pressure for the sample.

The second consolidation test was performed on the sample from boring #1 from a depth of 13' to 15'. This sample was less plastic and no squeezing problem was noted.

The preconsolidation pressure estimated from the consolidation test varied from more than 2 tsf for the sample in the depth range of 8' to 10' to 1.5 tsf for the sample in the depth range of 13' to 15'. Thus, for stress conditions less than the maximum past preconsolidation pressure, field consolidation should be small.

SOIL CONDITIONS

As indicated on the boring logs, the soil conditions vary moderately, particularly up to a depth of about 11'. In general, there appears to be a layer of surface clayey silt fill mixed with some cinders and rubble extending to depths varying from 2' to 3½', immediately underlain by predominantly tough silty clay or clayey silt to a depth on the order of 11'. The clay is of high plasticity and high water content and contains soft pockets. The clayey silt is of lower plasticity but also has an appreciable water content.

Below a depth of about 11', softer but less plastic clayey silt was encountered extending to depths on the order of 28' to 30' below which there is an appreciable increase in strength of the clayey deposit. Below depths on the order of 46' to 48', the clay becomes generally very tough to hard as indicated by high penetration resistance and high penetrometer values. The unconfined compressive strength values do not appear to be as high as the penetrometer values and this is due to failure at low strains because of gravel pieces or silt and sand seams within the clayey samples. Limestone gravel was noted within the clay below depths on the order of 30'. In the one boring that was extended below a depth of 50', shale was encountered at a depth of 51' and this shale extended to the end of the boring at a depth of 67'.

WATER TABLE CONDITIONS

Water level measurements taken during and after boring operations are noted on the boring logs. Since no drilling water was used in the boring operations, the observed water levels represent actual ground water encountered.

These water level measurements indicate a ground water table at the time of boring operations in the depth range of 9' to 11'. Fluctuations in the water table level can be anticipated throughout the years with variations in precipitation, runoff, and surface evaporation.

ANALYSIS AND RECOMMENDATIONS

On the basis of available soil information, foundation alternates consisting of footings, drilled caissons, and piles have been considered for support of the proposed structure.

Footings

If a moderate amount of settlement can be tolerated for the proposed structure, footing foundations located beneath the surface fill on the tough silty clay or loose clayey silt is possible using a maximum net allowable soil bearing pressure of 2,000 psf. Assuming column loads on the order of 200 kips, we estimate settlement on the order of 1". This settlement will be due primarily to reconsolidation of the clayey soils since the preconsolidation pressure indicated is equal to or greater than the proposed induced stress. With a 200 kip column load, a 10' x 10' footing would result and footing foundations may not be as economical as other foundation alternates. Footing excavations should be inspected by a qualified soil engineer prior to pouring of concrete in order to verify that soil conditions are as anticipated in the design.

Drilled Caissons

A preferred solution for the support of the proposed structure would be drilled caissons extended to the hard clay in the depth range of 46' to

48', where a maximum net allowable soil bearing pressure of 9,000 psf is recommended. If the caissons are extended down to the underlying shale, a net allowable soil bearing pressure of 15 tsf could be used. For this latter case, it might be possible to use straight shaft caissons since the size of the required bearing area would be much reduced.

Because of water seepage problems and the need to prevent cave-ins, steel casing would probably be required extended down to the top of the bell in the case of belled caissons, or extended down to shale in the case of straight shaft caissons to rock. If casing is used, and it is desired to retrieve the casing, particular care should be taken to make certain that the concrete does not tend to hang up with the casing when the casing is pulled. All caisson excavations and casing-pulling operations should be inspected by an experienced soil engineer to verify that conditions are as anticipated in the design.

Pile Foundations

Another foundation possibility would be intrusion piles or another type of augered pile extended down to the hard clay or down to the shale. Considerable side friction can be included in determining the pile capacity. We recommend assuming an available side friction of 1,000 psf in the tough clay below depths on the order of 27' and 2,500 psf in the very tough to hard clay below depths on the order of 43'. Driven piles could also be used although the presence of the adjacent basin structure raises a concern for possible vibration damage during driving. All pile installation operations should also be inspected by an experienced soil engineer to verify that conditions are as anticipated in the design.

General

With regard to first floor slab support, we recommend that the existing surface clayey silt fill be proofrolled with the heaviest available equipment to achieve any additional densification possible and to point out any overly soft spots that cannot be satisfactorily densified. Any overly soft spots should be removed and replaced with suitable fill properly compacted. Fill should be placed in lifts not exceeding 9" in loose thickness and should be compacted to a minimum of 90% of maximum density as determined by ASTM Specification D 1557-64T for floor loadings up to 500 psf and to 95% of maximum density for floor loadings 500 psf or greater.

With regard to the question of the magnitude of passive pressure available for thrust blocks at pressure pipe elbows, we understand that normal piping depth would be on the order of 3' to 4' or near the base of the surface fill or in the underlying loose clayey silt or tough silty clay. Considering the poorest soil conditions encountered and assuming that a minimum of movement is desired to develop sufficient resistance, we recommend assuming an available pressure of 500 psf. This figure would include a factor of safety of 2. Since this is based on the assumed worst condition, this value could be increased moderately for assumed average conditions. If a typical fairly clean sand backfill is used for the piping, a friction coefficient on the piping of 0.5 can conservatively be assumed.

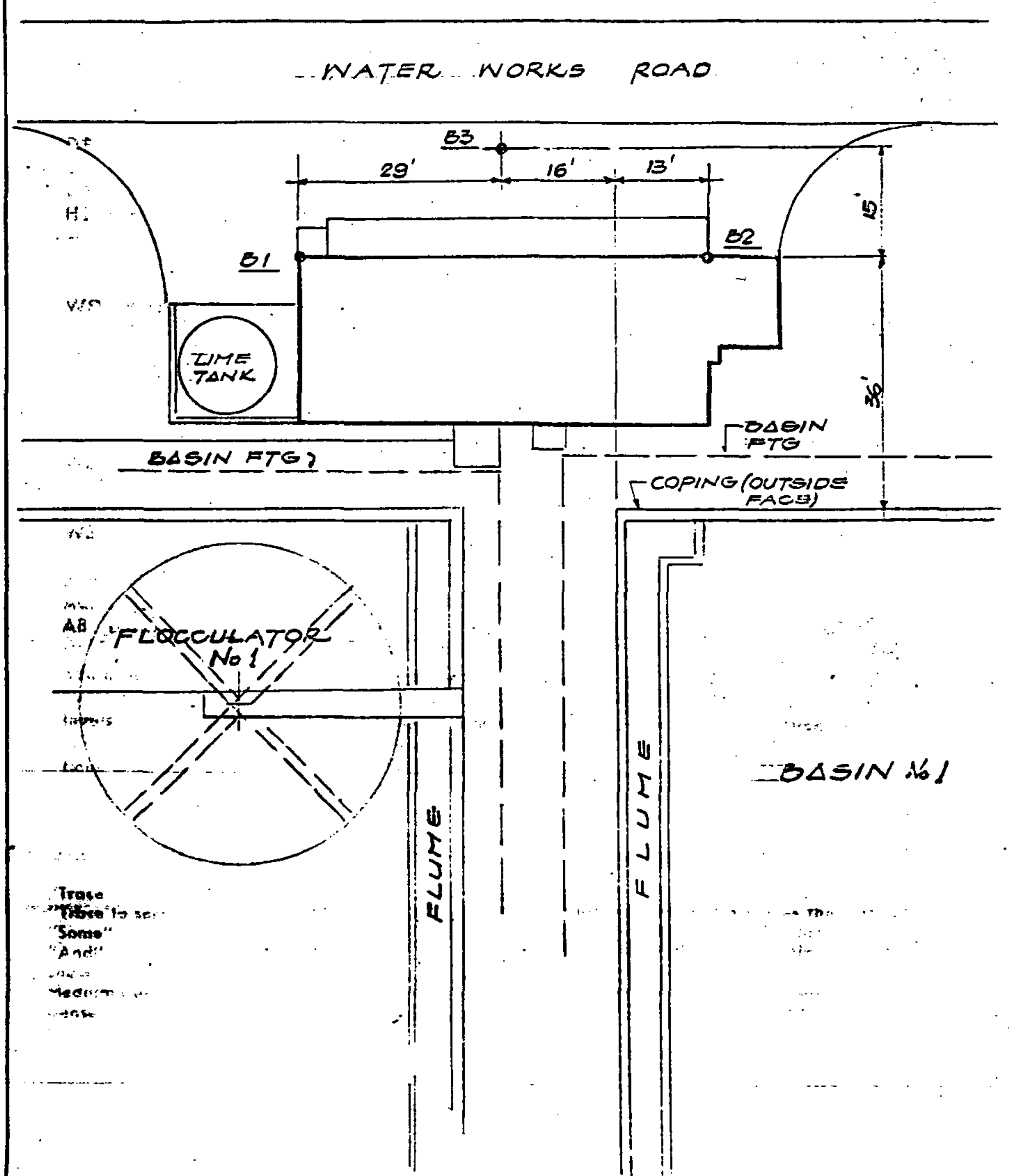
If you wish, we would be pleased to review plans and specifications for the project after they have been prepared so that we might have an opportunity to comment on the effect of soil conditions on the design and specifications.

APPENDIX

1. Location Diagram
2. General Notes
3. Boring Logs
4. Consolidation Tests
5. ASTM Specifications

    D 1586-64T
    D 1587-63T

6. Unified Soil Classification System
7. General Properties of Various Soil Types



SOIL BORING LOCATION DIAGRAM
PROPOSED CHEMICAL BUILDING
THE ST. JOSEPH WATER CO
ST. JOSEPH MO.

SOIL TESTING SERVICES, INC.
111 PFINGSTEN ROAD
NORTHBROOK ILLINOIS

MP	ONB	12-7-67	8903-D

GENERAL NOTES

1950 Chicago Building Code Soil Classifications are Used Except Where Noted

DRILLING & SAMPLING SYMBOLS

SS : Split-Spoon – 1⅜" I.D., 2" O.D., except where noted
ST : Shelby Tube – 2" O.D., except where noted
PA : Power Auger Sample
DB : *Diamond Bit – NX: BX: AX:*
CB : Carboloy Bit – NX: BX: AX:
OS : Osterberg Sampler – 3" Shelby Tube
HS : Housel Sampler
WS : Wash Sample
FT : *Fish Tail*
RB : Rock Bit
WO : Wash Out

Standard "N" Penetration: Blows per foot of a 140 pound hammer falling 30 inches *on a 2 inch OD split spoon, except where noted.*

WATER LEVEL MEASUREMENT SYMBOLS

WL : Water Level
WCI : Wet Cave In
DCI : Dry Cave In
WS : While Sampling
WD : While Drilling
BCR : Before Casing Removal
ACR : After Casing Removal
AB : After Boring

Water levels indicated on the boring logs are the levels measured in the boring at the times indicated. In pervious soils, the indicated elevations are considered reliable ground water levels. In impervious soils, the accurate determination of ground water elevations is not possible in even several days observation, and additional evidence on ground water elevations must be sought.

CLASSIFICATION

COHESIONLESS SOILS

"Trace"	:	1% to 10%	
"Trace to some"	:	10% to 20%	
"Some"	:	20% to 35%	
"And"	:	35% to 50%	
Loose	:	0 to 9 Blows	or equivalent
Medium Dense	:	10 to 29 Blows	or equivalent
Dense	:	30 to 59 Blows	or equivalent
Very Dense	:	≥ 60 Blows	or equivalent

COHESIVE SOILS

If clay content is sufficient so that clay dominates soil properties, then clay becomes the principle noun with the other major soil constituent as modifier; i.e., silty clay. Other minor soil constituents may be added according to classification breakdown for cohesionless soils; i.e., silty clay, trace to some sand, trace gravel.

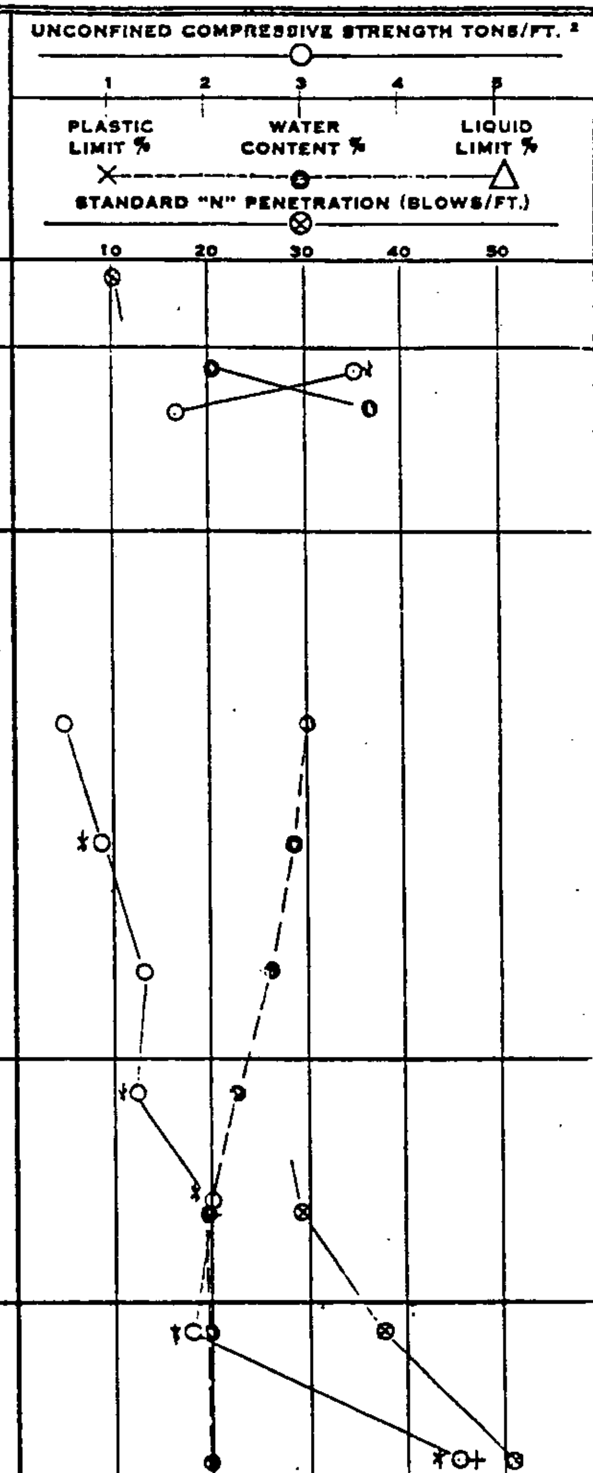
Soft	:	0.00 — 0.59 tons/ft²
Stiff	:	0.60 — 0.99 tons/ft²
Tough	:	1.00 — 1.99 tons/ft²
Very tough	:	2.00 — 3.99 tons/ft²
Hard	:	≥ 4.00 tons/ft²

LOG OF BORING NO. B-1

OWNER	ARCHITECT - ENGINEER
ST. JOSEPH WATER WORKS	AMERICAN WATER WORKS
SITE	**PROJECT NAME**
ST. JOSEPH, MISSOURI	PROPOSED CHEMICAL PLANT

SURFACE ELEVATION 822.4

DEPTH	SAMPLE NO.	TYPE SAMPLE	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.³
	1	SS	CLAYEY SILT, TRACE SAND, CINDERS, AND RUBBLE - DARK BROWN (FILL)	
	2	ST	SILTY CLAY, - GRAY AND BROWN TOUGH (CL)	
	3	ST	SILT SEAM AT 6.8'	81
10.0	4	3" ST		
	5	3" ST	CLAYEY SILT WITH PIECES OF BROKEN LIMESTONE - GRAY AND BROWN - SOFT TO TOUGH (ML-CL)	
20.0	6	ST		94
	7	ST		
30.0	8	ST		78
	9	ST	CLAYEY SILT WITH PIECES OF BROKEN LIMESTONE - BROWN MOTTLED WITH YELLOW - TOUGH (ML-CL)	
40.0	10	SS		
	11	SS	SILTY CLAY, TRACE SAND - GRAY AND BROWN - VERY TOUGH TO HARD (CL-ML)	
50.0	12	SS		
			END OF BORING	



*CALIBRATED PENETROMETER

WATER LEVEL OBSERVATIONS		
W.L.	11.0'	W.S. OR W.D.
W.L.	B.C.R.	A.C.R.
W.L.	9.0' A.B.	

SOIL TESTING SERVICES INC.
111 PFINGSTEN ROAD
NORTHBROOK, ILLINOIS

BORING STARTED	11/20/67		
BORING COMPLETED	11/28/67		
RIG		FOREMAN	
DRAWN	MP	APPROVED	CNB
JOB #	8908-D	SHEET	1 OF 1