APPENDIX M

HARDY CROSS NETWORK ANALYSES

APPENDIX M - HARDY CROSS NETWORK ANALYSES

Figures M-1 through M-3 represent the water system used for the hydraulic network analysis. The system was analyzed to determine the major line sizing and looping required to adequately meet the total system demand on a peak use day, with a major fire occurring in a commerical district. The system shown is that proposed for a population of 10,000 and a peak demand of 4500 gpm.

The network analysis was run using a teletype terminal which accessed a General Electric Time Sharing Computer Service. Software for the program was the August, 1967 manual, "Hydraulic Network Analysis-Users Guide."(42)

To present the Figures, the system had to be divided into loops as shown. Each loop was assigned a number, and each water line in each loop was assigned a number. The flow into the system was assumed to be 4500 gpm from the water treatment plant, and 3000 gpm from the two, one million gallon storage standpipes. No flow input from the elevated tank was assumed for this particular analysis. A major fire was assumed to occur in the commercial district shown on Fig. M-1. A major fire requires a flow of 3000 gpm for a 9 hour period as recommended by the National Board of Fire Underwriters and discussed previously. The three hydrants shown were assumed to contribute 1000 gpm each to fight the fire. The design of the major mains and loops was based on having a minimum pressure of 20 p.s.i. available at the worst possible fire location.

The supplement shows the pipe number used, the length of the pipe, the size of the pipe, the hydraulic coefficient "C" used, the actual flow in each pipe during the fire, and the head loss which occurs in each pipe. The system used contained 329 pipes, and 124 loops. The pressure at any point in the system is determined by adding up the pressure losses along any pipe route from the source of the water to the point to be determined, minus the elevation difference of the two points. Assuming the pressure leaving the water plant to be 70 p.s.i., the head losses added up from the plant to any of the three hydrants shown is no greater than 20 p.s.i. This leaves 50 p.s.i. available at the fire area, which is excellent. The accuracy of the flows shown is $\pm$ 10 gpm.

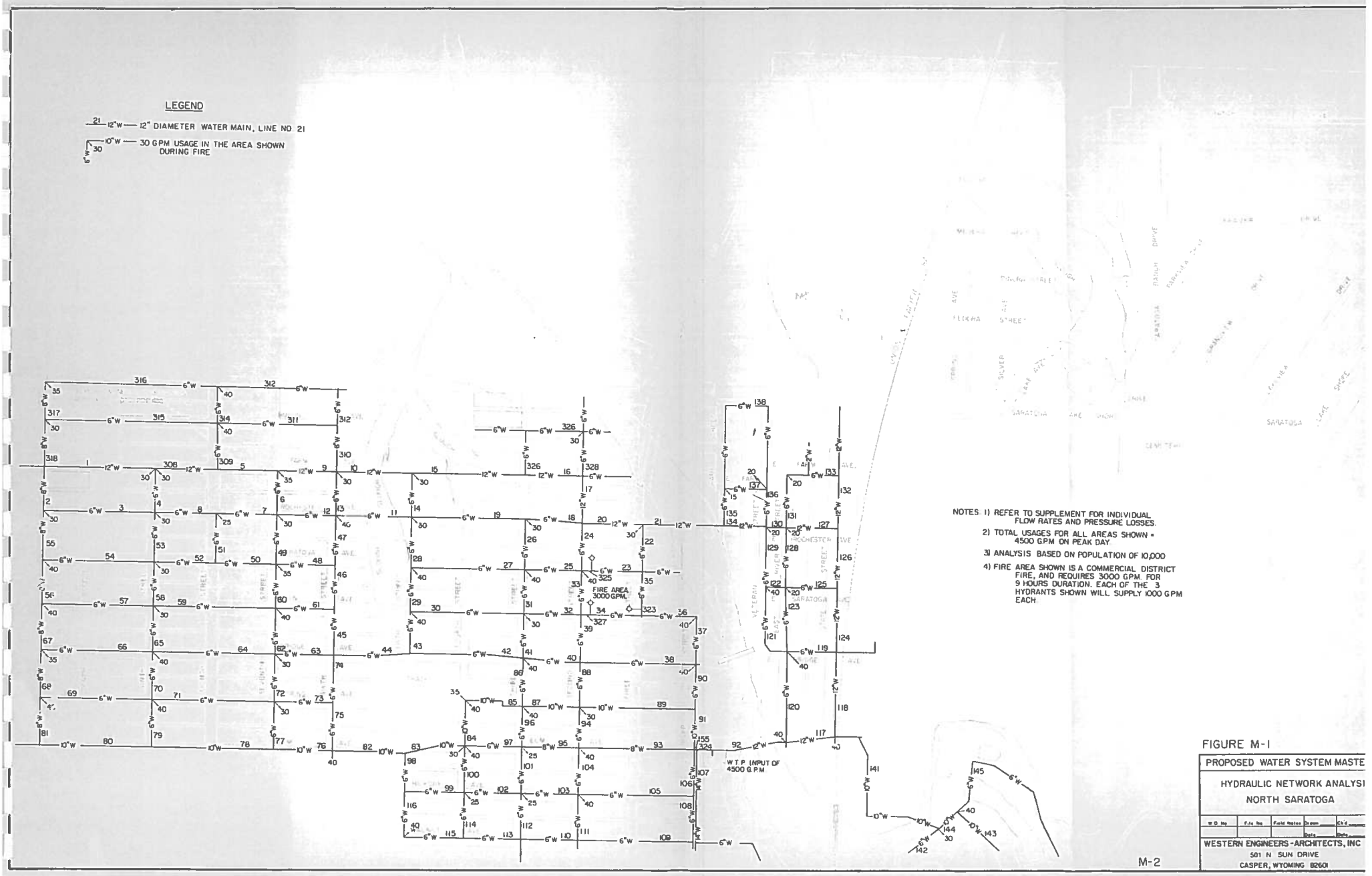


FIGURE M-1

PROPOSED WATER SYSTEM MASTE

HYDRAULIC NETWORK ANALYSI

NORTH SARATOGA

W.O. No.	File No.	Field Notes	Drawn	Chkd.
			Date	Date

WESTERN ENGINEERS-ARCHITECTS, INC
501 N. SUN DRIVE
CASPER, WYOMING 82601

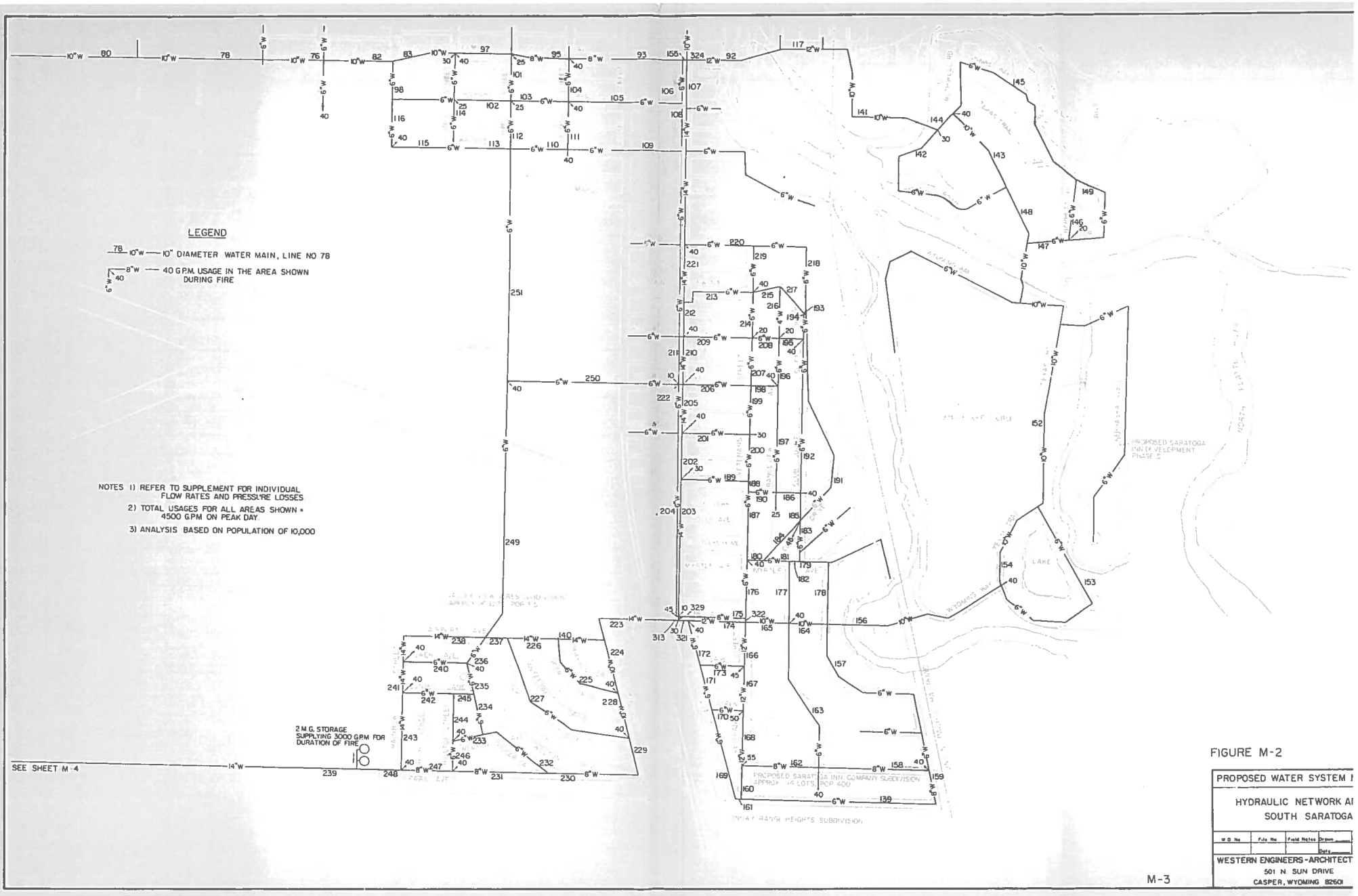


FIGURE M-2

PROPOSED WATER SYSTEM I

HYDRAULIC NETWORK AI
SOUTH SARATOGA

W.O. No.	File No.	Field Notes	Drawn
			Date

WESTERN ENGINEERS-ARCHITECT
501 N. SUN DRIVE
CASPER, WYOMING 82601

M-3

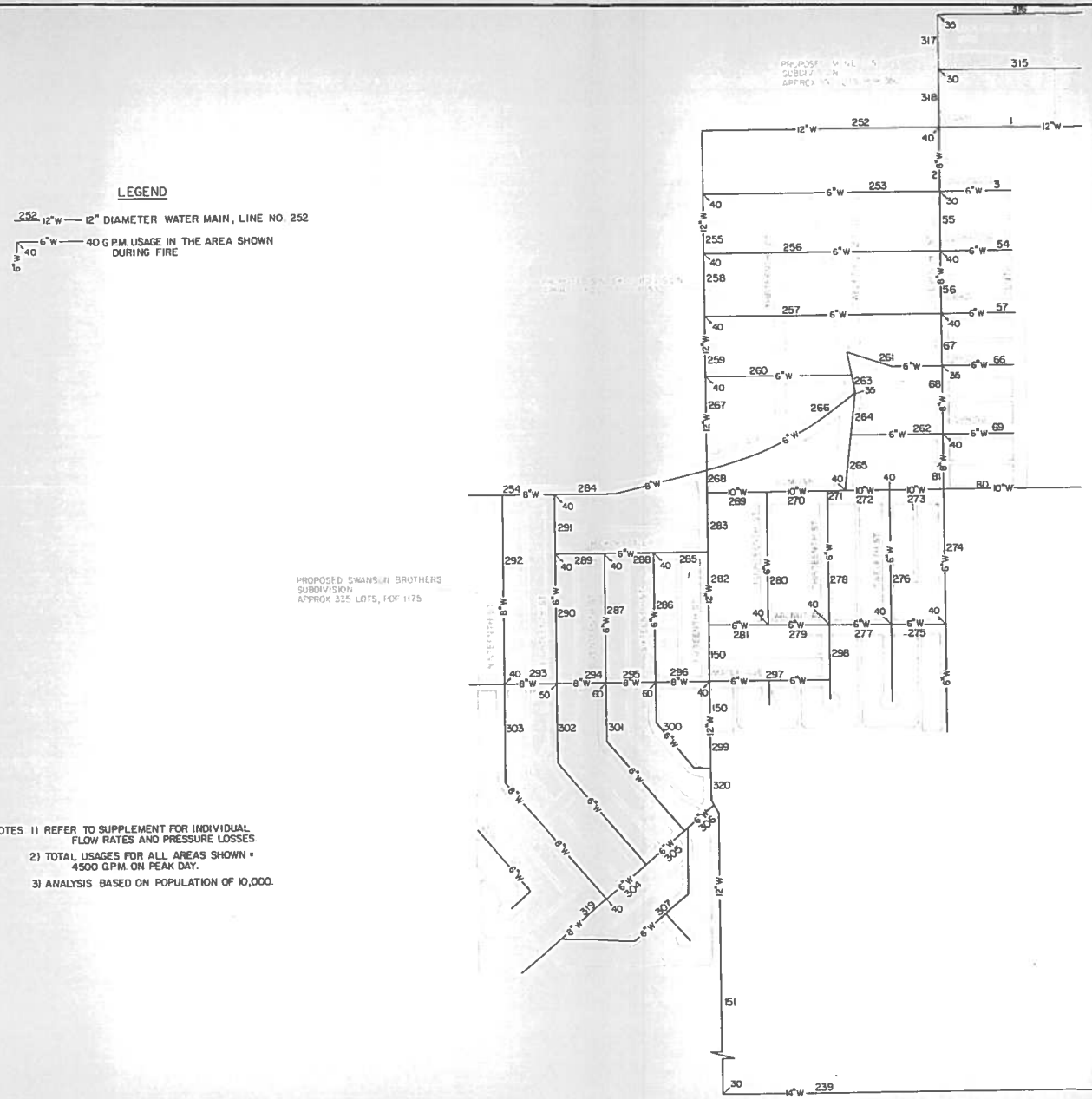


FIGURE M-3

PROPOSED WATER SYSTEM MASTE

HYDRAULIC NETWORK ANALYS

WEST BENCH SARATOGA

W.O. No.	File No.	Field Notes	Drawn	Ck'd
			Date	Date

WESTERN ENGINEERS-ARCHITECTS, INC
501 N. SUN DRIVE
CASPER, WYOMING 82601

SUPPLEMENT TO FIGURES M-1 THROUGH M-3

HYDRAULIC NETWORK ANALYSIS

PIPE NO.	LENGTH (ft.)	SIZE (in.)	C	FLOW (gpm)	HEAD LOSS (p.s.i.)
1	810	12	140	119.129	.015
2	310	8	140	54.533	.010
3	810	6	140	33.061	.041
4	310	6	140	18.189	.005
5	460	12	140	44.665	.001
6	310	6	140	12.059	.002
7	445	6	140	28.550	.017
8	460	6	140	19.064	.008
9	450	12	140	21.724	.000
10	545	12	140	55.525	.002
11	580	6	120	107.035	.344
12	450	6	140	37.024	.028
13	305	6	140	22.850	.008
14	300	6	140	156.105	.269
15	830	12	140	241.630	.057
16	390	12	140	233.601	.025
17	300	12	140	271.630	.026
18	380	6	140	211.01	.596
19	845	6	100	73.55	.351
20	470	12	140	981.761	.433
21	590	12	130	1716.075	1.752
22	340	6	140	704.314	4.955
23	435	6	120	219.205	.973
24	350	6	100	499.121	5.026
25	410	6	100	396.798	3.852
26	360	6	140	254.561	.798
27	840	6	100	128.425	.979
28	360	6	140	159.589	.337
29	320	6	140	8.835	.001
30	840	6	100	135.871	1.087
31	320	6	140	53.813	.040
32	410	6	100	426.670	4.405
33	320	6	100	115.124	.305
34	440	6	110	97.999	.261
35	320	6	140	445.109	1.995
36	440	6	110	456.892	4.498
37	380	6	140	496.892	2.904
38	825	6	100	5.875	.003
39	340	6	100	556.205	5.966
40	490	6	100	24.516	.027
41	321	6	140	374.612	1.450
42	810	6	140	.646	.000
43	300	6	140	184.706	.368
44	580	6	140	184.060	.707
45	330	6	140	70.296	.068
46	310	6	140	93.218	.107

SUPPLEMENT TO FIGURES M-1 THROUGH M-3

HYDRAULIC NETWORK ANALYSIS

PIPE NO.	LENGTH (ft.)	SIZE (in.)	C	FLOW (gpm)	HEAD LOSS (p.s.i.)
47	360	6	140	87.160	.110
48	420	6	140	6.058	.001
49	350	6	130	50.532	.045
50	450	6	140	.839	.000
51	350	6	140	34.487	.019
52	455	6	140	35.326	.026
53	350	6	140	34.191	.019
54	810	6	140	46.100	.076
55	360	8	140	89.876	.029
56	360	8	140	122.627	.051
57	810	6	140	48.124	.082
58	815	6	140	53.417	.101
59	910	6	140	45.024	.082
60	360	6	140	78.635	.091
61	400	6	140	22.922	.010
62	290	6	140	96.534	.107
63	415	6	140	70.732	.086
64	910	6	140	47.753	.091
65	285	6	140	80.318	.075
66	815	6	140	53.825	.102
67	270	8	140	161.790	.064
68	370	8	140	177.404	.104
69	815	6	140	48.047	.083
70	350	6	140	114.245	.176
71	910	6	140	23.773	.025
72	345	6	140	149.513	.286
73	420	6	140	10.918	.003
74	340	6	140	183.624	.412
75	350	6	120	194.542	.628
76	415	10	100	322.317	.221
77	350	6	120	144.822	.364
78	915	10	140	177.495	.087
79	350	6	140	129.971	.224
80	815	10	140	47.524	.007
81	350	8	140	203.763	.127
82	510	10	100	556.858	.745
83	465	10	100	396.210	.362
84	320	10	140	14.881	.000
85	450	10	140	60.119	.006
86	335	6	100	390.742	3.059
87	455	10	100	359.543	.296
88	330	6	140	586.595	3.429
89	825	10	100	700.722	1.844
90	330	6	100	531.017	5.315
91	320	10	100	1231.739	2.031
92	730	12	130	1749.021	2.245

SUPPLEMENT TO FIGURES M-1 THROUGH M-3

HYDRAULIC NETWORK ANALYSIS

PIPE NO.	LENGTH (ft.)	SIZE (in.)	C	FLOW (gpm)	HEAD LOSS (p.s.i.)
93	815	8	140	690.164	2.818
94	320	6	140	275.417	.821
95	450	8	140	458.257	.729
96	270	6	100	131.318	.328
97	420	10	100	392.466	.321
98	280	6	140	160.648	.265
99	460	6	140	96.197	.169
100	345	6	140	88.625	.109
101	340	6	100	90.528	.208
102	400	6	120	133.103	.355
103	450	6	120	157.512	.546
104	290	6	140	83.510	.082
105	860	6	140	232.619	1.614
106	330	6	140	300.244	.993
107	1285	14	130	528.832	.204
108	310	6	140	67.625	.059
109	815	6	140	223.815	1.424
110	450	6	140	135.413	.310
111	340	6	140	48.402	.035
112	345	6	100	91.119	.213
113	400	6	140	181.170	.473
114	340	6	140	76.718	.082
115	450	6	140	104.451	.192
116	335	6	140	64.451	.059
117	350	12	130	1371.126	.686
118	620	12	130	1573.180	1.567
119	350	6	140	140.289	.258
120	670	6	140	337.895	2.509
121	600	6	140	205.153	.893
122	190	6	140	131.125	.123
123	465	6	140	233.031	.876
124	465	12	130	1432.891	.989
125	330	6	140	114.425	.167
126	435	12	130	1318.466	.793
127	380	12	130	1206.462	.588
128	440	6	100	196.332	1.125
129	430	6	140	296.277	1.263
130	150	12	130	1474.798	.336
131	385	6	100	92.004	.242
132	390	12	130	112.004	.007
133	380	6	100	112.004	.344
134	315	12	130	1562.091	.786
135	290	6	140	153.984	.254
136	290	6	140	188.984	.371
137	315	6	140	118.348	.169
138	1515	6	140	50.636	.169

SUPPLEMENT TO FIGURES M-1 THROUGH M-3

HYDRAULIC NETWORK ANALYSIS

PIPE NO.	LENGTH (ft.)	SIZE (in.)	C	FLOW (gpm)	HEAD LOSS (p.s.i.)
139	1400	6	140	28.173	.053
140	350	14	140	780.759	.100
141	1265	10	130	242.054	.244
142	1290	6	140	46.987	.126
143	600	10	140	225.971	.089
144	250	10	140	225.067	.037
145	1880	6	140	39.096	.130
146	450	6	140	22.659	.011
147	290	6	140	59.096	.043
148	450	10	140	272.958	.094
149	815	6	140	16.437	.011
150	300	12	140	777.605	.180
151	1400	14	130	1538.712	1.603
152	2220	10	140	332.054	.669
153	1610	6	140	45.706	.149
154	650	10	140	286.348	.149
155	20	8	140	990.408	.135
156	1340	10	130	372.054	.572
157	1530	6	140	27.140	.054
158	810	8	140	38.967	.014
159	250	8	140	28.173	.002
160	250	12	130	8.131	.000
161	70	6	140	20.042	.001
162	540	8	140	88.212	.042
163	1080	6	140	9.245	.005
164	280	10	140	282.084	.062
165	310	10	140	322.274	.088
166	280	12	130	185.866	.014
167	330	12	130	181.282	.015
168	400	12	130	151.343	.013
169	680	6	120	20.042	.018
170	230	6	120	20.061	.006
171	335	6	120	40.103	.032
172	300	6	120	80.519	.105
173	315	6	140	40.416	.023
174	390	12	130	488.120	.113
175	485	6	120	74.031	.146
176	440	6	140	54.010	.055
177	460	6	140	22.736	.012
178	470	6	140	62.829	.078
179	195	6	120	95.0	.093
180	105	6	140	52.265	.012
181	180	6	140	32.969	.009
182	80	6	140	42.405	.006
183	290	6	140	20.425	.006
184	400	6	140	19.295	.008

SUPPLEMENT TO FIGURES M-1 THROUGH M-3

HYDRAULIC NETWORK ANALYSIS

PIPE NO.	LENGTH (ft.)	SIZE (in.)	C	FLOW gpm)	HEAD LOSS (p.s.i.)
185	200	6	140	26.514	.007
186	200	6	140	49.291	.021
187	505	6	140	38.255	.034
188	60	6	140	89.185	.019
189	490	6	140	65.875	.089
190	195	6	140	50.93	.022
191	1610	6	140	19.615	.031
192	1310	6	140	17.223	.020
193	50	6	140	6.605	.000
194	220	6	140	23.465	.006
195	170	6	140	33.758	.009
196	310	6	140	10.563	.002
197	790	6	140	23.361	.021
198	195	6	140	52.798	.024
199	360	6	140	1.883	.000
200	425	6	140	23.310	.011
201	490	6	140	55.193	.064
202	355	14	130	136.903	.005
203	1000	14	130	232.778	.035
204	1720	6	120	26.701	.078
205	360	14	130	41.709	.001
206	490	6	140	50.762	.055
207	310	6	140	.152	.000
208	185	6	140	45.914	.017
209	490	6	140	53.757	.061
210	305	14	130	281.278	.015
211	970	6	140	156.191	.871
212	190	14	130	375.035	.016
213	560	6	140	51.961	.066
214	320	6	140	12.309	.003
215	175	6	140	35.267	.010
216	350	6	140	18.407	.006
217	270	6	140	16.86	.004
218	850	6	140	26.22	.028
219	300	6	140	35.615	.017
220	490	6	140	61.835	.079
221	410	14	130	426.997	.044
222	20	6	140	232.225	.037
223	620	14	130	1027.148	.336
224	330	10	140	246.389	.057
225	600	6	140	39.533	.042
226	325	14	130	820.293	.116
227	1250	6	140	43.325	.105
228	330	10	140	246.856	.057
229	310	10	140	243.531	.053
230	550	8	140	243.531	.277

SUPPLEMENT TO FIGURES M-1 THROUGH M-3

HYDRAULIC NETWORK ANALYSIS

PIPE NO.	LENGTH (ft.)	SIZE (in.)	C	FLOW (gpm)	HEAD LOSS (p.s.i.)
231	800	8	140	183.917	.240
232	670	6	140	59.614	.101
233	260	6	140	64.50	.045
234	280	6	140	4.886	.000
235	220	6	140	85.196	.064
236	200	6	100	115.593	.192
237	150	14	130	863.618	.059
238	775	14	130	832.164	.285
239	2200	14	130	1568.712	2.611
240	495	6	140	70.397	.102
241	215	14	130	942.562	.099
242	355	6	140	82.242	.097
243	515	14	130	1064.803	.298
244	350	6	140	1.931	.000
245	175	6	140	80.31	.046
246	215	6	140	102.568	.089
247	355	8	140	326.485	.307
248	415	14	130	1431.288	.416
249	1950	6	100	84.140	1.039
250	1260	6	140	92.735	.431
251	1610	6	100	136.876	2.111
252	1655	12	140	192.545	.075
253	1325	6	140	37.719	.086
254	280	8	140	114.665	.035
255	350	12	140	270.263	.030
256	1330	6	140	43.348	.112
257	1330	6	140	48.961	.140
258	360	12	140	353.612	.050
259	340	12	140	442.573	.072
260	810	6	140	25.732	.026
261	700	6	140	73.211	.155
262	530	6	140	61.688	.085
263	130	6	140	47.479	.013
264	185	6	140	13.655	.002
265	320	6	140	75.343	.075
266	920	6	140	68.824	.181
267	520	12	140	508.305	.142
268	125	12	140	429.508	.025
269	340	10	140	216.794	.047
270	350	10	140	256.830	.066
271	95	10	140	297.717	.023
272	245	10	140	182.374	.024
273	310	10	140	151.049	.022
274	755	6	140	5.190	.001
275	325	6	140	45.190	.029
276	750	6	140	8.675	.003

SUPPLEMENT TO FIGURES M-1 THROUGH M-3

HYDRAULIC NETWORK ANALYSIS

PIPE NO.	LENGTH (ft.)	SIZE (in.)	C	FLOW (gpm)	HEAD LOSS (p.s.i.)
277	335	6	140	93.865	.117
278	750	6	140	40.887	.056
279	350	6	140	79.297	.090
280	750	6	140	40.036	.054
281	340	6	140	159.334	.317
282	400	12	140	618.272	.157
283	340	12	140	646.302	.145
284	905	10	140	147.621	.061
285	315	6	140	28.030	.012
286	710	6	140	91.463	.237
287	715	6	140	67.971	.138
288	280	6	140	23.433	.008
289	295	6	140	51.404	.034
290	715	6	140	61.552	.115
291	330	6	140	72.956	.073
292	1055	8	140	114.665	.132
293	280	8	140	73.205	.015
294	290	8	140	135.907	.050
295	290	8	140	193.004	.095
296	310	8	140	173.871	.084
297	690	6	140	135.455	.476
298	305	6	140	95.455	.110
299	550	12	140	1126.931	.654
300	690	6	140	170.595	.730
301	1010	6	140	70.875	.210
302	1210	6	140	48.85	.127
303	1440	8	140	81.460	.096
304	275	6	140	62.904	.046
305	270	6	140	111.754	.131
306	410	6	140	241.185	.823
307	1140	6	140	58.557	.167
308	440	12	140	77.318	.004
309	335	6	140	32.653	.017
310	340	6	140	24.399	.010
311	880	6	140	11.212	.006
312	1135	6	140	13.187	.011
313	30	14	130	71.701	.000
314	260	6	140	16.352	.004
315	1260	6	140	12.488	.011
316	1260	6	140	10.461	.008
317	290	8	140	45.461	.007
318	315	8	140	87.949	.024
319	270	8	140	58.557	.010
320	120	12	130	1297.527	.212
321	90	12	140	608.639	.034
322	20	6	140	20.021	.000
323	45	6	140	554.891	.422
324	100	12	130	2750.979	.711

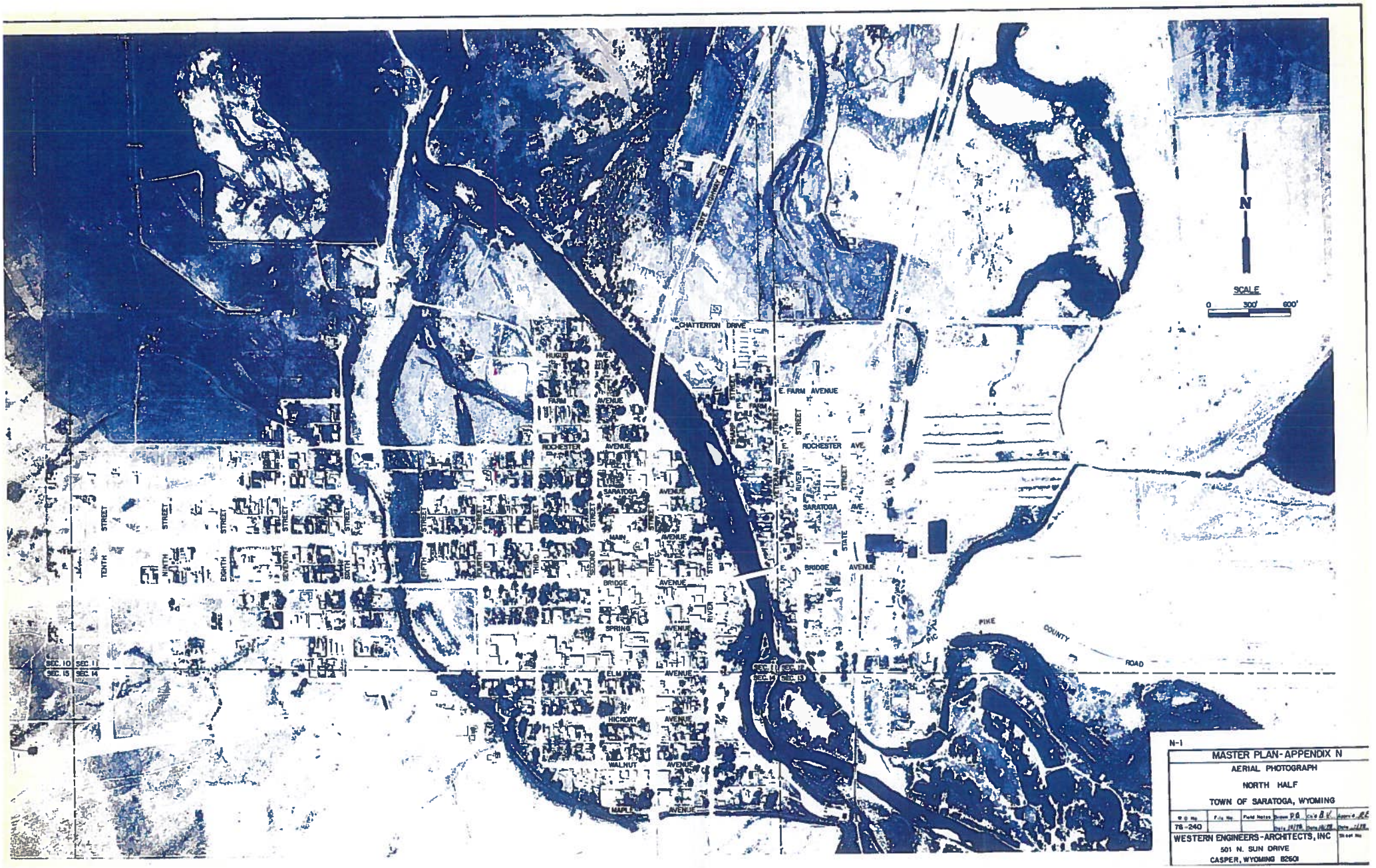
SUPPLEMENT TO FIGURES M-1 THROUGH M-3

HYDRAULIC NETWORK ANALYSIS

PIPE NO.	LENGTH (ft.)	SIZE (in.)	C	FLOW (gpm)	HEAD LOSS (p.s.i.)
325	30	6	110	780.795	.827
326	780	6	140	8.029	.003
327	30	6	140	1097.999	.994
328	340	6	140	38.029	.022
329	20	14	140	388.509	.002

APPENDIX N

AERIAL PHOTOGRAPH - TOWN OF SARATOGA



N-1

MASTER PLAN-APPENDIX N

AERIAL PHOTOGRAPH

NORTH HALF

TOWN OF SARATOGA, WYOMING

W O No.	File No.	Field Notes	Drawn PG	Ck'd BK	Approved
78-240			Date 10/78	Date 10/78	Date

WESTERN ENGINEERS-ARCHITECTS, INC
501 N. SUN DRIVE
CASPER, WYOMING 82601

Sheet No.

N-2

MASTER PLAN-APPENDIX N

AERIAL PHOTOGRAPH

SOUTH HALF

TOWN OF SARATOGA, WYOMING

W.O. No.	File No.	Field Notes	Drawn	Ck'd	Approved
76-243					

WESTERN ENGINEERS-ARCHITECTS, INC

501 N. SUN DRIVE

CASPER, WYOMING 82601

APPENDIX O

LIST OF KEY PROJECT PERSONNEL

LIST OF KEY PROJECT PERSONNEL

WESTERN ENGINEERS-ARCHITECTS, INC.

RUSSELL L. DONLEY	PROJECT ENGINEER
BARRY VENN	FIELD ENGINEER AND DESIGNER
EVELYN L. LYNCH	TYPIST
GORDON GRAY	DRAFTING
DEBORAH BURLEY	DRAFTING
BILL BLEVINS	DRAFTING

APPENDIX P

REFERENCES

LIST OF REFERENCES

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