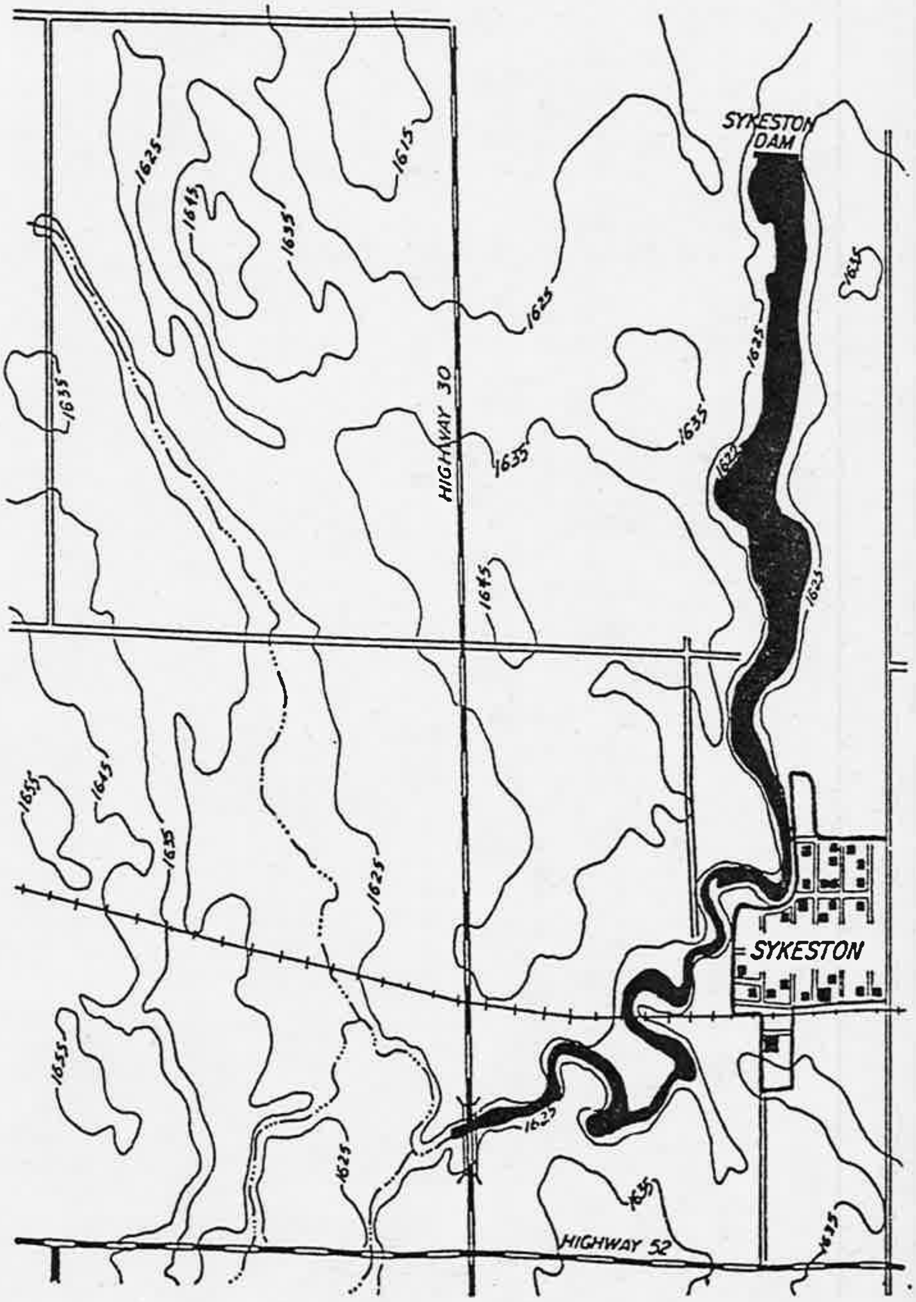
PRELIMINARY ENGINEERING REPORT

SYKESTON DAM

S.W.C. PROJECT NO. 450

WELLS COUNTY



NORTH DAKOTA

STATE WATER COMMISSION

DECEMBER 1988

PRELIMINARY ENGINEERING REPORT

SYKESTON DAM

SWC PROJECT #450

North Dakota State Water Commission
900 East Boulevard
Bismarck, ND 58505-0187

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INTRODUCTION

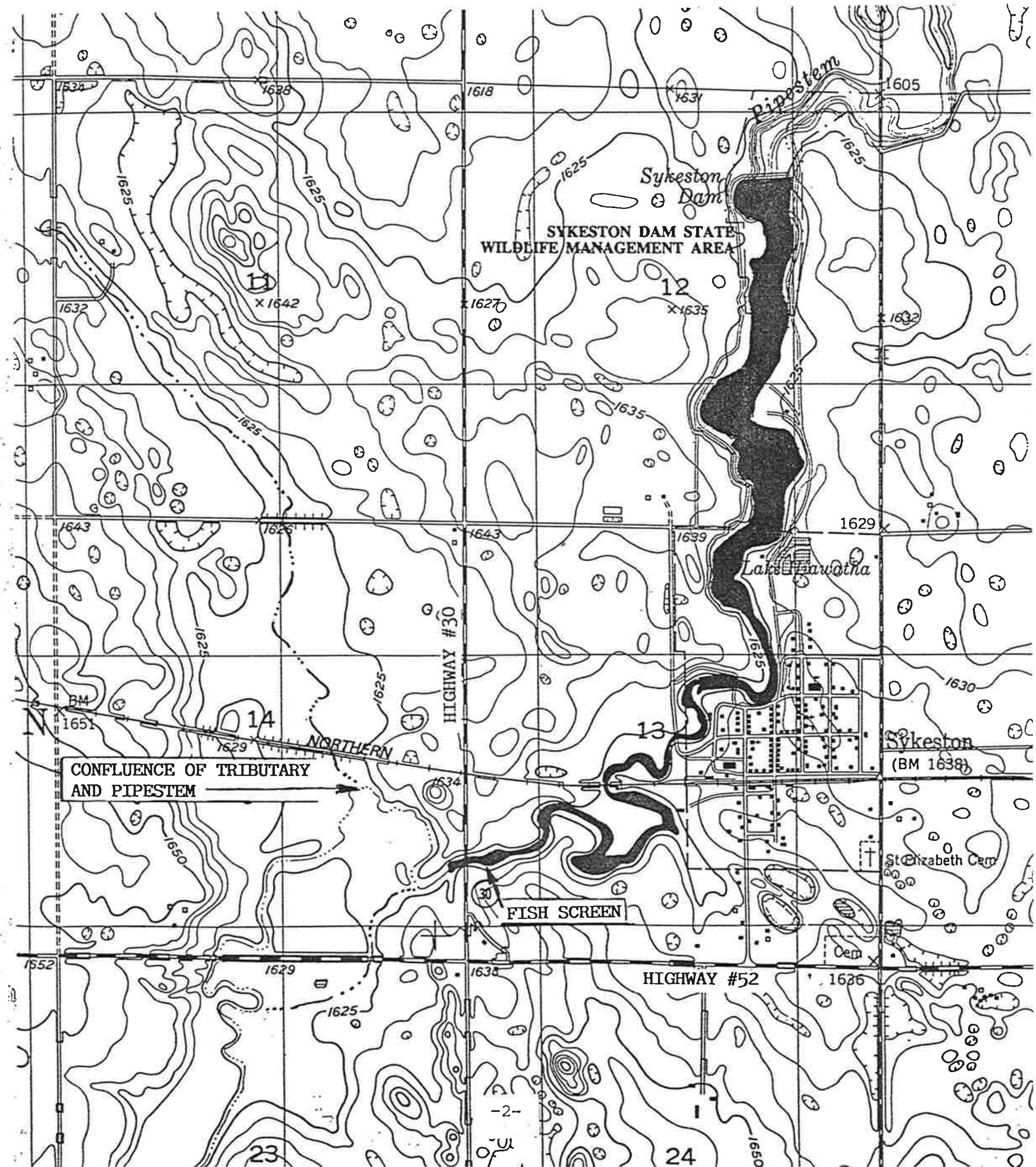
Background:

The original Sykeston Dam was built around 1908 by Mr. Sykes, the founder of Sykeston and by the Northern Pacific Railroad on the Pipestem Creek, a tributary of the James River. The railroad assumed responsibility for the maintenance of the dam since the reservoir was used as a water supply for the railroad. About 1936, the dam was rebuilt with the railroad furnishing the materials and the WPA furnishing the labor. Since that time, the city became the major user of the reservoir and assumed responsibility for the dam.

By 1960, the dam was leaking severely, and it was decided to build a new dam about 1/2-mile downstream in Section 12, Township 146 North, Range 69 West (Figure 1). The new dam was constructed by the State Water Commission, the Wells County Water Resource District, and the State Game and Fish Department. The earth work for the new embankment began in November 1962, and the final cleanup work was completed in May 1963. The old dam was breached in July of 1964.

The dam, completed in 1963, has been causing water to back up on privately owned land upstream of Highway 30 in Sections 11 and 14 since it was completed. In October 1987, the North Dakota State Water Commission entered into an agreement with the Wells County Water Resource District to investigate ways to prevent the flooding. The area was surveyed in late November 1987.

SYKESTON DAM
PROJECT LOCATION
FIGURE 1



A fish screen was constructed in the 1960s, located across the channel in Section 13 approximately 500 feet east of Highway 30. The channel had filled with sediment in the area of the fish screen. The channel blockage in the fish screen area, as well as the sediment and cattails in the spillway approach channel, increased the flooding upstream of Highway 30.

In the fall of 1988, the Wells County Water Resource District removed the remnants of the fish screen. The sediment in the channel in this area was also cleaned out. Sediment and cattails in the spillway approach channel were also removed.

A tributary enters the main stem approximately 300 feet southeast of the railroad in Section 14 (Figure 1). Backwater from the reservoir flows north through the railroad up this tributary during high flows, flooding the area north of the railroad. It has been proposed that flap gates be installed on the railroad culverts to reduce the flooding north of the railroad. These gates would be opened to allow the runoff from north of the railroad to flow into the reservoir during times of low water. The gates would be closed when the backwater of the reservoir is high, decreasing the flooding in the area north of the railroad.

<u>Scope</u>:

The objective of this investigation is to determine an effective method of alleviating the damage caused by flooding occuring on private property. The investigation evaluated the hydrologic conditions of the basin, the effects of the recently completed channel improvement work, and the effects of installing the proposed flap gates on the railroad culverts.

This report includes a hydrologic and hydraulic analysis of the drainage basin, proposed solutions, and a statement of conclusions and recommendations regarding the feasibility of the solutions.

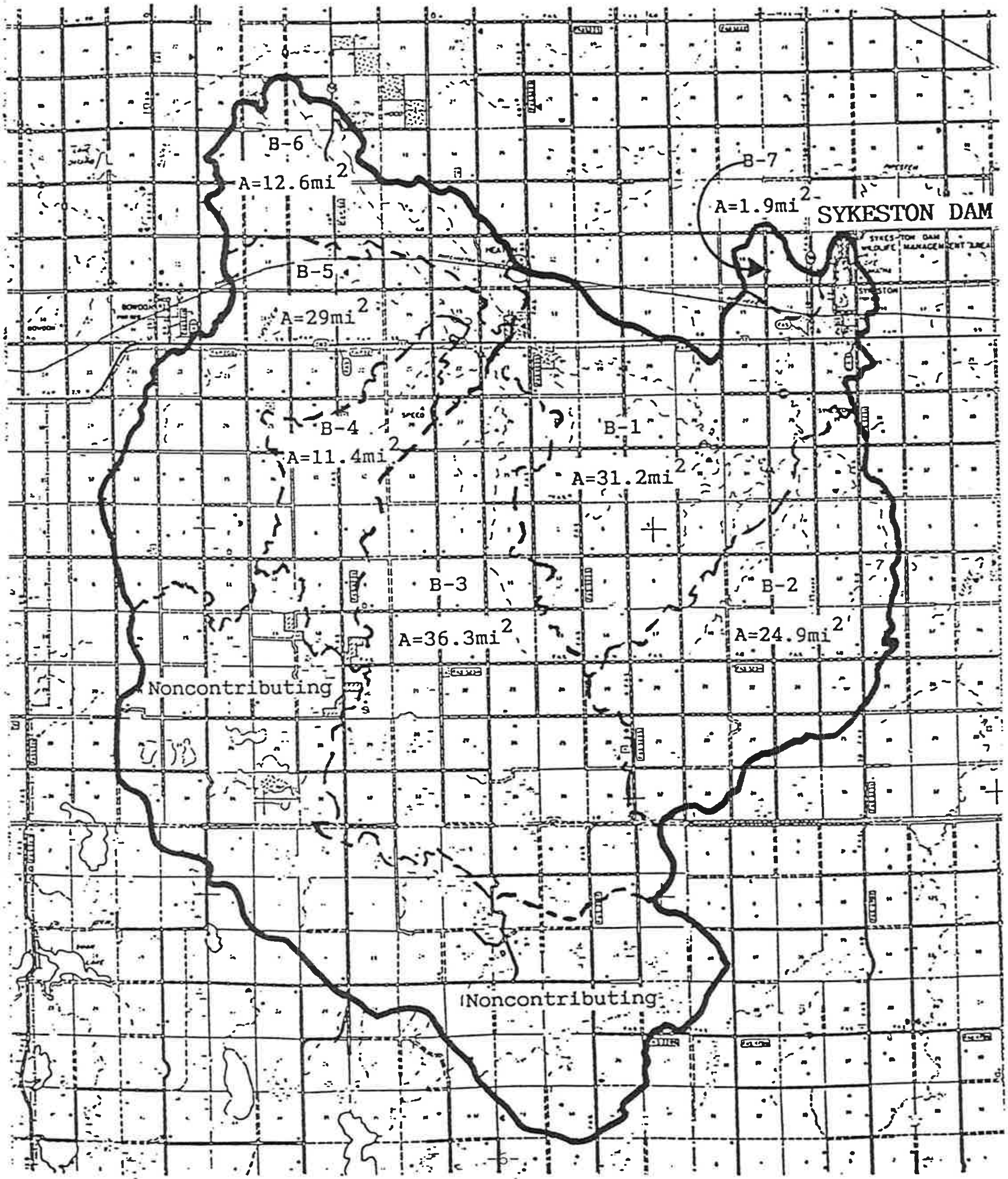
HYDROLOGY

A hydrologic analysis of the watershed was performed using the HEC-1 computer model developed by the U.S. Army Corps of Engineers. The model was used to determine the peak discharges and flow volumes of various frequency storms. HEC-1 formulates a mathematical hydrologic model of the watershed based on the following data: the amount of rainfall, the rainfall distribution, soil type, land use, and the hydraulic characteristics of channels and drainage areas. The model is designed to calculate the surface runoff of the watershed in relation to precipitation by representing the basin as an interconnected system of hydrologic and hydraulic components. Each component of the model represents an aspect of the precipitation-runoff process within a portion of the subbasin. A component may represent subbasin runoff, channel-routing, or reservoir-routing.

The first step in the analysis was to delineate the watershed boundary on a topographic map. Once the watershed was delineated, it was divided into seven subbasins. The subbasins are areas of similar hydrologic features. Their limits are determined by finding where hydrologic conditions change or by outlining areas of particular interest. Figure 2 shows the watershed and its subbasins. The total watershed area is 204.6 square miles. Of this, 57.3 square miles do not contribute runoff to the dam.

SYKESTON DAM WATERSHED

FIGURE 2



After the subbasins were determined, the time of concentration for each subbasin was calculated. Time of concentration is the travel time from the hydrologically most distant point in the basin to the basin outlet. Profiles of the stream channels were drawn to determine channel gradients. The channel condition and shape was estimated. From this information average flow velocities were calculated and the time of travel determined. The gradient of the watershed is rather flat. This results in large time of concentrations.

The soil type and land use were determined. From this information, a curve number was selected for each subbasin. The curve numbers is a representation of the relationship between rainfall and runoff in a subbasin. The model uses curve numbers to determine the runoff for various events.

The HEC-1 model was used to determine the flow into the reservoir. In this investigation, various frequency rainfall and snowmelts were used to determine inflow and outflow of the reservoir. These events are summarized in Table 1.

Table 1 shows that the 10-day snowmelt causes the greatest peak inflow of the three events for all of the modeled return periods. Therefore, the snowmelt hydrographs were used as input for the Network model. These hydrographs are shown in Figure 3.

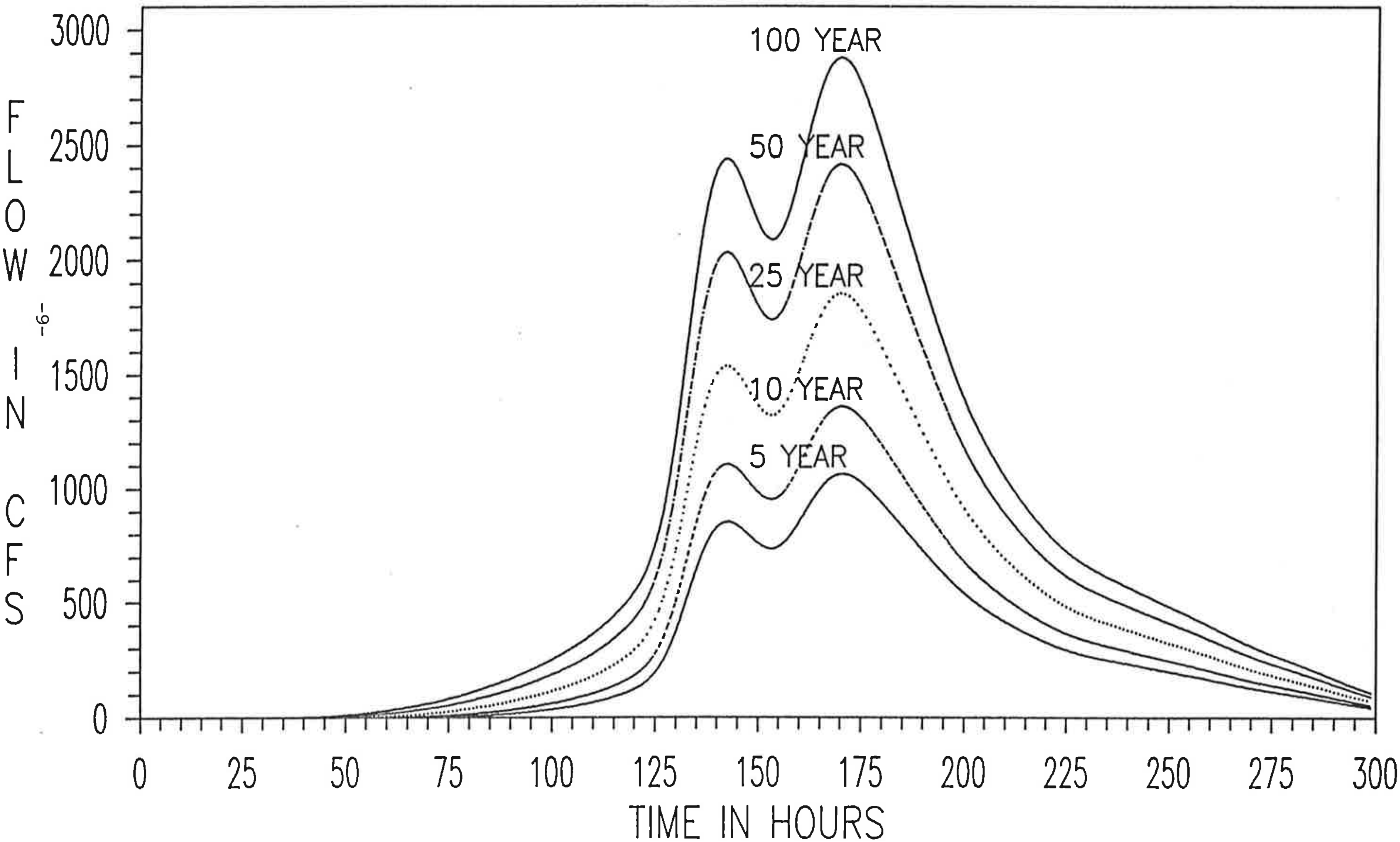
Table 1 - Peak Inflow For Selected Events

Event	Return Frequency	Precipitation Inches	Volume Acre-feet	Peak Inflow CFS
24 Hour Rainfall	5-Year	2.80	3,165	646
24 Hour Rainfall	10-Year	3.30	5,204	1025
24 Hour Rainfall	25-Year	3.80	6,583	1342
24 Hour Rainfall	50-Year	4.30	8,835	1801
24 Hour Rainfall	100-Year	4.90	11,041	2252
10 Day Rainfall	25-Year	6.60	8,266	1197
10 Day Rainfall	50-Year	7.60	11,214	1659
10 Day Rainfall	100-Year	8.50	14,422	2167
10 Day Snowmelt	5-Year	1.47	6,613	1011
10 Day Snowmelt	10-Year	2.27	8,511	1291
10 Day Snowmelt	25-Year	2.94	11,752	1762
10 Day Snowmelt	50-Year	3.36	15,497	2298
10 Day Snowmelt	100-Year	4.20	18,615	2739

10 DAY SNOWMELT

INFLOW HYDROGRAPHS

FIGURE 3



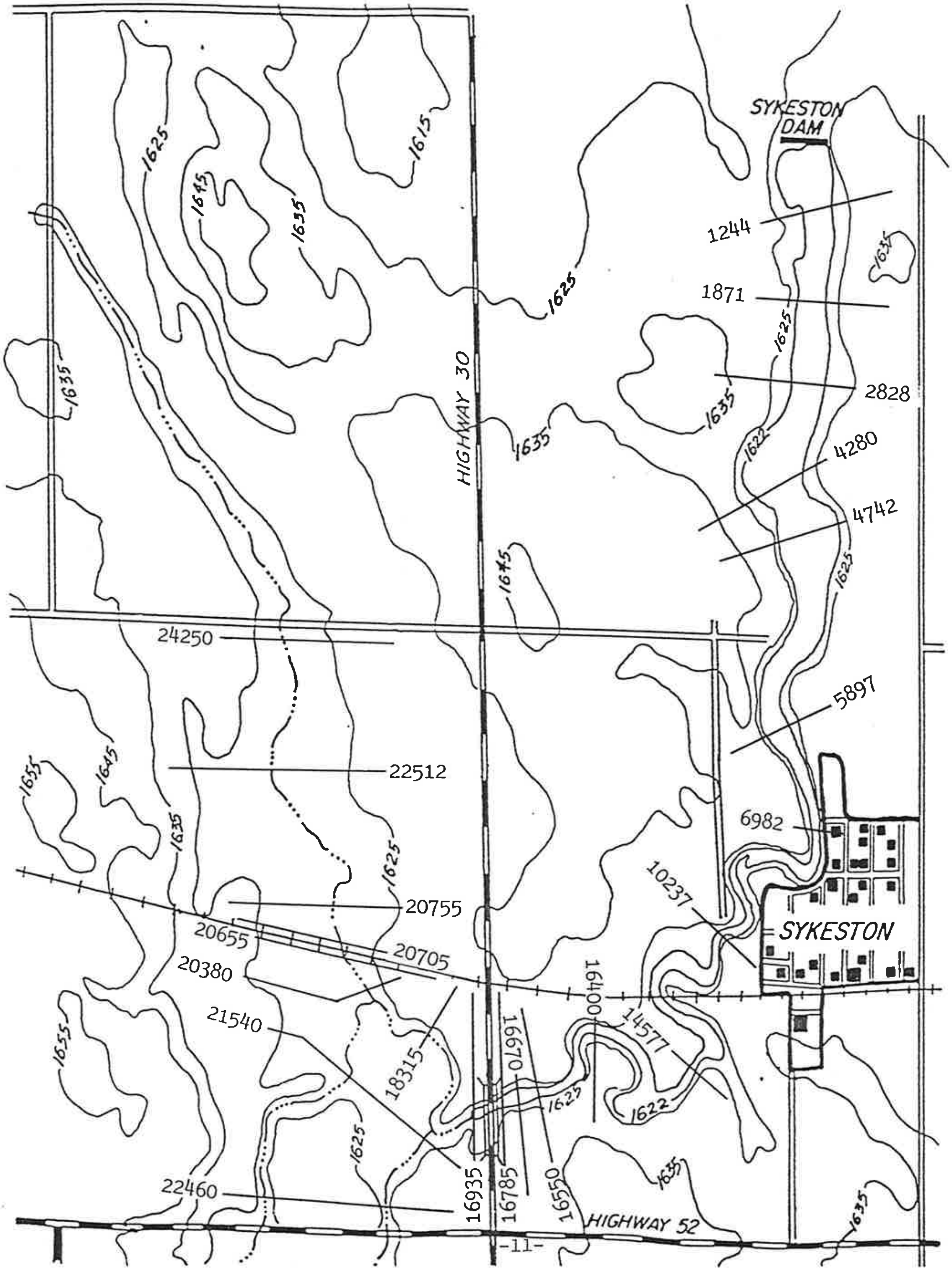
HYDRAULICS

The hydraulics of the stream system were modeled using the Network computer model developed by D. L. Fread of the National Oceanic and Atmospheric Administration. The model was used to estimate the water surface elevation at various locations as the flood peak made its way through the study area.

The Network model estimates the water surface elevations at each cross section at specified time intervals based on: the inflow hydrograph, the downstream rating curve, cross section geometry, channel slope, and obstructions to flow. The Network model was chosen for this study because it is a dynamic wave routine capable of directly addressing backwater conditions and because tributaries can be added to the main channel. Network also has the advantage of modeling varying flow, allowing the entire hydrograph to be modeled. Therefore the model can show the affects of backwater flowing up the tributary.

Cross-sections were taken at various locations along the stream channel (Figure 4). The conditions which existed before the channel and spillway clean out work was done were modeled. Then the cross sections and the downstream rating curve were modified to reflect the channel and spillway cleaning and the effects of the proposed installation of flap gates in the railroad. The detailed results of the modeling are presented in the Appendix.

AREA MAP
SELECTED CROSS SECTIONS
FIGURE 4

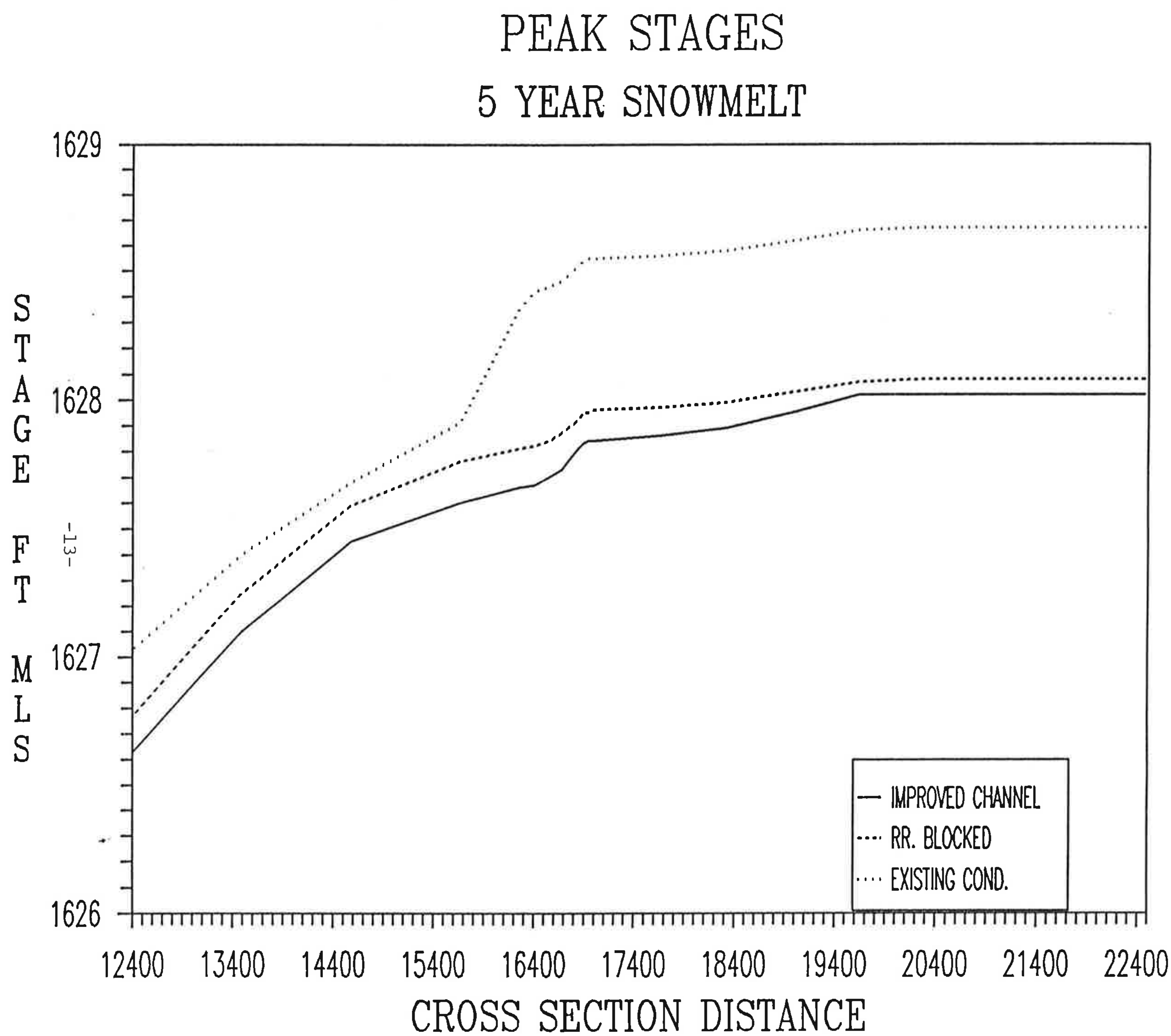


RESULTS

The channel and spillway clean out work resulted in a significant reduction in the water surface elevations at all cross-sections and time intervals. The water surface profile at the peak stage on the Pipestem Creek for the 5-year snowmelt is shown in Figure 5. The 100-year snowmelt profile is shown in Figure 6. In both figures the "EXISTING COND." line represents the water surface profile modeled using the conditions that existed before any work was done. The "IMPROVED CHANNEL" line represents the conditions existing after the channel and spillway clean out was completed. The "RR. BLOCKED" line models the effects of installing flap gates on the railroad culverts. Figures 5 and 6 show the channel and spillway clean out reduce the peak water surface elevations between 0.60 and 0.75 feet at all the cross-sections in the area of concern for all events modeled. The reduction in water surface elevation caused fewer acres to be flooded. A summary of the acres flooded in Sections 11 and 14, before and after the channel and spillway cleanout was completed,is presented in Table 2. Tables showing the peak stages at all the cross-sections for each event are provided in the Appendix.

Table 2

Runoff Event Return Frequency Years	Area Flooded Existing Conditions Acres	Area Flooded Improved Channel Acres	Reduction In Area Flooded Acres
5	489	445	44
10	526	492	34
25	589	545	44
50	639	601	38
100	676	632	44



PEAK STAGES
5 YEAR SNOWMELT
STAGE FT MLS
1629
1628
1627
1626
12400
13400
14400
15400
16400
17400
18400
19400
20400
21400
22400
CROSS SECTION DISTANCE
IMPROVED CHANNEL
RR. BLOCKED
EXISTING COND.

FIGURE 5

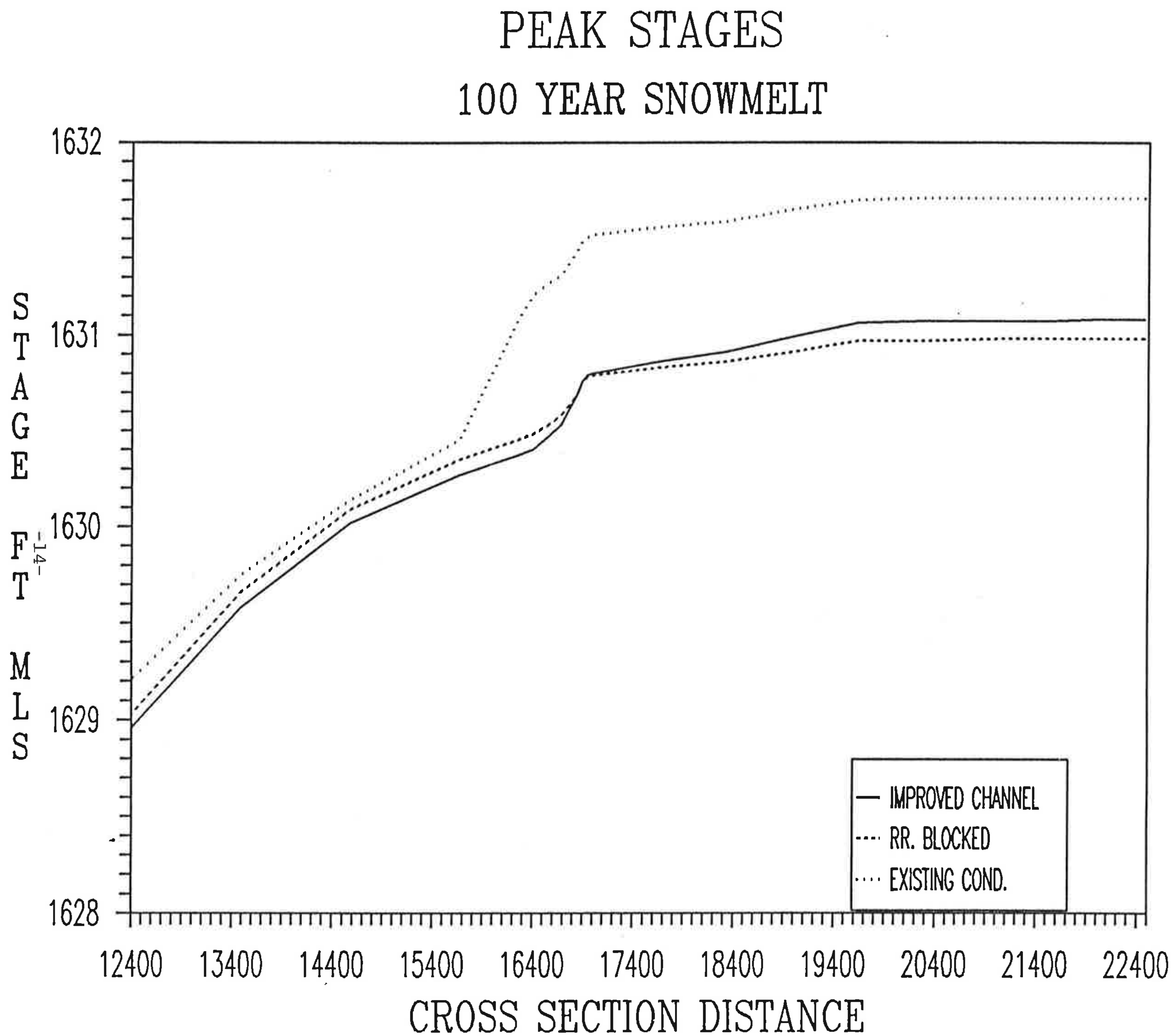

PEAK STAGES
100 YEAR SNOWMELT
STAGE FT MLS
1632
1631
1630
1629
1628
12400
13400
14400
15400
16400
17400
18400
19400
20400
21400
22400
CROSS SECTION DISTANCE
IMPROVED CHANNEL
RR. BLOCKED
EXISTING COND.

FIGURE 6

The change in water surface elevation with flap gates installed on the railroad culverts is very small, less than .1 feet for the 100-year snowmelt. Such small differances in the water surface elevation can not be modeled accurately using the Network model. Therefore, the flap gates have virtually no effect on the water surface elevation downstream of the railroad. The model also predicted that the water would overtop the railroad during an event with a return frequency greater than 5 years, thus eliminating any effect of the railroad.

The spillway crest elevation is 1622 feet msl. There is an area of approximately 9.5 acres in Section 14 below the 1622 elevation. The area below 1622 feet must be considered as part of the reservoir. This area in Section 14 is shown in Figure 7. There is a considerable area above the 1622 contour that will be flooded for short periods of time during runoff events. The peak elevation that the water should reach during a 100-year event is 1631.1 feet msl. The area flooded by the peak stage of the 5-year snowmelt is shown in Figure 8. The area flooded by the 100-year snowmelt is shown in Figure 9.

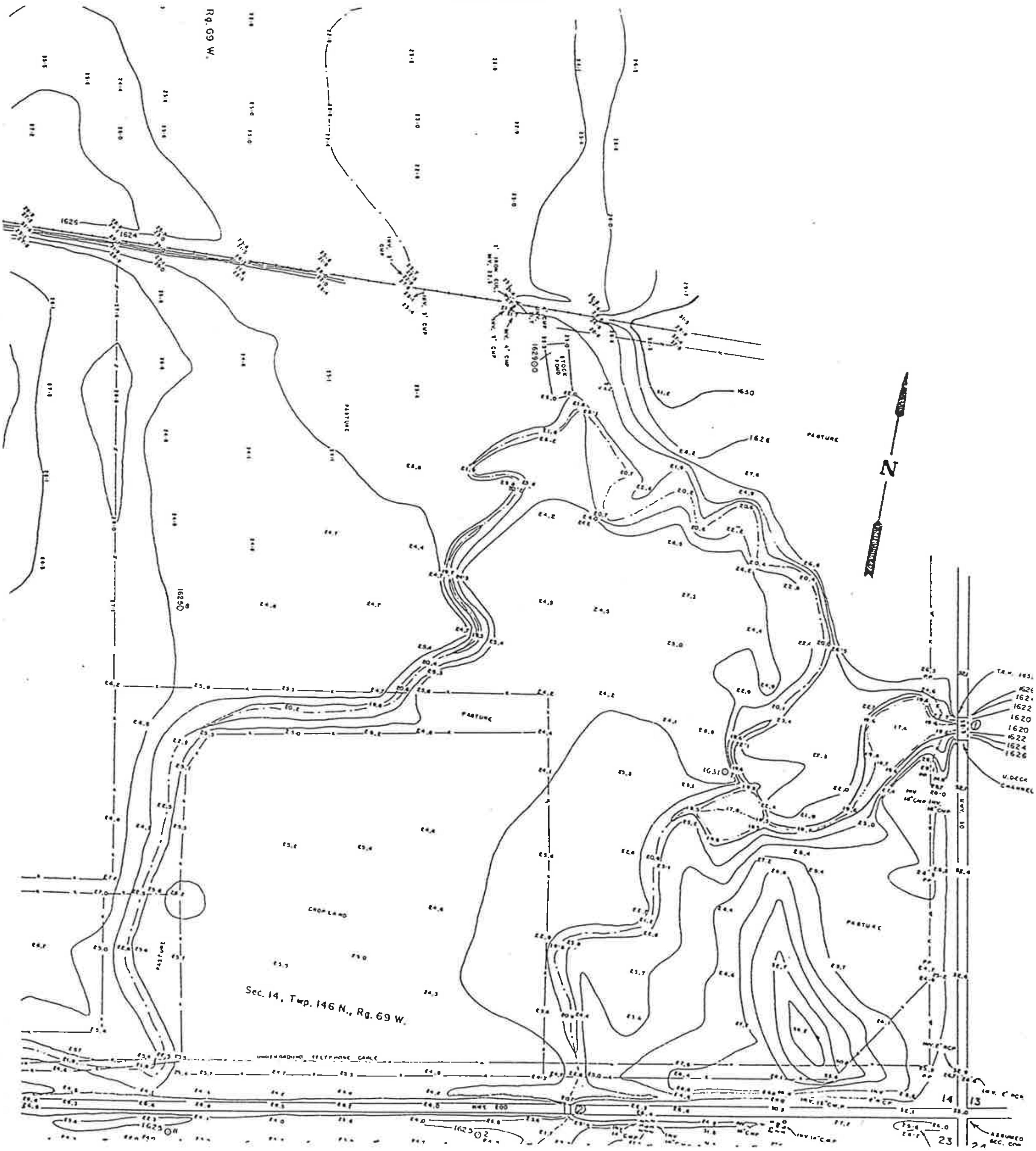
The area flooded above the normal pool and the length of time during which flooding occurs for each event is given in Table 3. This time was estimated from the time the inflow begins until the pool has returned to an elevation of 1622 feet msl. Therefore, the water would not be at the peak elevations for this length of time.

TABLE 3

Runoff Event Return Frequency Years	Area Flooded Above 1622 Ft. MSL Acres	Time That Area Is Flooded Hours
5	436	335
10	482	349
25	535	364
50	592	374
100	623	379

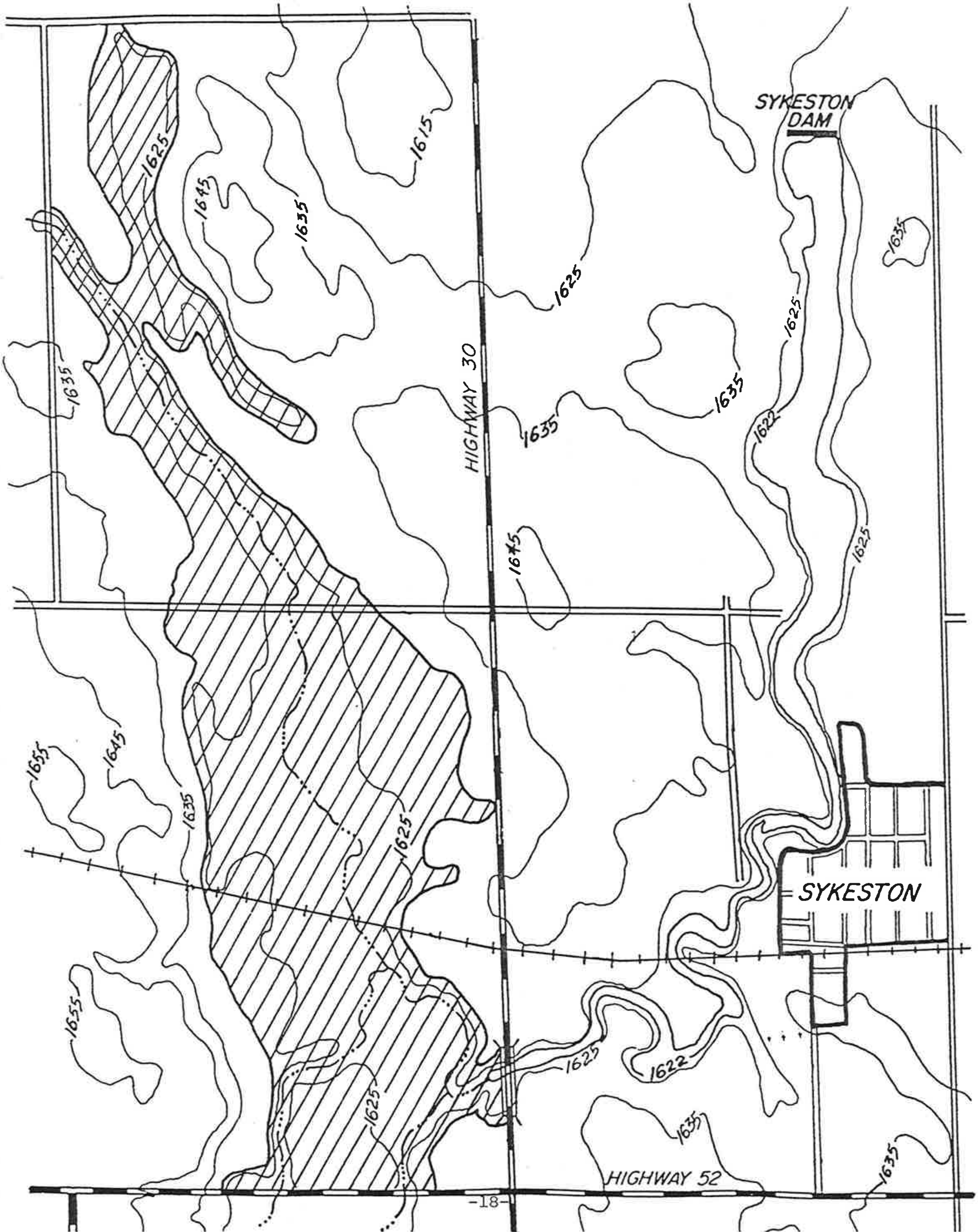
AREA BELOW 1622 FT. MSL IN SECTION 14

FIGURE 7



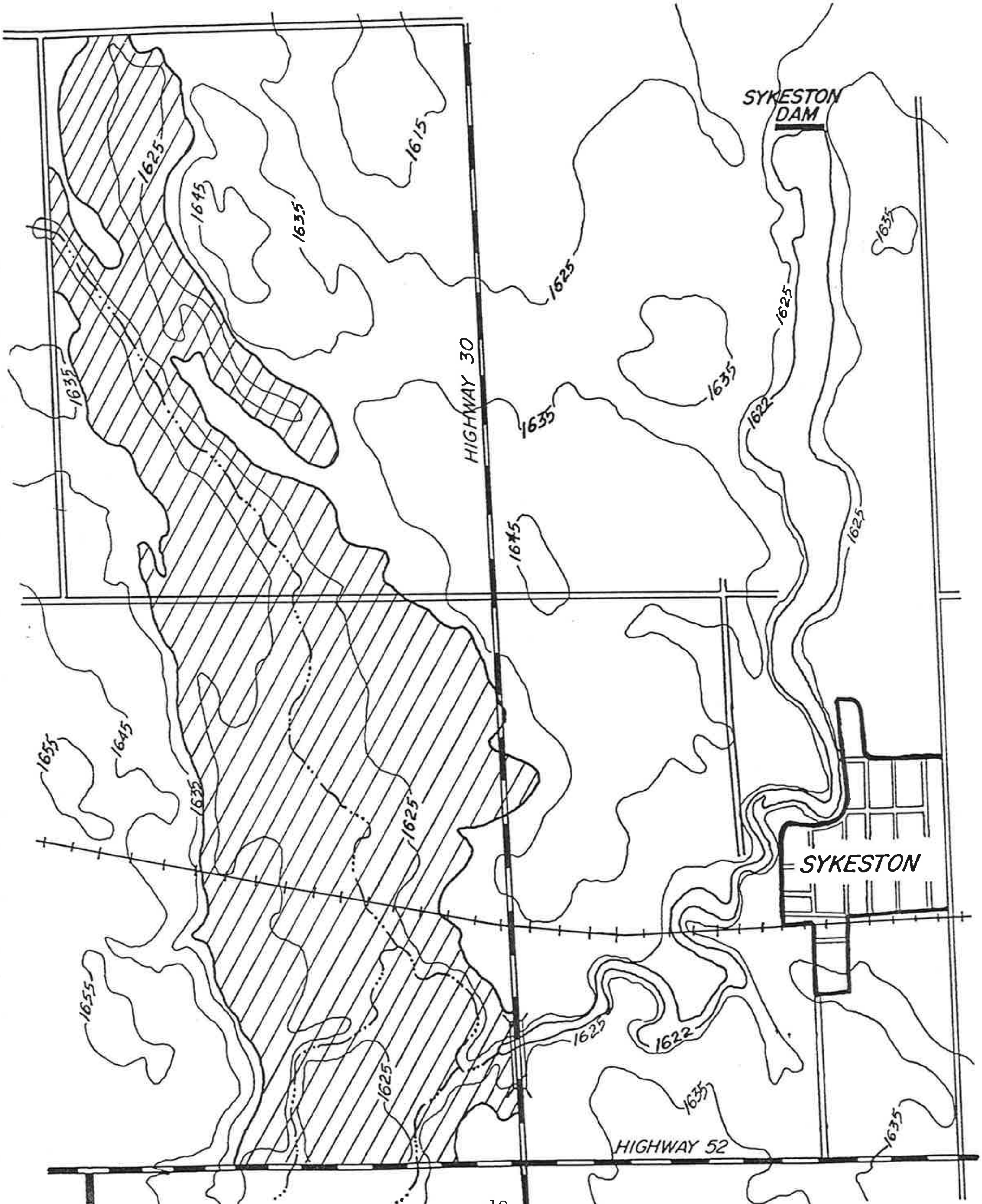
AREA INUNDATED BY THE 5 YEAR SNOWMELT

FIGURE 8



AREA INUNDATED BY THE 100 YEAR SNOWMELT

FIGURE 9



PROPOSED SOLUTIONS

The channel and spillway cleanout has already been completed, resulting in significant reductions of the water surface elevations. As installing flap gates on the railroad culverts would not affect the water surface elevation and the railroad would be overtopped by a runoff greater than the 5-year event, flap gates were not considered to be a viable solution.

The privately owned land below an elevation of 1622 feet msl should be acquired either in fee title or by easement by the Wells County Water Resource District. This area has been inundated since completion of the new dam in 1963 and the filling of the reservoir. The land below 1622 feet in Section 14 is approximately 9.5 acres. Flood easements should be negotiated with the owners of the land subject to flooding above the 1622 contour. The area flooded by a 5-year snowmelt is shown in Figure 8, the area flooded by the 100-year snowmelt is shown in Figure 9.

SUMMARY

Sykeston Dam has been causing flooding problems for upstream landowners since it was built in 1963. The Wells County Water Resource District performed channel and spillway clean out work during 1988 in the area of the old fish screen and in the spillway approach. The channel and spillway cleaning resulted in a substantial reduction in water surface elevation and area that is flooded. However, the flooding problem still exists.

Installing flap gates in the railroad crossing in Section 14 would not provide any flood protection during runoff events having a return frequency greater than 5 years. The gates would have little or no effect on the water surface elevation downstream of the railroad and would not protect the area upstream of the railroad during a flood greater the 5 year flood as the railroad would be overtopped.

The land below 1622 feet msl will be flooded by the normal pool. Land between the elevations of 1622 and 1631.1 will be flooded by runoff events with a return frequency of 100 years or less. There does not appear to be any effective structural means of reducing the flooding on private land, caused by the existing dam, other than acquisition of land rights by the Wells County Water Resource Board.

RECOMMENDATIONS

Since there are no effective structural means of reducing the flooding caused by Sykeston Dam, it is recommended that the land rights below 1622 feet msl be acquired, either by fee title or easement, and that flood easements be acquired for the land above 1622 feet msl being flooded. The area which would currently be flooded by a 5-year snowmelt is shown in Figure 8, the area flooded by a 100-year snowmelt is shown in Figure 9. The Wells County Water Resource District must decided which, if any, of these lands and/or easements will be acquired.

APPENDIX

5 YEAR SNOWMELT
IMPROVED CHANNEL

CROSS SECTION NUMBER	CROSS SECTION DISTANCE	TIME TO PEAK HOURS	DEPTH FEET	CWSEL FT. MSL	FLOW CFS	VELOCITY FT./SEC.
1	22,460	61	8.52	1628.02	935.20	0.12
2	22,000	61	8.52	1628.02	932.00	0.12
3	21,540	61	8.72	1628.02	934.80	0.11
4	21,080	61	8.72	1628.02	935.90	0.11
5	20,270	61	10.22	1628.02	933.10	0.09
6	24,250	61	6.82	1628.02	4.00	0.00
7	23,600	61	4.92	1628.02	4.20	0.00
8	23,056	61	4.92	1628.02	4.40	0.00
9	22,512	61	4.92	1628.02	4.70	0.00
10	21,968	61	5.22	1628.02	4.80	0.00
11	21,424	61	5.22	1628.02	4.30	0.00
12	20,880	61	5.22	1628.02	3.30	0.00
13	20,805	61	5.22	1628.02	3.20	0.00
14	20,755	61	5.62	1628.02	3.10	0.01
15	20,705	61	6.02	1628.02	2.70	0.01
16	20,655	61	6.32	1628.02	2.30	0.04
17	20,555	61	6.32	1628.02	1.90	0.01
18	20,505	61	6.32	1628.02	1.80	0.00
19	20,455	61	6.32	1628.02	1.70	0.00
20	20,380	61	4.62	1628.02	1.70	0.00
21	19,850	61	6.22	1628.02	1.70	0.00
22	19,625	61	7.82	1628.02	934.80	0.56
23	18,980	61	7.75	1627.95	935.10	0.57
24	18,315	61	7.69	1627.89	935.10	0.58
25	17,650	61	10.46	1627.86	934.50	0.36
26	16,985	61	9.84	1627.84	933.70	0.43
27	16,935	61	9.84	1627.84	933.80	0.50
28	16,885	61	9.83	1627.83	934.00	0.70
29	16,835	61	9.81	1627.81	934.20	1.10
30	16,785	61	9.67	1627.67	934.00	2.59
31	16,670	61	9.73	1627.73	933.80	1.02
32	16,550	61	9.70	1627.70	933.90	1.03
33	16,400	61	9.77	1627.67	933.90	0.64
34	16,245	61	9.76	1627.66	933.80	0.65
35	15,662	61	9.70	1627.60	934.00	0.58
36	14,577	62	8.25	1627.45	931.60	0.86
37	13,492	62	7.90	1627.10	931.40	0.97
38	12,407	64	7.43	1626.63	924.60	1.15
39	11,322	64	6.65	1625.85	924.10	1.54
40	10,237	66	19.85	1625.85	913.60	0.16
41	9,152	66	19.85	1625.85	913.50	0.16
42	8,067	66	19.85	1625.85	913.50	0.16
43	6,982	66	19.84	1625.84	914.20	0.16
44	5,897	66	19.84	1625.84	913.00	0.16
45	5,512	66	19.84	1625.84	913.50	0.16
46	5,127	66	19.44	1625.84	914.70	0.13
47	4,742	66	19.44	1625.84	914.20	0.13
48	4,280	66	5.83	1625.83	912.90	1.42
49	3,620	66	19.43	1625.83	912.70	0.18
50	2,828	66	20.33	1625.83	913.10	0.16
51	1,871	66	20.33	1625.83	913.10	0.12
52	1,244	66	20.33	1625.83	913.10	0.13

10 YEAR SNOWMELT
IMPROVED CHANNEL

CROSS SECTION NUMBER	CROSS SECTION DISTANCE	TIME TO PEAK HOURS	DEPTH FEET	CWSEL FT. MSL	FLOW CFS	VELOCITY FT./SEC.
1	22,460	60	9.25	1628.75	1215.00	0.13
2	22,000	60	9.25	1628.75	1214.50	0.13
3	21,540	60	9.44	1628.74	1216.00	0.11
4	21,080	60	9.44	1628.74	1218.70	0.12
5	20,270	60	10.94	1628.74	1216.50	0.09
6	24,250	60	7.54	1628.74	5.00	0.00
7	23,600	60	5.64	1628.74	6.10	0.00
8	23,056	60	5.64	1628.74	7.20	0.00
9	22,512	60	5.64	1628.74	7.90	0.00
10	21,968	60	5.94	1628.74	7.50	0.00
11	21,424	60	5.94	1628.74	8.20	0.00
12	20,880	60	5.94	1628.74	9.40	0.00
13	20,805	60	5.94	1628.74	9.50	0.00
14	20,755	60	6.34	1628.74	9.50	0.01
15	20,705	60	6.74	1628.74	9.50	0.01
16	20,655	60	7.04	1628.74	9.60	0.02
17	20,555	60	7.04	1628.74	10.40	0.02
18	20,505	60	7.04	1628.74	10.60	0.01
19	20,455	60	7.04	1628.74	10.40	0.00
20	20,380	60	5.34	1628.74	10.20	0.00
21	19,850	60	6.94	1628.74	11.70	0.00
22	19,625	60	8.54	1628.74	1228.20	0.60
23	18,980	60	8.47	1628.67	1228.70	0.61
24	18,315	60	8.40	1628.60	1228.10	0.62
25	17,650	60	11.17	1628.57	1228.30	0.40
26	16,985	60	10.54	1628.54	1228.40	0.52
27	16,935	60	10.54	1628.54	1228.40	0.58
28	16,885	60	10.53	1628.53	1228.50	0.80
29	16,835	60	10.49	1628.49	1228.60	1.27
30	16,785	60	10.31	1628.31	1228.70	3.09
31	16,670	60	10.40	1628.40	1228.70	1.20
32	16,550	60	10.36	1628.36	1228.90	1.21
33	16,400	60	10.43	1628.33	1228.90	0.72
34	16,245	60	10.41	1628.31	1228.90	0.73
35	15,662	60	10.35	1628.25	1228.80	0.65
36	14,577	60	8.87	1628.07	1228.60	0.93
37	13,492	60	8.51	1627.71	1228.80	1.04
38	12,407	60	7.99	1627.19	1228.40	1.25
39	11,322	60	7.07	1626.27	1228.10	1.74
40	10,237	60	20.26	1626.26	1227.30	0.21
41	9,152	60	20.26	1626.26	1225.30	0.21
42	8,067	62	20.26	1626.26	1224.60	0.21
43	6,982	62	20.25	1626.25	1223.40	0.21
44	5,897	62	20.25	1626.25	1223.60	0.21
45	5,512	62	20.25	1626.25	1222.80	0.21
46	5,127	62	19.84	1626.24	1222.60	0.16
47	4,742	62	19.84	1626.24	1223.50	0.16
48	4,280	62	6.22	1626.22	1223.80	1.68
49	3,620	62	19.83	1626.23	1223.90	0.22
50	2,828	62	20.73	1626.23	1223.70	0.20
51	1,871	62	20.72	1626.22	1223.50	0.16
52	1,244	62	20.72	1626.22	1223.60	0.17

25 YEAR SNOWMELT
IMPROVED CHANNEL

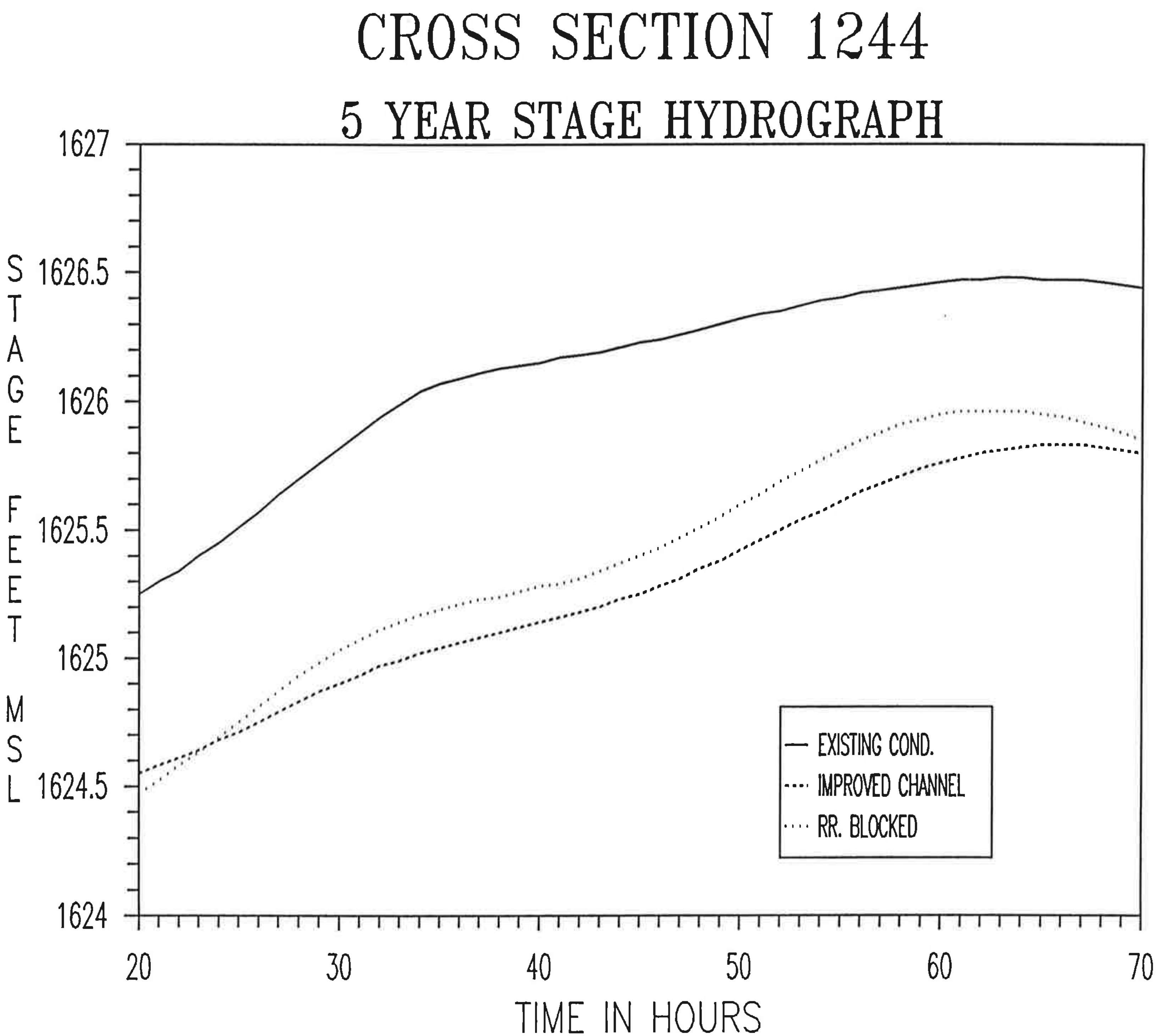
CROSS SECTION NUMBER	CROSS SECTION DISTANCE	TIME TO PEAK HOURS	DEPTH FEET	CWSEL FT. MSL	FLOW CFS	VELOCITY FT./SEC.
1	22,460	58	10.18	1629.68	1713.00	0.14
2	22,000	58	10.18	1629.68	1710.60	0.14
3	21,540	58	10.38	1629.68	1712.10	0.13
4	21,080	58	10.38	1629.68	1714.60	0.13
5	20,270	58	11.87	1629.68	1719.20	0.11
6	24,250	58	8.48	1629.68	7.50	0.00
7	23,600	58	6.58	1629.68	7.30	0.00
8	23,056	58	6.58	1629.68	7.20	0.00
9	22,512	58	6.58	1629.68	7.40	0.00
10	21,968	58	6.87	1629.68	7.50	0.00
11	21,424	58	6.87	1629.68	7.40	0.00
12	20,880	58	6.87	1629.68	7.90	0.00
13	20,805	58	6.87	1629.68	7.90	0.00
14	20,755	58	7.28	1629.68	8.00	0.01
15	20,705	58	7.67	1629.67	8.30	0.00
16	20,655	58	7.98	1629.68	8.40	0.01
17	20,555	58	7.97	1629.67	7.60	0.00
18	20,505	58	7.97	1629.67	7.20	0.00
19	20,455	58	7.98	1629.68	6.70	0.00
20	20,380	58	6.28	1629.68	5.60	0.00
21	19,850	58	7.87	1629.68	1.30	0.00
22	19,625	58	9.47	1629.67	1720.50	0.65
23	18,980	58	9.40	1629.60	1719.60	0.66
24	18,315	58	9.32	1629.52	1718.80	0.68
25	17,650	58	12.08	1629.48	1719.60	0.46
26	16,985	58	11.44	1629.44	1719.70	0.64
27	16,935	58	11.43	1629.43	1719.70	0.68
28	16,885	58	11.42	1629.42	1719.70	0.95
29	16,835	58	11.37	1629.37	1719.70	1.52
30	16,785	58	11.08	1629.08	1719.90	3.88
31	16,670	58	11.23	1629.23	1719.70	1.48
32	16,550	58	11.19	1629.19	1719.50	1.49
33	16,400	58	11.25	1629.15	1719.40	0.84
34	16,245	58	11.22	1629.12	1719.20	0.85
35	15,662	58	11.15	1629.05	1719.50	0.76
36	14,577	58	9.64	1628.84	1719.60	1.02
37	13,492	58	9.24	1628.44	1719.00	1.15
38	12,407	59	8.67	1627.87	1717.60	1.38
39	11,322	60	7.56	1626.76	1713.60	2.03
40	10,237	60	20.75	1626.75	1713.30	0.27
41	9,152	60	20.75	1626.75	1712.30	0.27
42	8,067	60	20.74	1626.74	1713.20	0.27
43	6,982	60	20.73	1626.73	1711.80	0.27
44	5,897	60	20.72	1626.72	1710.50	0.27
45	5,512	60	20.72	1626.72	1710.60	0.27
46	5,127	60	20.32	1626.72	1711.00	0.21
47	4,742	60	20.32	1626.72	1711.10	0.21
48	4,280	60	6.69	1626.69	1710.70	1.69
49	3,620	60	20.27	1626.67	1710.70	0.30
50	2,828	60	21.16	1626.66	1710.20	0.27
51	1,871	60	21.16	1626.66	1710.30	0.22
52	1,244	60	21.16	1626.66	1709.10	0.23

50 YEAR SNOWMELT
IMPROVED CHANNEL

CROSS SECTION	CROSS SECTION	TIME TO PEAK	DEPTH FEET	CWSEL FT. MSL	FLOW CFS	VELOCITY FT./SEC.
1	22,460	57	11.00	1630.50	2268.80	0.16
2	22,000	57	10.99	1630.49	2270.20	0.16
3	21,540	57	11.19	1630.49	2268.30	0.15
4	21,080	57	11.19	1630.49	2269.10	0.15
5	20,270	57	12.69	1630.49	2270.50	0.13
6	24,250	57	9.29	1630.49	9.80	0.00
7	23,600	57	7.39	1630.49	10.10	0.00
8	23,056	57	7.39	1630.49	9.50	0.00
9	22,512	57	7.39	1630.49	9.40	0.00
10	21,968	57	7.69	1630.49	8.40	0.00
11	21,424	57	7.69	1630.49	6.70	0.00
12	20,880	57	7.69	1630.49	7.80	0.00
13	20,805	57	7.69	1630.49	8.90	0.00
14	20,755	57	8.09	1630.49	9.40	0.00
15	20,705	57	8.49	1630.49	9.70	0.00
16	20,655	57	8.79	1630.49	10.10	0.00
17	20,555	57	8.79	1630.49	10.10	0.00
18	20,505	57	8.79	1630.49	9.90	0.00
19	20,455	57	8.79	1630.49	9.80	0.00
20	20,380	57	7.09	1630.49	9.70	0.00
21	19,850	57	8.69	1630.49	8.40	0.00
22	19,625	57	10.28	1630.48	2279.00	0.71
23	18,980	57	10.21	1630.41	2278.10	0.72
24	18,315	57	10.13	1630.33	2278.10	0.73
25	17,650	57	12.88	1630.28	2278.20	0.50
26	16,985	57	12.23	1630.23	2278.10	0.70
27	16,935	57	12.22	1630.22	2278.10	0.77
28	16,885	57	12.20	1630.20	2278.10	1.07
29	16,835	57	12.14	1630.14	2278.20	1.74
30	16,785	57	11.69	1629.69	2278.20	4.94
31	16,670	57	12.00	1630.00	2278.30	1.76
32	16,550	57	11.95	1629.95	2278.20	1.78
33	16,400	57	11.99	1629.89	2278.10	0.95
34	16,245	57	11.97	1629.87	2278.00	0.96
35	15,662	57	11.88	1629.78	2277.40	0.85
36	14,577	57	10.34	1629.54	2277.40	1.11
37	13,492	57	9.92	1629.12	2276.50	1.25
38	12,407	57	9.31	1628.51	2274.70	1.49
39	11,322	59	8.12	1627.32	2267.80	2.20
40	10,237	59	21.31	1627.31	2267.10	0.34
41	9,152	59	21.30	1627.30	2266.50	0.34
42	8,067	60	21.29	1627.29	2258.80	0.33
43	6,982	60	21.27	1627.27	2259.90	0.34
44	5,897	60	21.26	1627.26	2259.80	0.34
45	5,512	60	21.26	1627.26	2259.40	0.34
46	5,127	60	20.86	1627.26	2259.80	0.26
47	4,742	60	20.85	1627.25	2259.50	0.26
48	4,280	60	7.22	1627.22	2259.20	1.42
49	3,620	60	20.78	1627.18	2260.40	0.36
50	2,828	60	21.67	1627.17	2260.90	0.33
51	1,871	60	21.66	1627.16	2262.00	0.27
52	1,244	60	21.65	1627.15	2261.70	0.29

100 YEAR SNOWMELT
IMPROVED CHANNEL

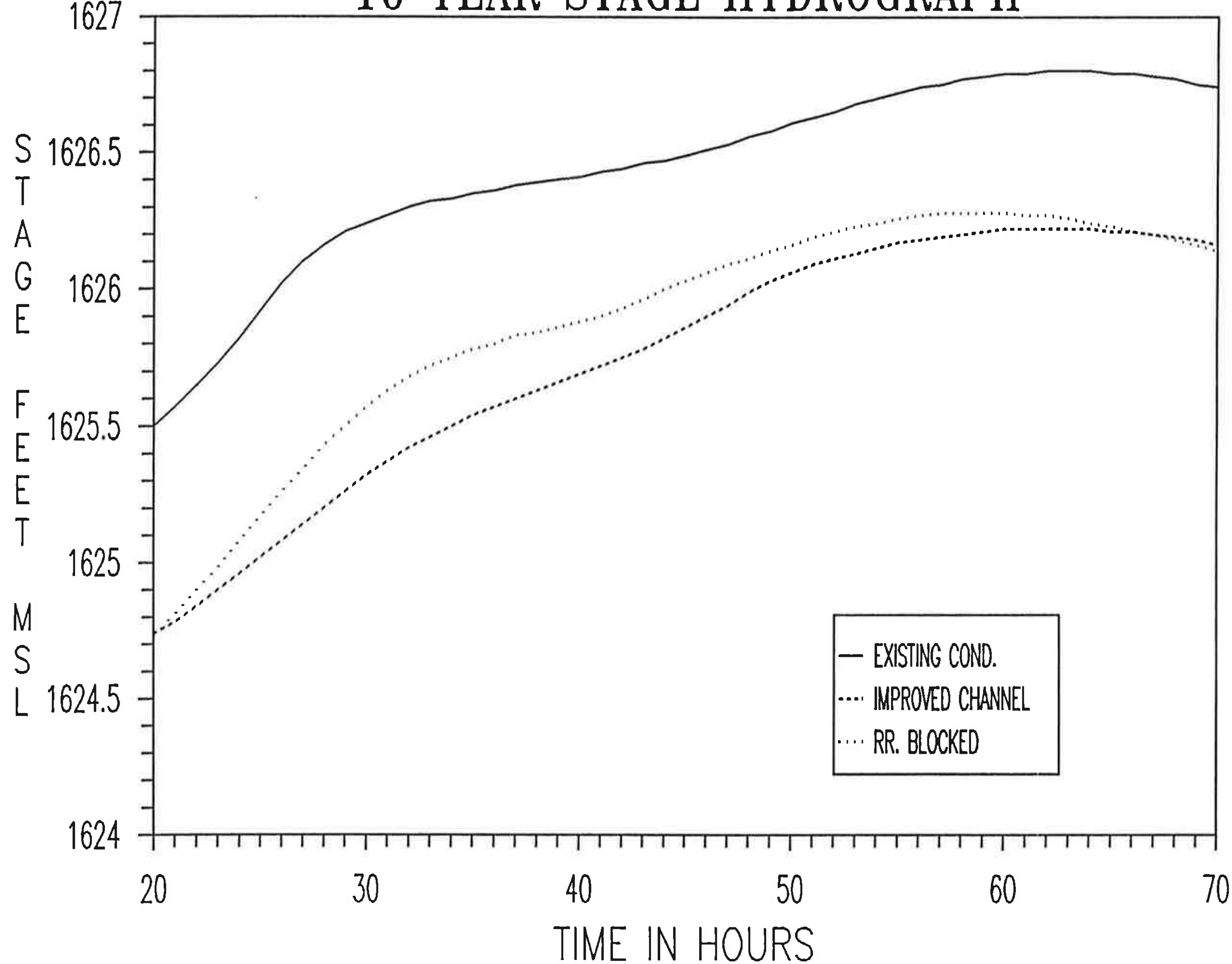
CROSS SECTION NUMBER	CROSS SECTION DISTANCE	TIME TO PEAK HOURS	DEPTH FEET	CWSEL FT. MSL	FLOW CFS	VELOCITY FT./SEC.
1	22,460	57	11.58	1631.08	2698.00	0.17
2	22,000	57	11.58	1631.08	2699.60	0.17
3	21,540	57	11.77	1631.07	2702.30	0.16
4	21,080	57	11.77	1631.07	2706.40	0.16
5	20,270	57	13.27	1631.07	2707.20	0.14
6	24,250	57	9.87	1631.07	10.70	0.00
7	23,600	57	7.97	1631.07	10.30	0.00
8	23,056	57	7.97	1631.07	7.90	0.00
9	22,512	57	7.97	1631.07	3.00	0.00
10	21,968	57	8.27	1631.07	4.40	0.00
11	21,424	57	8.27	1631.07	5.40	0.00
12	20,880	57	8.27	1631.07	3.40	0.00
13	20,805	57	8.27	1631.07	2.90	0.00
14	20,755	57	8.67	1631.07	2.50	0.00
15	20,705	57	9.07	1631.07	2.00	0.00
16	20,655	57	9.37	1631.07	1.30	0.00
17	20,555	57	9.37	1631.07	0.70	0.00
18	20,505	57	9.37	1631.07	0.80	0.00
19	20,455	57	9.37	1631.07	0.70	0.00
20	20,380	57	7.67	1631.07	0.60	0.00
21	19,850	57	9.27	1631.07	5.40	0.00
22	19,625	57	10.86	1631.06	2712.50	0.74
23	18,980	57	10.79	1630.99	2717.40	0.75
24	18,315	57	10.71	1630.91	2718.10	0.76
25	17,650	57	13.46	1630.86	2719.80	0.53
26	16,985	57	12.80	1630.80	2721.10	0.72
27	16,935	57	12.79	1630.79	2721.00	0.81
28	16,885	57	12.76	1630.76	2721.10	1.14
29	16,835	57	12.69	1630.69	2721.10	1.86
30	16,785	57	12.07	1630.07	2721.20	5.89
31	16,670	57	12.53	1630.53	2721.40	1.97
32	16,550	57	12.47	1630.47	2721.00	1.98
33	16,400	57	12.50	1630.40	2721.10	1.03
34	16,245	57	12.47	1630.37	2721.10	1.03
35	15,662	57	12.37	1630.27	2720.80	0.91
36	14,577	57	10.82	1630.02	2720.40	1.17
37	13,492	59	10.38	1629.58	2704.60	1.31
38	12,407	59	9.76	1628.96	2705.60	1.55
39	11,322	59	8.55	1627.75	2706.40	2.27
40	10,237	59	21.73	1627.73	2705.80	0.38
41	9,152	59	21.72	1627.72	2704.50	0.38
42	8,067	59	21.71	1627.71	2704.90	0.38
43	6,982	59	21.69	1627.69	2703.10	0.38
44	5,897	59	21.68	1627.68	2704.40	0.38
45	5,512	59	21.67	1627.67	2705.00	0.38
46	5,127	59	21.27	1627.67	2704.00	0.30
47	4,742	59	21.27	1627.67	2703.40	0.30
48	4,280	59	7.63	1627.63	2702.80	1.28
49	3,620	59	21.18	1627.58	2701.60	0.41
50	2,828	59	22.07	1627.57	2703.70	0.37
51	1,871	59	22.05	1627.55	2701.90	0.31
52	1,244	59	22.05	1627.55	2700.20	0.33



CROSS SECTION 1244
5 YEAR STAGE HYDROGRAPH
STAGE FEET MSL
1627
1626.5
1626
1625.5
1625
1624.5
1624
20
30
40
50
60
70
TIME IN HOURS
EXISTING COND.
IMPROVED CHANNEL
RR. BLOCKED

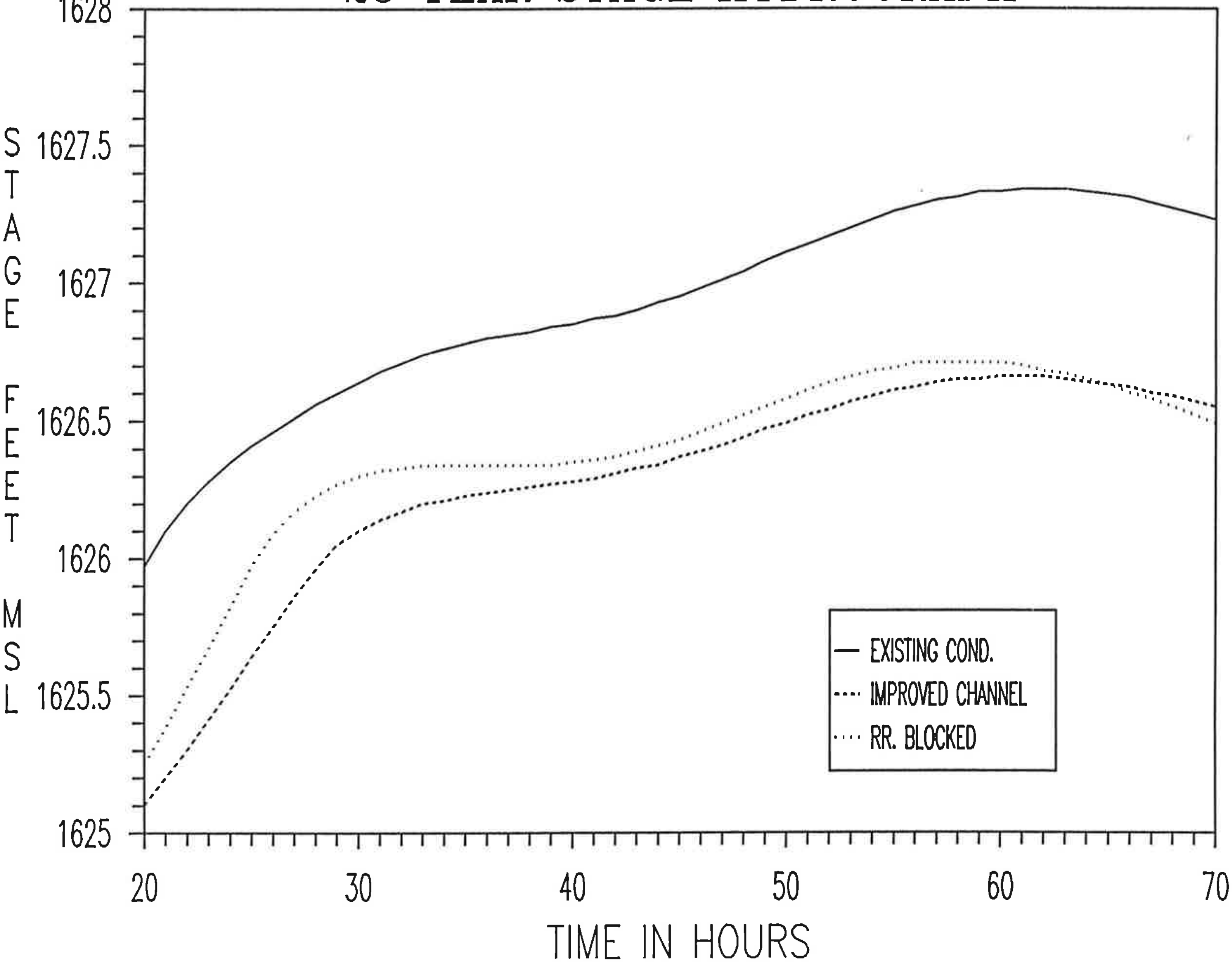
CROSS SECTION 1244

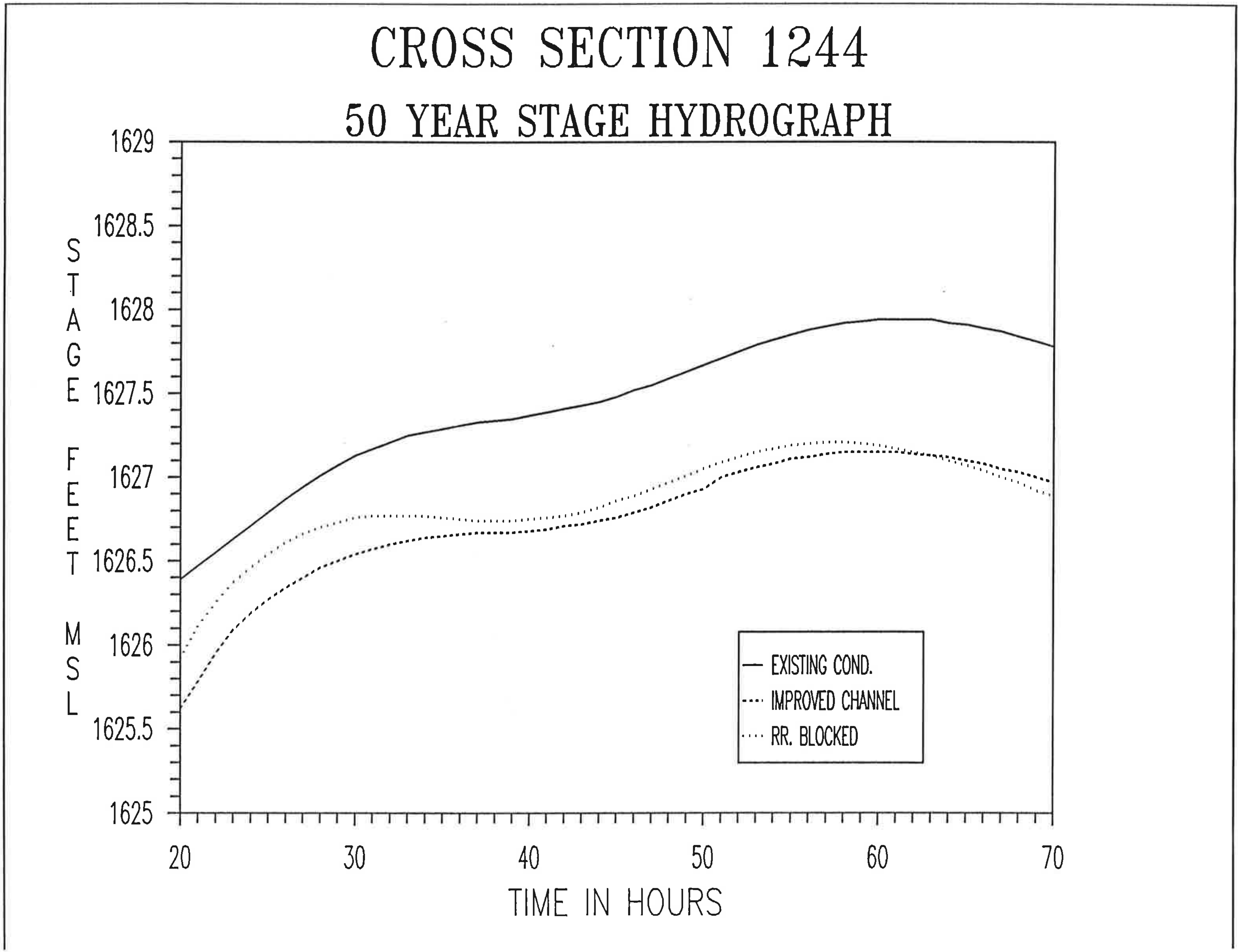
10 YEAR STAGE HYDROGRAPH



CROSS SECTION 1244

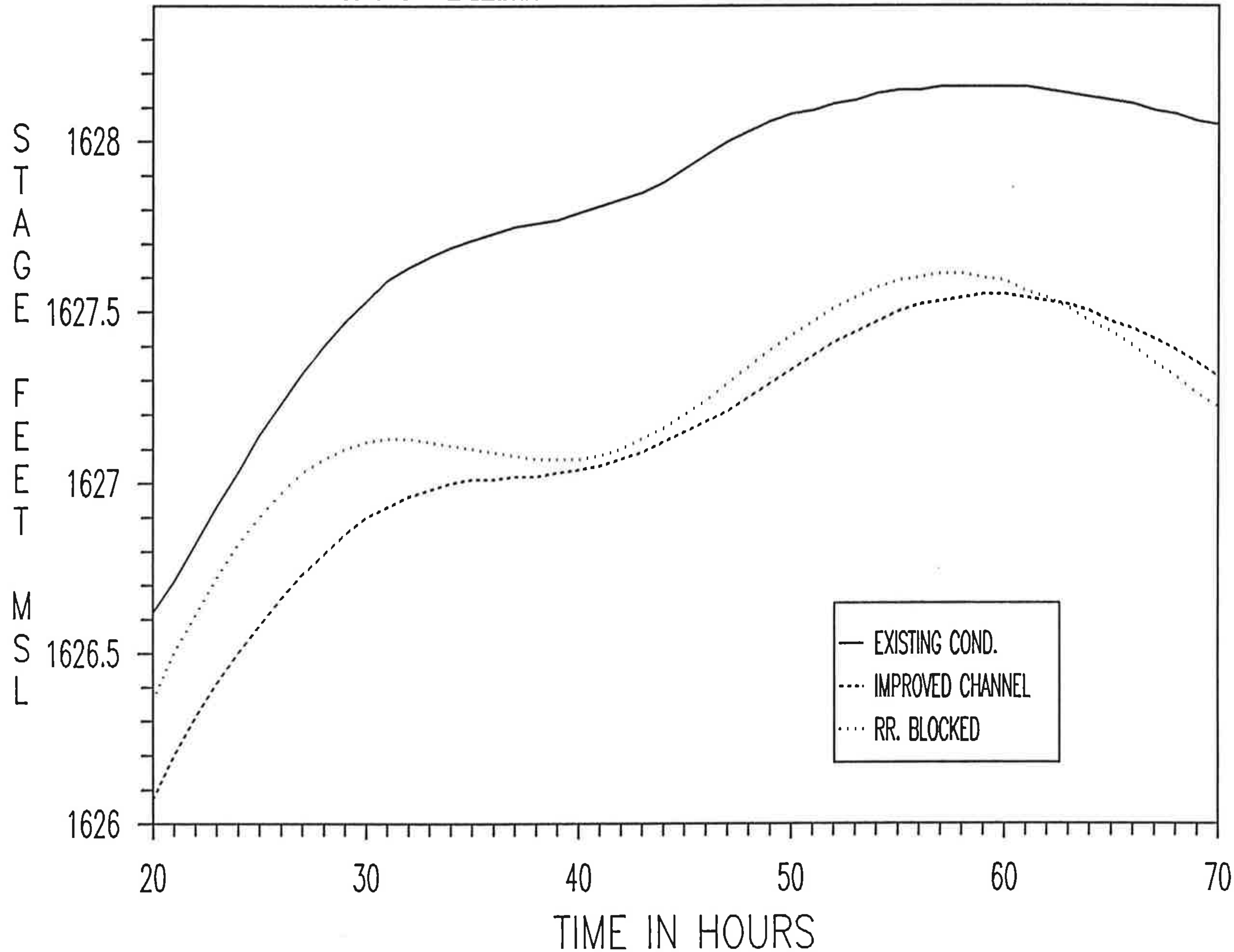
25 YEAR STAGE HYDROGRAPH

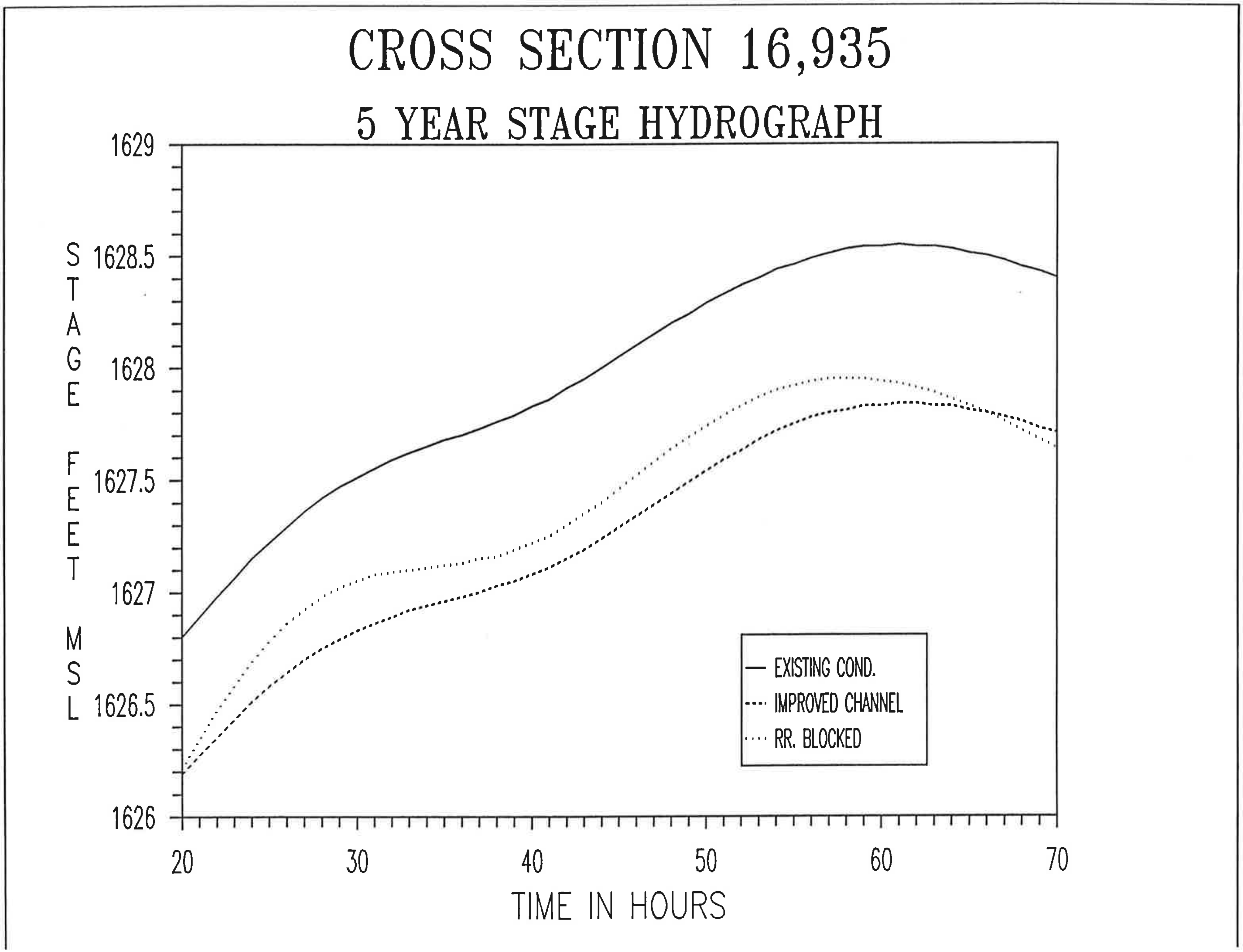



CROSS SECTION 1244
50 YEAR STAGE HYDROGRAPH
STAGE FEET MSL
1629
1628.5
1628
1627.5
1627
1626.5
1626
1625.5
1625
20
30
40
50
60
70
TIME IN HOURS
EXISTING COND.
IMPROVED CHANNEL
RR. BLOCKED

CROSS SECTION 1244

100 YEAR STAGE HYDROGRAPH

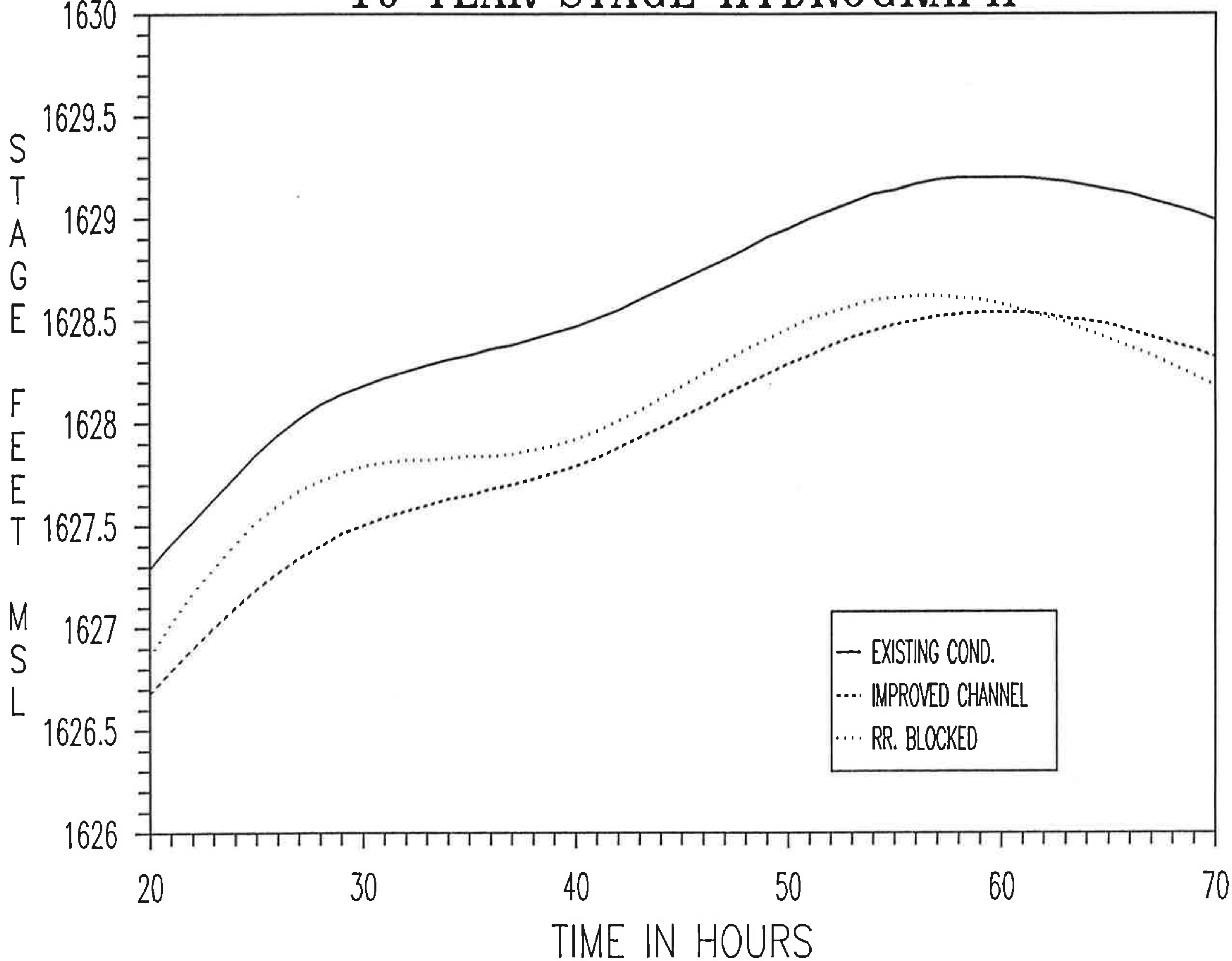




CROSS SECTION 16,935
5 YEAR STAGE HYDROGRAPH
STAGE FEET MSL
1629
1628.5
1628
1627.5
1627
1626.5
1626
20
30
40
50
60
70
TIME IN HOURS
EXISTING COND.
IMPROVED CHANNEL
RR. BLOCKED

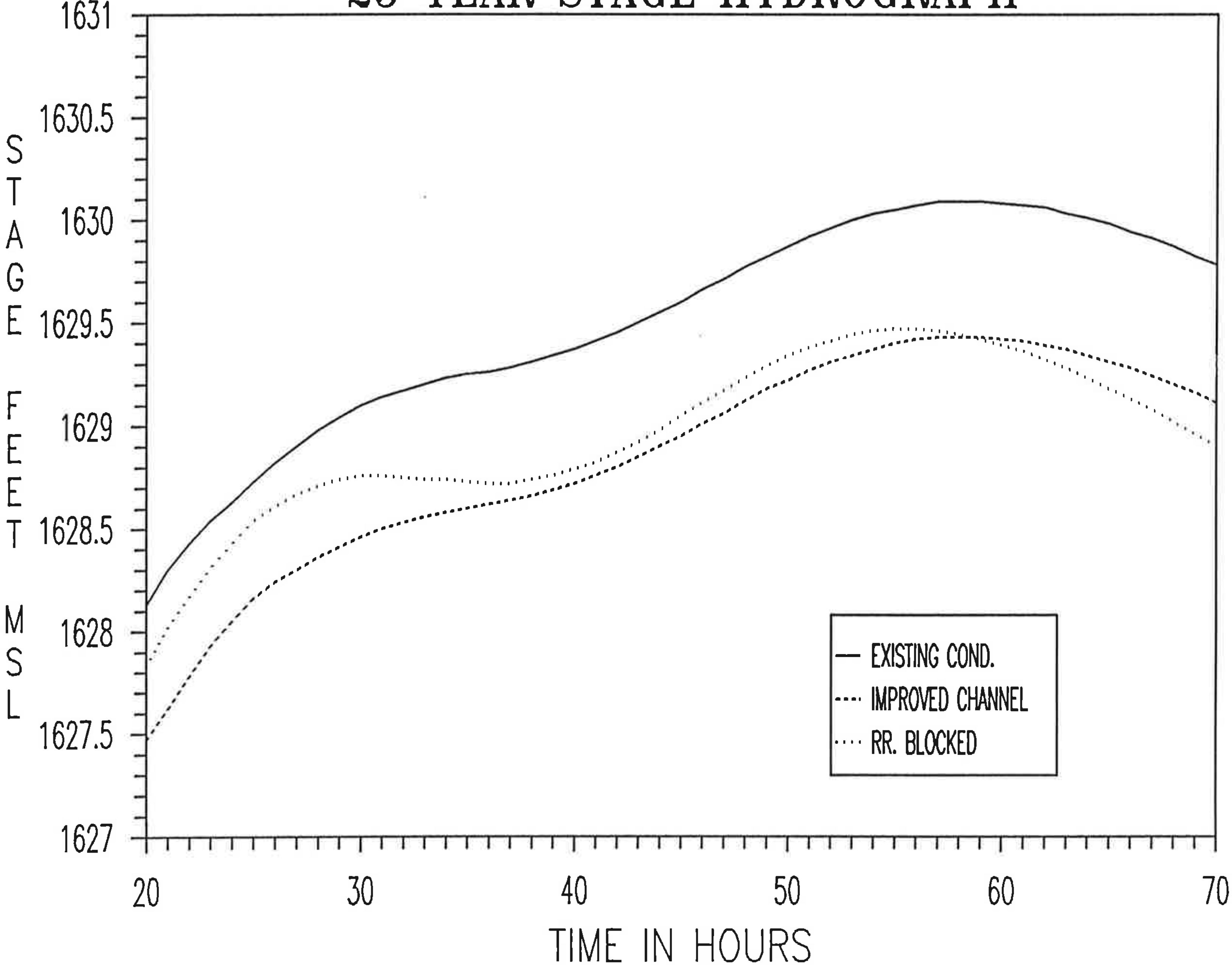
CROSS SECTION 16,935

10 YEAR STAGE HYDROGRAPH



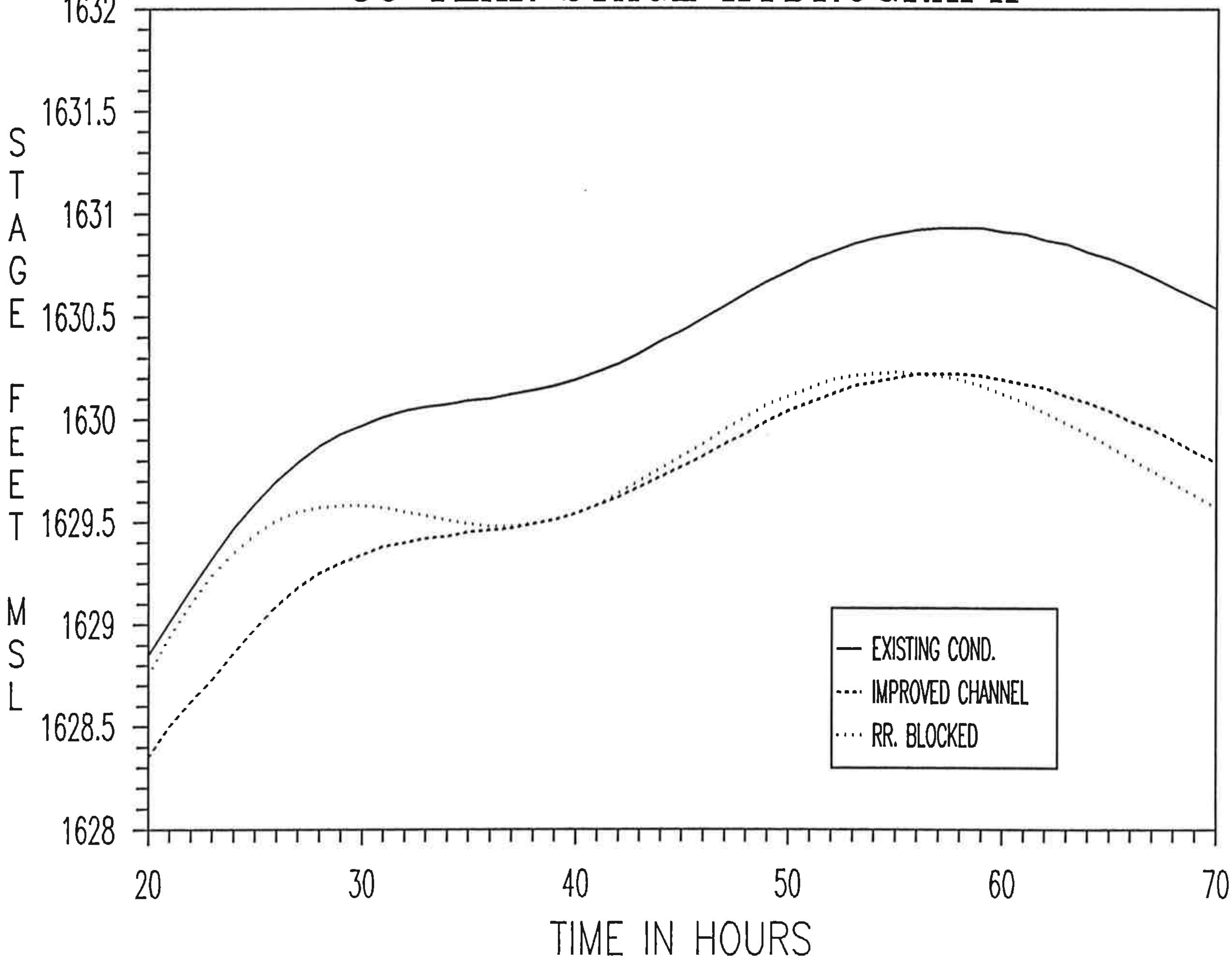
CROSS SECTION 16,935

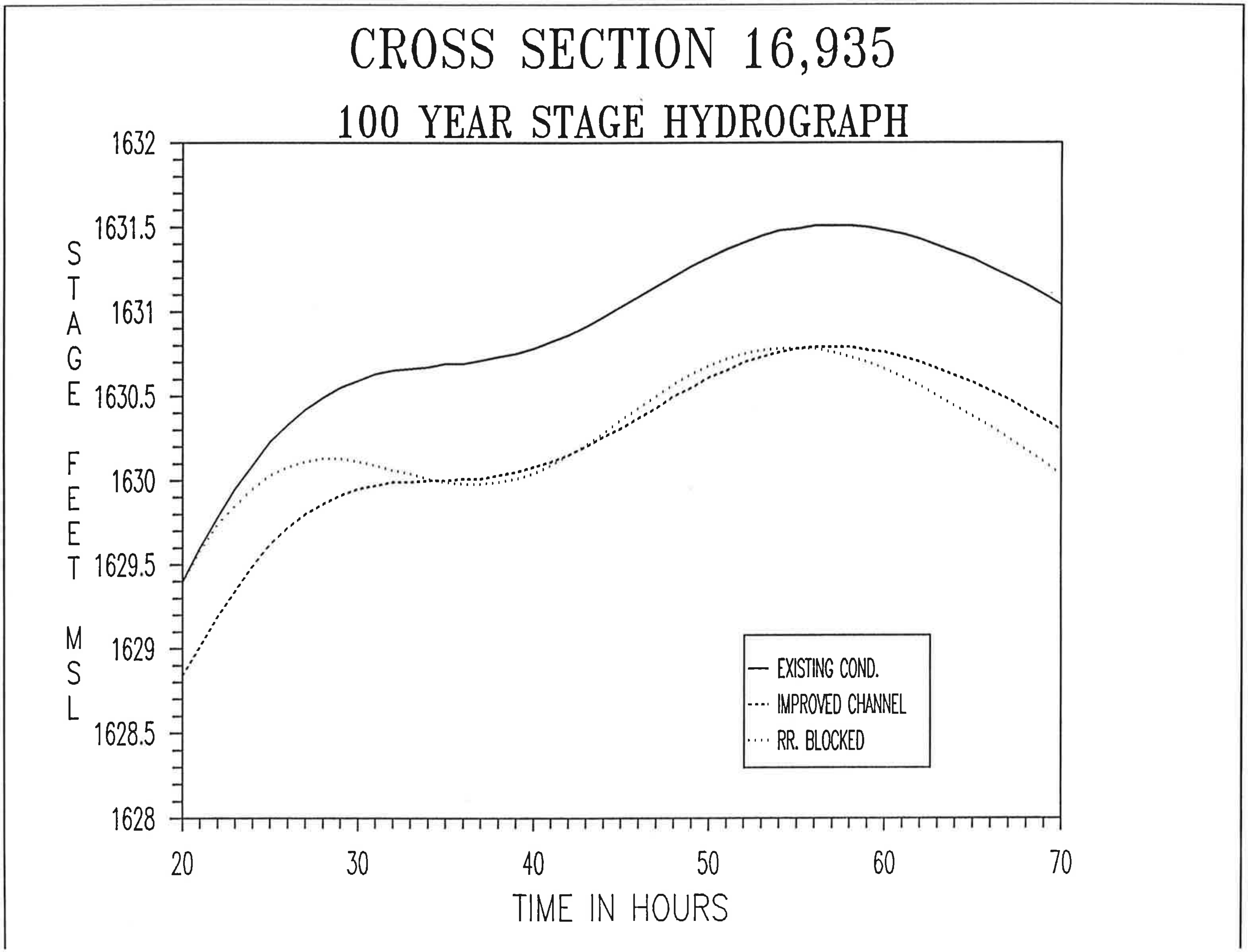
25 YEAR STAGE HYDROGRAPH



CROSS SECTION 16,935

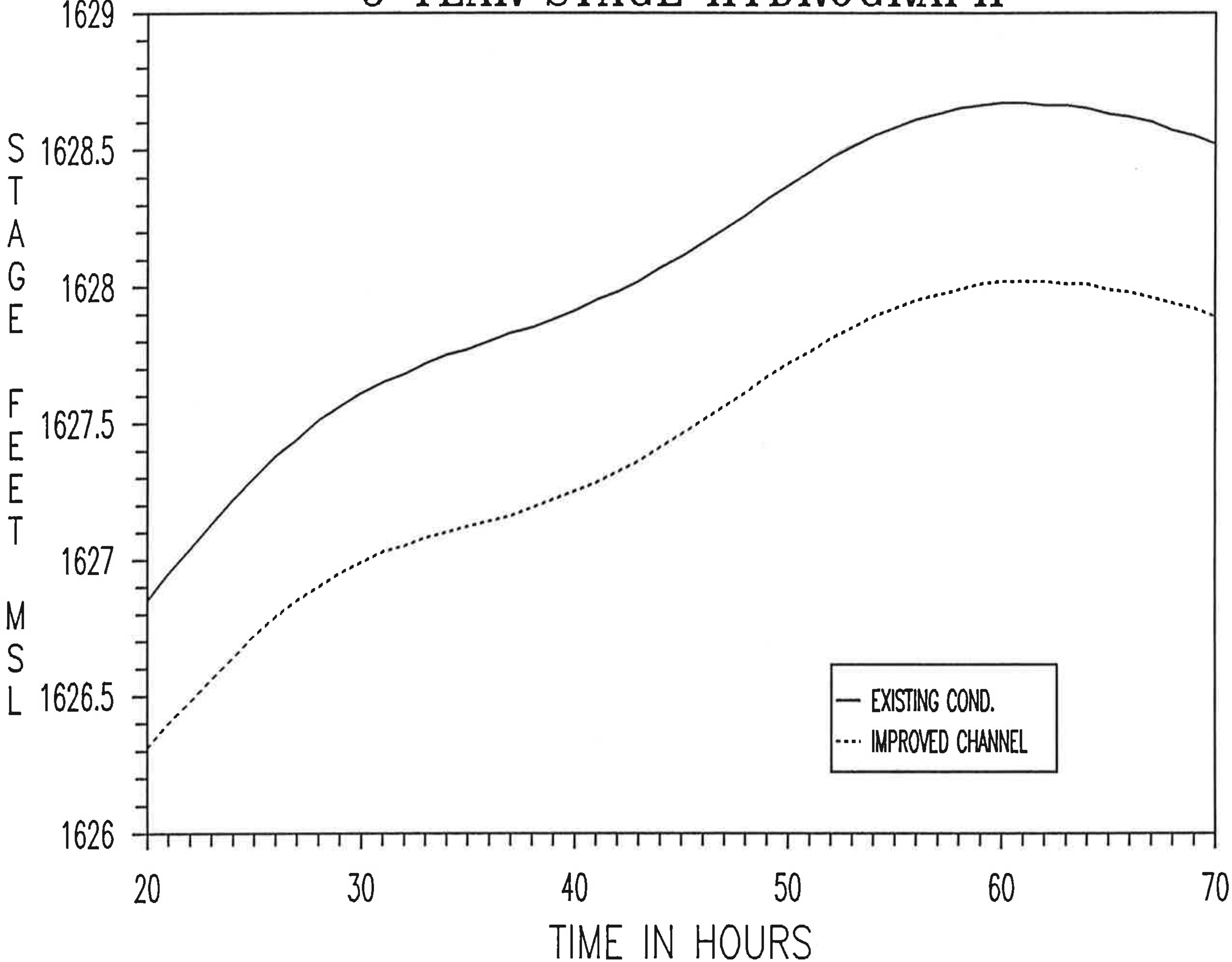
50 YEAR STAGE HYDROGRAPH

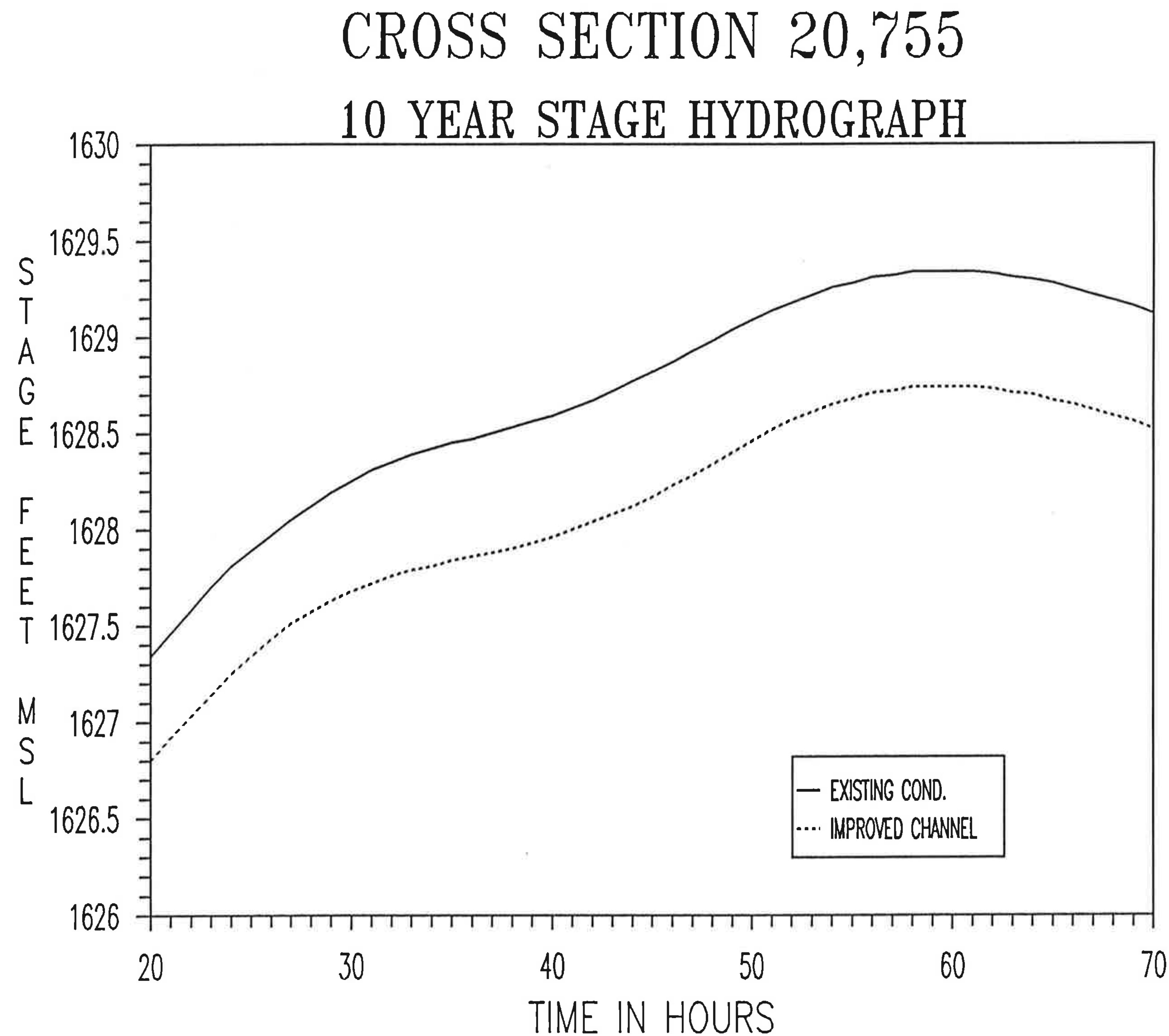



CROSS SECTION 16,935
100 YEAR STAGE HYDROGRAPH
STAGE FEET MSL
1632
1631.5
1631
1630.5
1630
1629.5
1629
1628.5
1628
20
30
40
50
60
70
TIME IN HOURS
EXISTING COND.
IMPROVED CHANNEL
RR. BLOCKED

CROSS SECTION 20,755

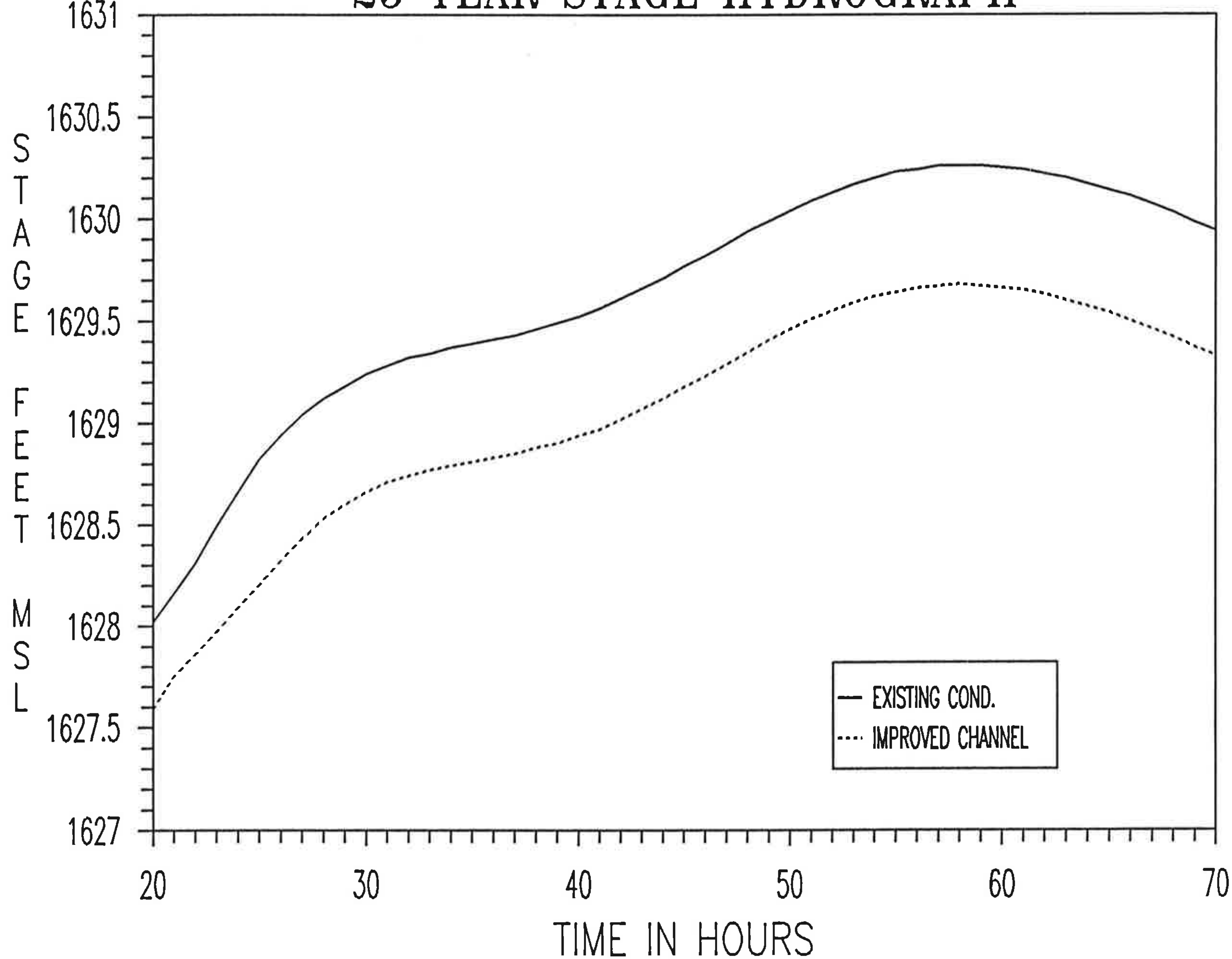
5 YEAR STAGE HYDROGRAPH

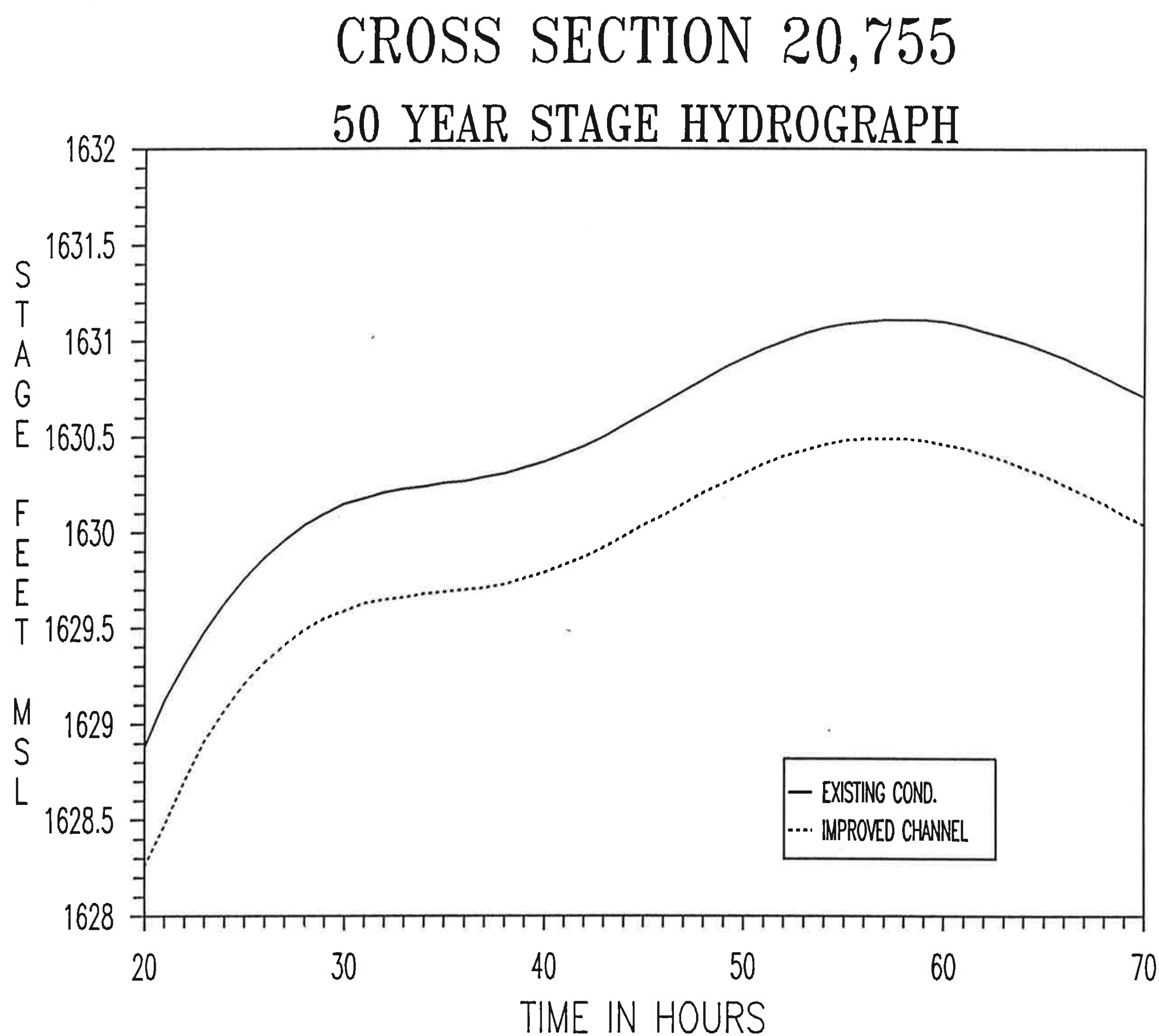


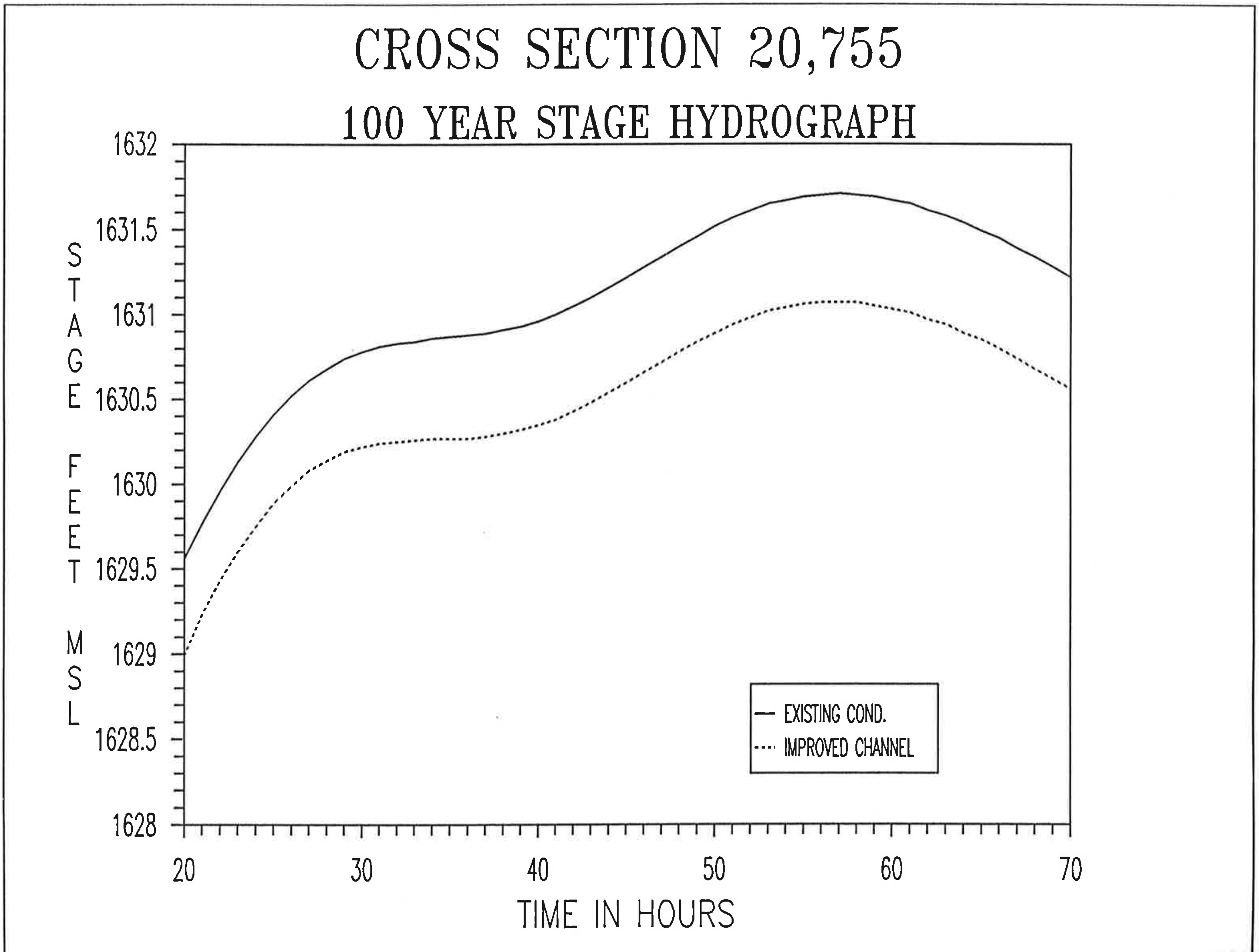

CROSS SECTION 20,755
10 YEAR STAGE HYDROGRAPH
STAGE FEET MSL
1630
1629.5
1629
1628.5
1628
1627.5
1627
1626.5
1626
20
30
40
50
60
70
TIME IN HOURS
EXISTING COND.
IMPROVED CHANNEL

CROSS SECTION 20,755

25 YEAR STAGE HYDROGRAPH




CROSS SECTION 20,755
50 YEAR STAGE HYDROGRAPH
STAGE FEET MSL
1632
1631.5
1631
1630.5
1630
1629.5
1629
1628.5
1628
20
30
40
50
60
70
TIME IN HOURS
EXISTING COND.
IMPROVED CHANNEL



CROSS SECTION 20,755
100 YEAR STAGE HYDROGRAPH
STAGE FEET MSL
1632
1631.5
1631
1630.5
1630
1629.5
1629
1628.5
1628
20
30
40
50
60
70
TIME IN HOURS
EXISTING COND.
IMPROVED CHANNEL