TABLE V (continued)

TIME DRAWDOWN RECOVERY METHOD (From Ground Water and Wells, 1975)

$$T = \frac{264\ Q}{\text{change in } s'}$$

T, Q = Same as above
s' = change in feet in residual drawdown per logarithmic c values of t/t' (minutes), (t) is the time since pumping started, (t') is the time since pumping stopped.

Note: At least one observation well in the vicinity of the pumping well is needed to use this method.

EXPLANATION OF DARCEY'S LAW (1856) (From Heath and Trainer, 1968)

Defined as the laminar flow rate through a prcous medium is proportional to the head loss and inversely proportional to the length of the flow path.

Equation: $$Q = KA\frac{h}{l}$$

Q = volume of flow per unit of time
K = coefficient of permeability of a porous medium (gpd/ft^2)
A = cross-sectional area of a porous medium normal to the flow
h = head loss (vertical)
l = length of the flow path (horizontal)
h/l = hydraulic gradient

*EQUILIBRIUM METHOD (From Heath and Trainer, 1968)

$$^{*}T = \frac{527.7\ Q\ \log_{10}(r_2/r_1)}{(h_0-h)_1 - (h_0-h)_2}$$

T = transmissibility in gpd/ft
Q = pumping rate in gpm
r = distance in feet from the pumping well to the observation well(s)
h = drawdown in feet in the observation well(s)

**From Ground Water Manual, 1977)

**Confined Aquifers

$$T = \frac{Q \log e\ r_e/r_w}{2\pi\ (h_e - h_w)}$$

Unconfined Aquifers

$$T = \frac{QM \log e\ r_e/r_w}{\pi\ (h_e'^2 - h_w'^2)}$$

h_e = piezometric pressure at the circumference of the area of influence
h_w = piezometric pressure at well
r_e = radius of area of influence
r_w = radius of well
log e = natural log
h'_e = saturated thickness of aquifer at the circumference of area of influence
h'_w = saturated thickness at well

(cont'd.)

TABLE V (continued)

ASSUMPTIONS MADE WHEN USING THE NON-EQUILIBRIUM METHOD

1. The aquifer is homogeneous in character and constant permeability, uniform in thickness, and infinite in aerial extent.

2. The pumping well is infinitesimally small in diameter, penetrates and receives water from the full thickness of the aquifer.

3. The water is discharged from storage instantaneously with a reduction in head pressure due to drawdown.

4. Groundwater flow to the well is radial and horizontal.

5. The aquifer receives no recharge during pumping.

ASSUMPTIONS MADE WHEN USING THE EQUILIBRIUM METHOD

1. The aquifer is homogeneous in character and constant permeability, uniform in thickness.

2. The pumping well penetrates and receives water from the full thickness of the aquifer.

3. The cone of depression has reached equilibrium, i.e., there is no further change in the drawdown or radius of influence with continued pumping at the given rate.

4. Groundwater flow to the pumping well is horizontal, radial and laminar within the radius of influence of the pumping well.

5. The well is pumped at a constant rate and is 100 percent efficiently pumped.

TABLE VI

GROUND WATERSHED AREAS

	Watershed	Area in Wayland (Acres)	Area in Other Town (Acres)	Total Area (Acres)
1.	Sudbury River I	286	Not Determined	286
2.	Sudbury River II	253	None	253
3.	Sudbury River III	386	None	386
4.	Sudbury River IV	147	None	147
5.	Sudbury River V	577	None	577
6.	Sudbury River VI	768	None	768
7.	Sudbury River VII	404	None	404
8.	Trout Brook	363	139	502
9.	Hazel Brook	925	220	1,145
10.	Mill Brook	661	None	661
11.	Pine Brook	1,208	400	1,608
12.	Hayward Brook	169	620	789
13.	Snake Brook	1,377	92	1,469
14.	Lake Cochituate	863	136	999
15.	Charles River	191	44	235
		8,578	1,651	10,204
	Remaining Sudbury R.	1,590		1,590
	TOTALS:	10,168		11,319

TABLE VII

PERMEABILITY OF GEOLOGIC MATERIALS

Material	Comparative Values of Permeability Column 1 (ft/day)	 Column 2 (m/day)	 Column 3 (m/day)
Coarse Gravel	400-670		
Medium Gravel	270-670	1,000-10,000	gt 1,000
Gravel	200-400		
Fine Gravel	200-400		
Sandy Gravel	135-400	0.3-10	100-1,000
Sand and Gravel	135-335		
Very Coarse Sand	135-400		
Coarse Sand	105-335	10-3,000	10-100
Medium Sand	33-135		
Fine Sand	7-67	0.01-10	0.1-10
Very Fine Sand	3-20		
Silty Sand	10-16		
Sand and Silt	3-10		0.0001-0.1
Sand, Silt and Clay	3-6		
Silt	3	0.0001-1	
Silt and Clay	2-3		0.00001-0.0001
Clay	1		
Loess	-		
Glacial Till	-		

References:

Column 1: Cervione, M. A., et.al., 1972. Water Resources Inventory of Connecticut, Part 6, Upper Housatonic River Basin, Connecticut Water Resources Bulletin #21, 84 p.

Column 2: Dunne, Thomas and Luna B. Leopold, 1978. Water in Environmental Planning, W. H. Freeman and Company, 818 p.

Column 3: Ground Water Manual, 1977. A Water Resources Technical Publication, U.S. Department of the Interior, U.S. Government Printing Office, Washington, D.C., 480 p.

TABLE VIII

SURFACE AREA CLASSIFICATION

Primary Recharge:

Areas with optimum characteristics for accepting and transmitting water from the surface into the groundwater system. They exhibit the highest degree of infiltration and vertical permeability. Features identified for this classification include flat to moderate slopes, stratified medium to coarse sand and gravel deposits and a water table above surrounding areas.

Secondary Recharge:

Areas with high or intermediate characteristics for accepting and transmitting water from the surface into the groundwater system. They exhibit a high degree of infiltration and good vertical permeability. Features identified for this classification include moderate to steep slopes, stratified fine to medium sand and gravel deposits and a water table above surrounding areas.

Limited Recharge:

Areas with a low potential for accepting and transmitting water from the surface into the groundwater system. They exhibit a limited degree of infiltration and vertical permeability. Features identified in this classification include flat to moderate slopes, shallow sand and gravel type deposits, primarily fine to medium grain sizes (limited coarse grains) with the possibility of confining layers at depth (i.e. clay hardpan), and a water table above surrounding areas.

Till and Bedrock:

Areas consisting predominantly of thin till overlying bedrock with limited potential for accepting and transmitting water from the surface into the groundwater system. Slopes are moderate to steep with high runoff rates.

Discharge Areas:

Areas where the predominant water movement is from the groundwater system to surface flow during most of the year. These areas are characterized by wetland environments sustained by a water table at or near the surface. In areas where groundwater elevations fluctuate up and down to a large degree, discharge areas may function to some extent as recharge areas, yet for lack of specific water level measurements, only the discharge function has been identified.

TABLE IX

AQUIFER FAVORABILITY CLASSIFICATION

Deep Aquifers

1. Highest favorability and potential yield for municipal water supply. Generally have greater than 60 feet of saturated thickness, sand and gravel deposits with coarse grains and are closely associated with primary and secondary recharge areas.

2. Moderate favorability and potential yield for municipal water supply. Generally have greater than 60 feet of saturated thickness, sand, gravel and clay deposits with fine grains limiting groundwater flow; and frequently are closely associated with primary and secondary recharge areas.

3. Low favorability and potential yield for municipal water supply. Generally have greater than 60 feet of saturated thickness, primarily fine sand, clay with some gravel sediments. High storage but low permeability.

Intermediate Aquifers

1. High favorability and potential yield in terms of supplementing groundwater flow into the deep aquifers. Generally have greater than 40 feet of saturated thickness, sand and gravel deposits with coarse grains and are associated with primary and secondary recharge areas. Good for domestic water supply.

2. Low to moderate favorability and potential yield in terms of supplementing groundwater flow into the deep aquifers. Generally have greater than 40 feet of saturated thickness, sand, gravel and clay deposits with fine grains limiting groundwater flow; and are associated with some primary but mostly secondary and limited recharge areas.

Shallow Aquifers

1. Highest importance to the maintainance of stream and wetland environments in upland areas in terms of base flow and water quality. Generally have greater than 20 feet of saturated thickness, sand and gravel deposits with coarse grains and are associated with primary and secondary recharge areas.

2. Moderate importance to the maintainance of stream and wetland environments in upland areas. Generally have greater than 10 feet of saturated thickness, sand and gravel deposits with coarse grains; and are associated with secondary and limited recharge areas.

3. Low importance to the maintainance of stream and wetland environments in upland areas. Generally have greater than 10 feet of saturated thickness, sand, gravel and clay deposits with fine grains limiting groundwater flow; and are associated with limited and secondary recharge areas.

4. Limited favorability for stream and wetland environments. Less than 10 feet of saturated thickness; bedrock, till or shallow stratified deposits.

TABLE X

WELL DESIGN AND PUMPING CAPABILITY

Station	Year	Diameter	Horsepower	Rate (gpm)
Baldwin Pond #1	1962	18"	40	400
#2	1962	24"	50	500
#3	1955	24"	75	650
Happy Hollow #1	1947	24"	40	500
#2	1953	24"	75	700
Meadow View #1	1972	24"	50	400
Campbell Road #1	1968	24"	50	400

Information provided by John Roche, Superintendent, Wayland Water Department, April 11, 1980.

TABLE XI

WATER QUALITY LIMITATIONS
(Values are in ppm or mg/l)

Permissible, Desirable and Standard Concentrations of Constituents in Drinking Water Supplies Throughout the United States.

Town Tested Constituent	Permissible Level	Desirable Level	Standard Approved For Drinking Water Supplies
Turbidity	--	low	--
Sediment	--	low	--
Color	75	<10	--
Odor	--	none	--
pH	6.0-8.5	6.0-8.5	--
Alkalinity	500	>30	--
Hardness	--	<150	--
Calcium	200	<145	200
Magnesium	125	<120	125
Sodium	20	<20	20*
Iron	1.0	none	1.0
Manganese	0.05	0.05	0.05
Silica	--	<72	--
Sulfate	250	<200	250
Chloride	250	<200	250
Spec. Cond.	--	--	--
Nitrite) Nitrate)	45	10	10*
Copper	1.0	none	1.0
Potassium	--	<30	--
Free Amonia	--	--	--
Other Constituents			
Total Solids	500	<500	500
Antimony	--	--	0.05
Arsenic	0.05	none	0.05*
Barium	--	--	1.0*
Bicarbonate	--	--	500
Boron	--	--	20
Cadmium	--	--	0.01*
Chromium	--	--	0.05*
Cyanide	--	0.01	0.2
Fluoride	--	0.8	1.5
Hydrogen Sulfide	--	--	1.0
Lead	--	--	0.05*
Selenium	--	--	0.01*
Silver	--	--	0.05*
Zinc	--	<5	5

*Maximum level allowed by Mass. DEQE Regulation Standards for Public Water Supplies.

Reference: Federal Water Pollution Control Administration, 1968. Water Quality Criteria-Public Water Supplies: Report of the National Technical Advisory Committee to the Secretary of the Interior: Federal Water Pollution Control Administration, pp. 18-26. Also: Feth, J.H., 19__. Water Facts for Planners and Managers, Water in the Urban Environment, 29 p. Contains drinking water standards of the World Health Organization (1971) and U.S. Public Health Service (1962).

TABLE XII

SURFICIAL GEOLOGIC DEPOSITS FOR THE GIVEN WATERSHED

	Watershed	Till (Acres)	Stratified Drift (Acres)	Lake Bottom (Acres)	Wetland (Acres)	Allivium (Acres)	Total (Acres)
1.	Trout Brook						
	(Wayland)		240		54		294
	(Lincoln)		106				106
2.	Hazel Brook						
	(Wayland)	48	437		106		591
	(Weston)	26	92		18		136
3.	Mill Brook						
	(Wayland)	130	750	75	95		1,050
	(Weston)		7				7
4.	Hayward Brook						
	(Wayland)	126	320	108	76		630
	(Weston)	204	159	97	179		639
5.	Pine Brook						
	(Wayland)	267	381	146	73		867
	(Weston)	239	103		15		378
6.	Sudbury River						
	I		92	7	7		106
	II	101	149	172	26		448
	III		202		44	18	264
7.	Dudley Brook	92	507	40	4		643
8.	Snake Brook	790	580		99		1,469
9.	Lake Cochituate		305				305
10.	Charles River	66	136				202
							6,869
	Remaining Sudbury R.						3,299
	TOTAL						10,168

Note: This table was used for application of stratified drift acreage in the computation of groundwater outflow from surface watershed.

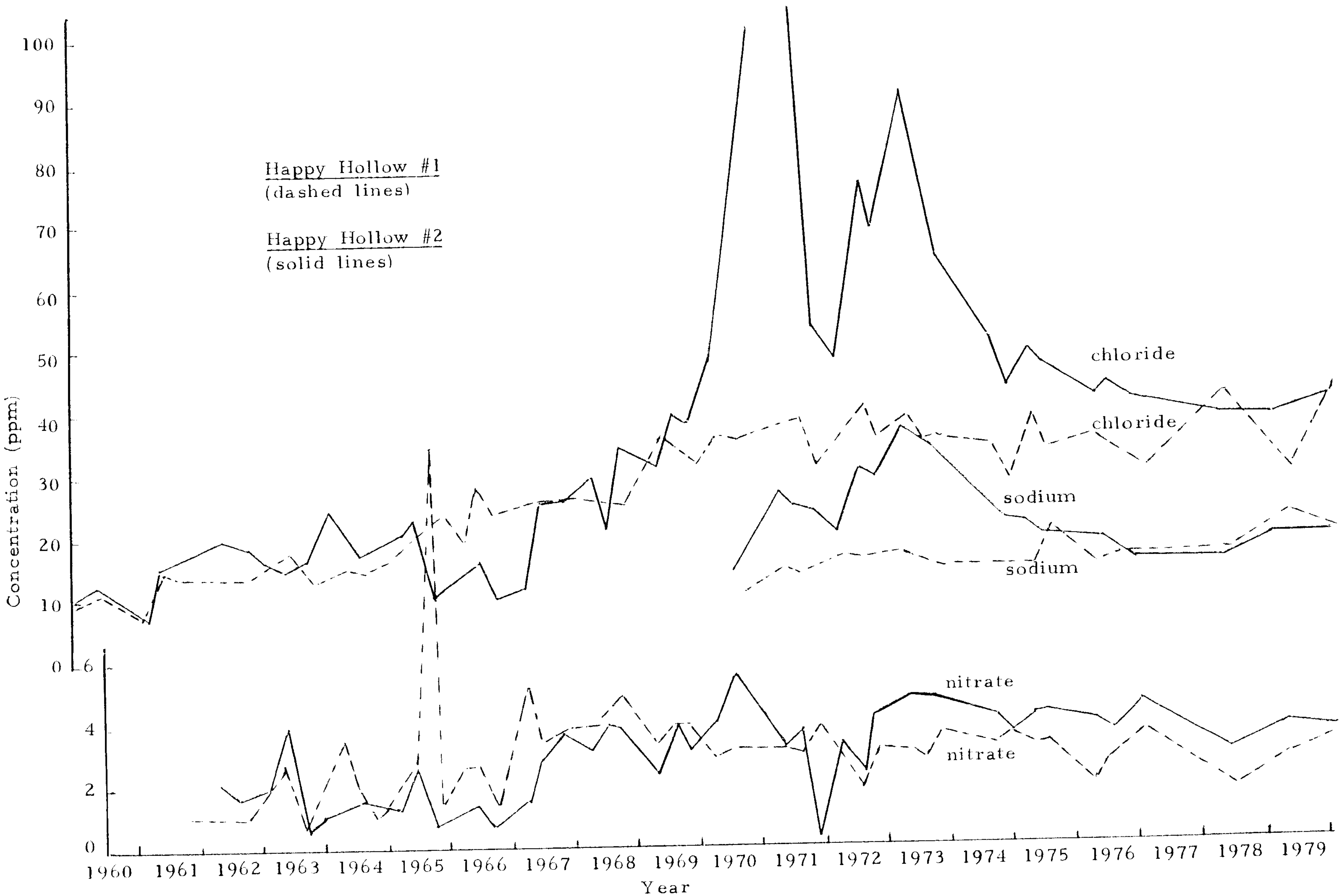


Figure I:
Graph of water quality data for the indicated parameters at Happy Hollow #1 and #2.
Records collected by the Wayland Water Department.

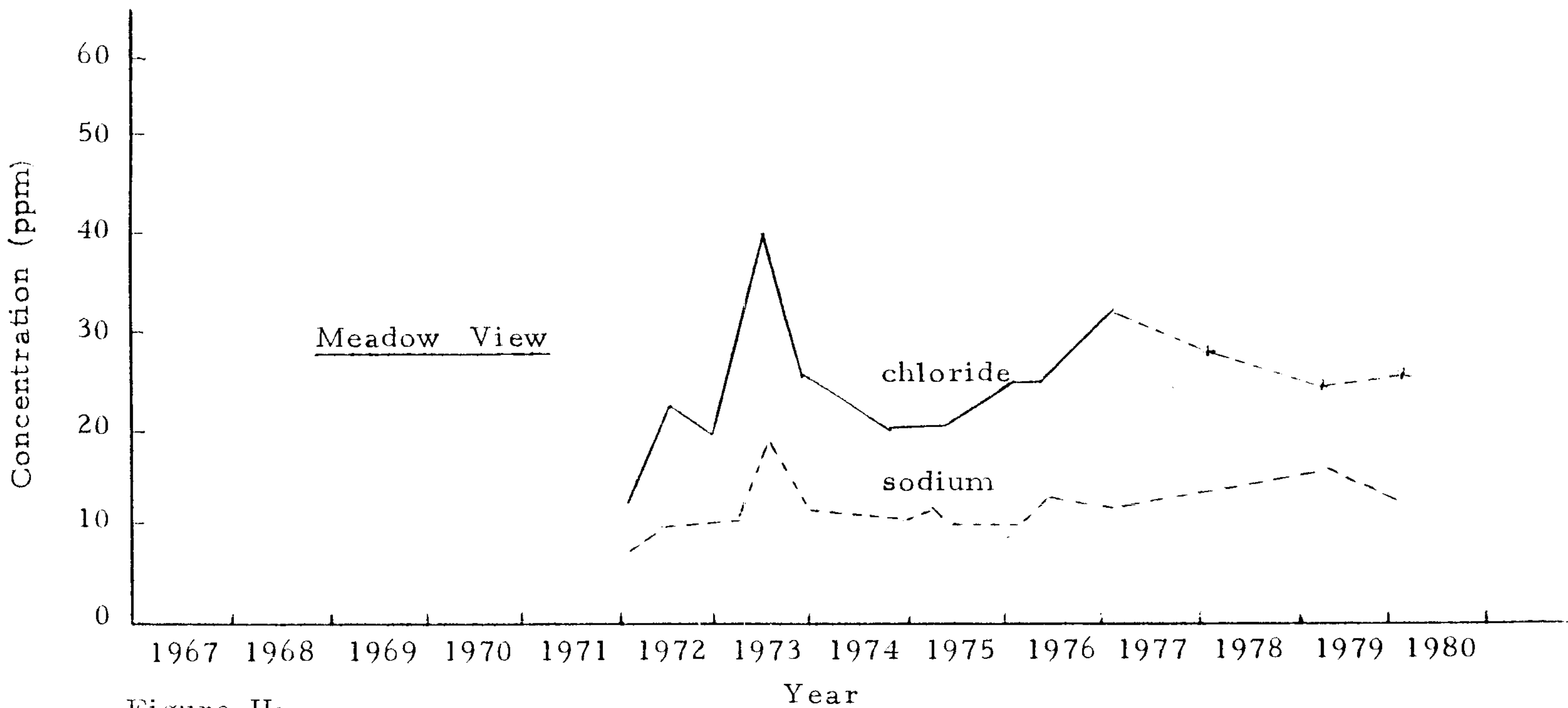


Figure II:
Graph of water quality data for the indicated parameters at Meadow View. Records collected by the Wayland Water Department.

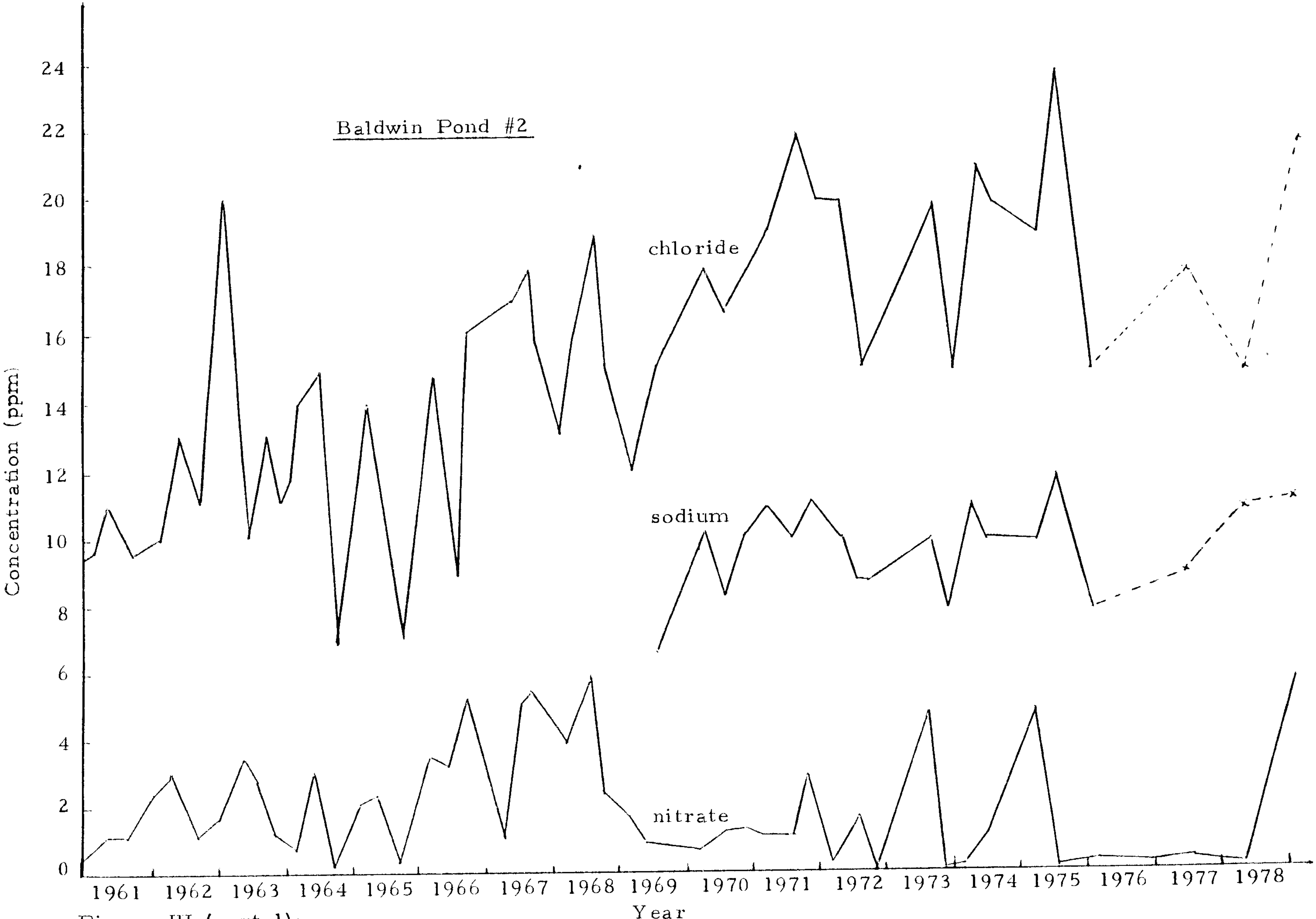


Figure III (part 1):
Graph of water quality data for the indicated parameters at Baldwin Pond #2.
Records collected by the Wayland Water Department.

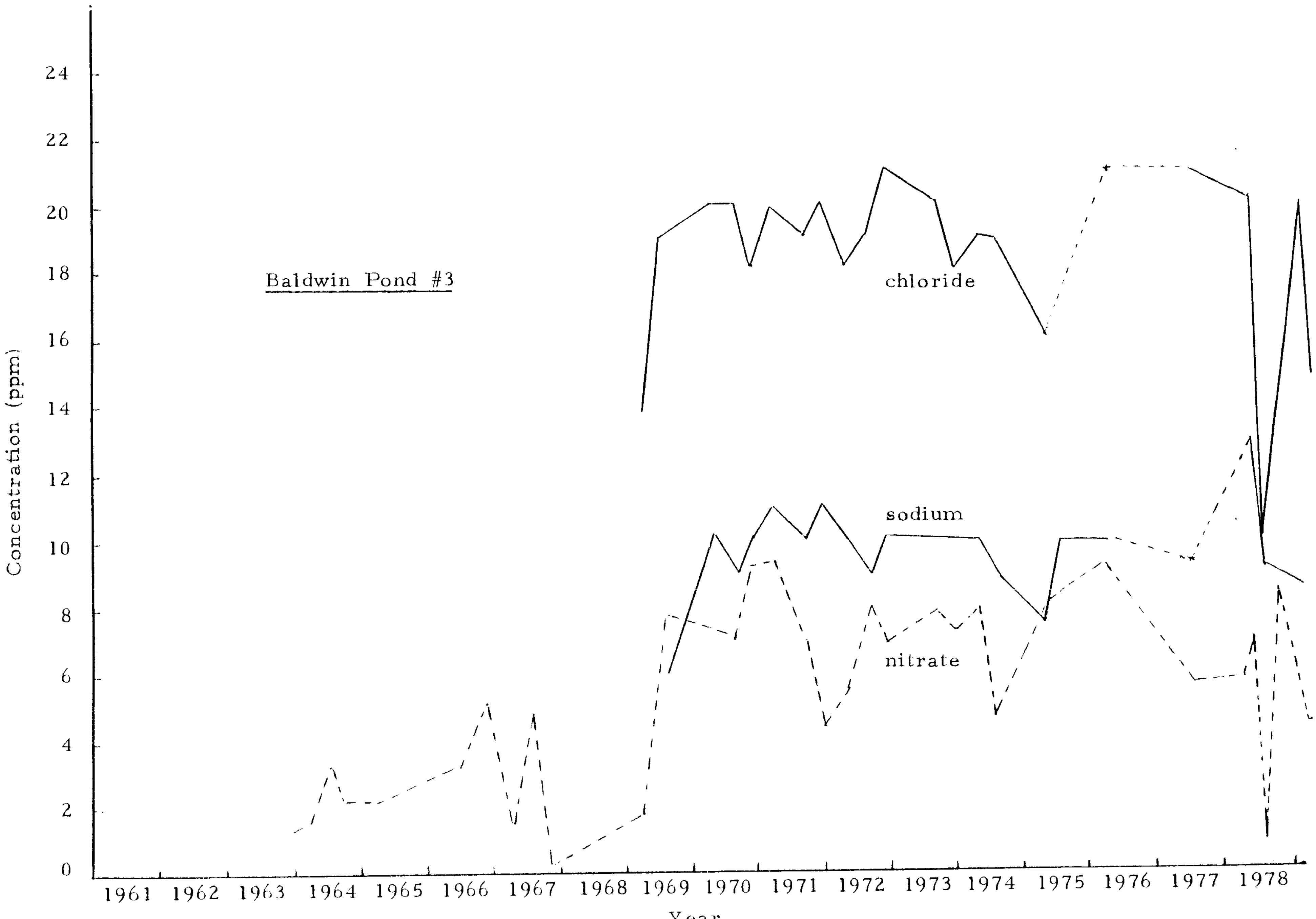


Figure III (part 2):
Graph of water quality data for the indicated parameters at Baldwin Pond #3.
Records collected by the Wayland Water Department.

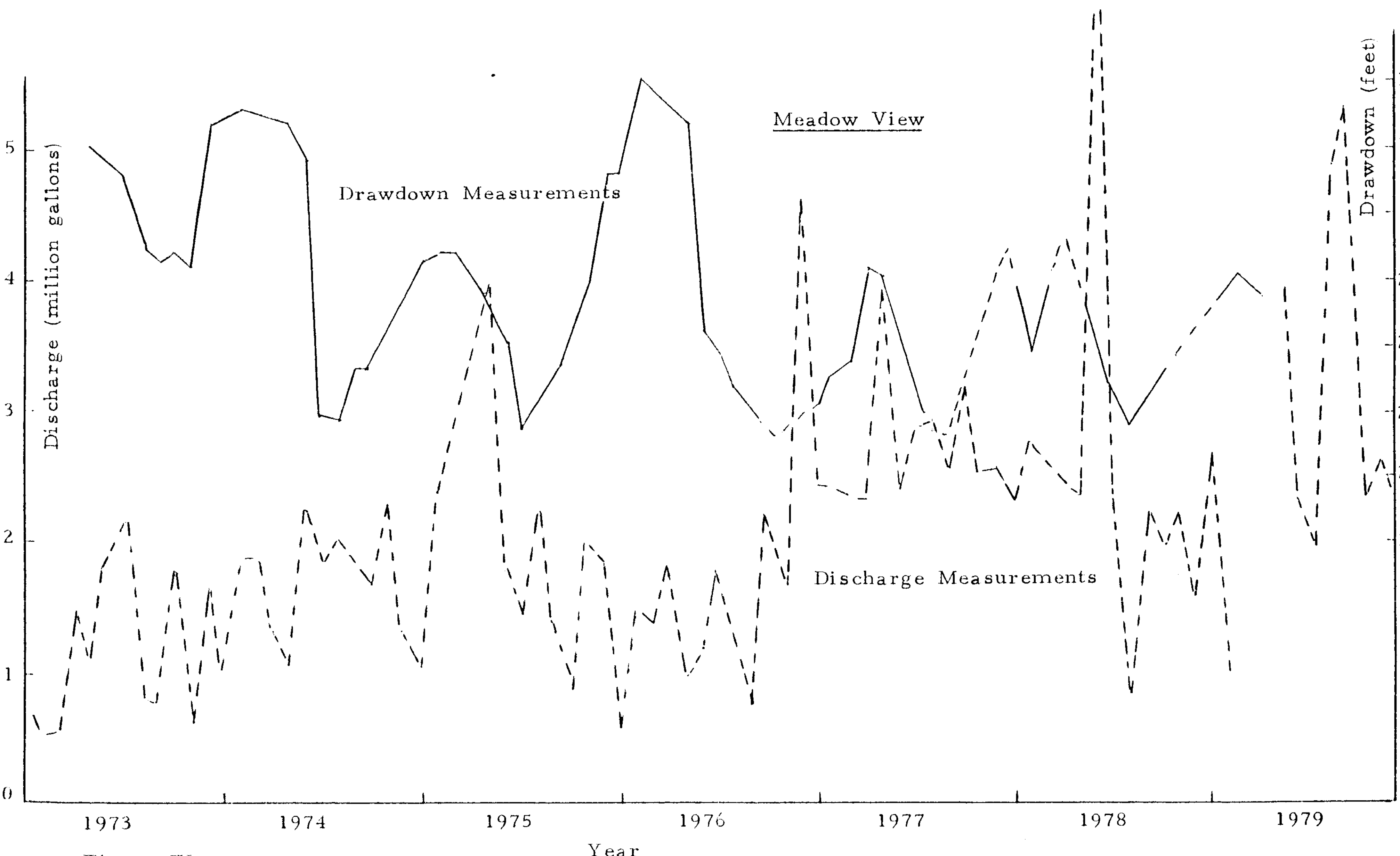


Figure IV:
Comparison of drawdown measurements in an observation well with discharge data for the indicated well during pumping. Records collected by the Wayland Water Department.

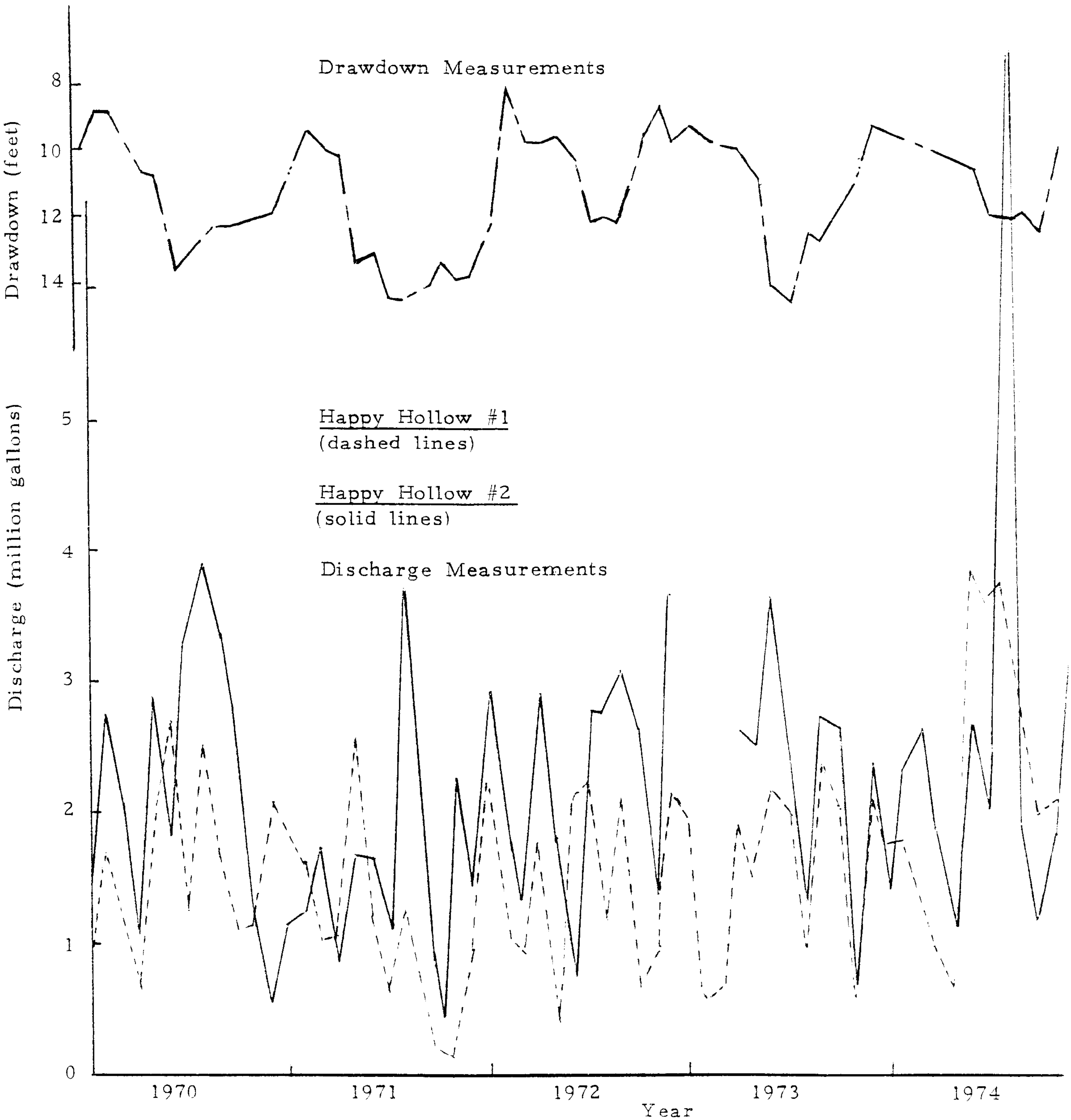


Figure V (part 1):

Comparison of drawdown measurements in an observation well with discharge data for the indicated wells during pumping. Records collected by the Wayland Water Department.

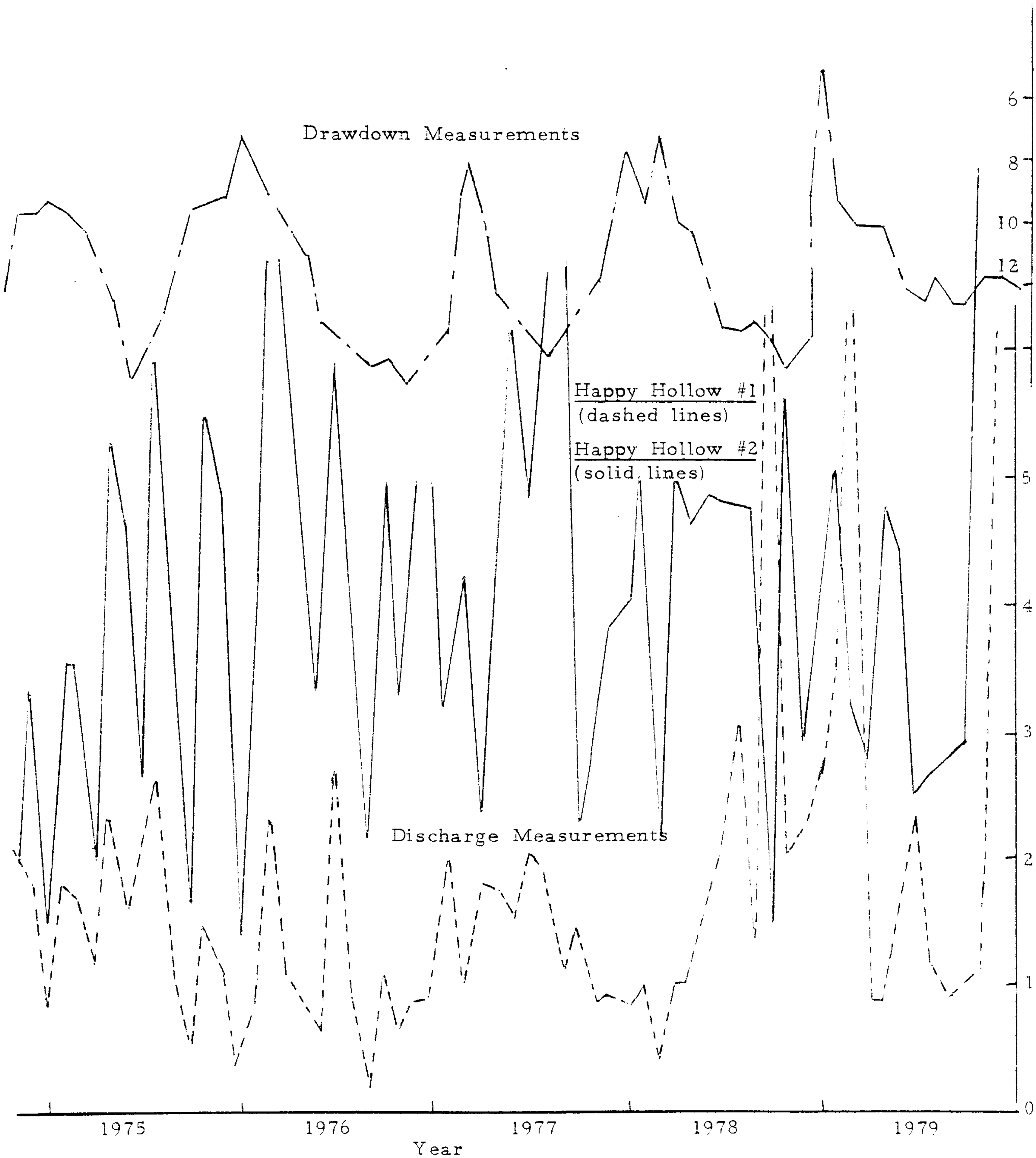


Figure V (part 2):

Comparison of drawdown measurements in an observation well with discharge data for the indicated wells during pumping. Records collected by the Wayland Water Department.

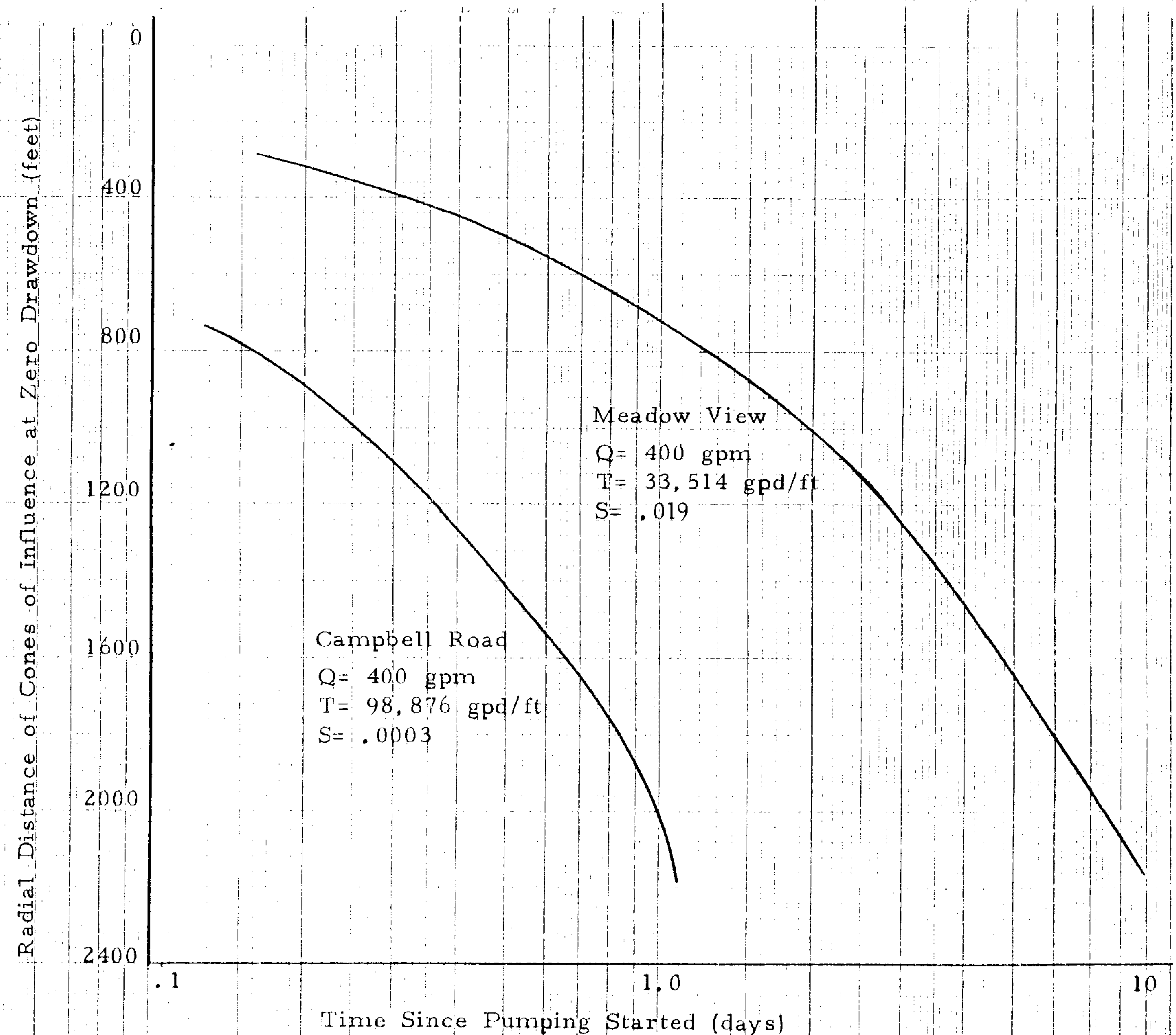
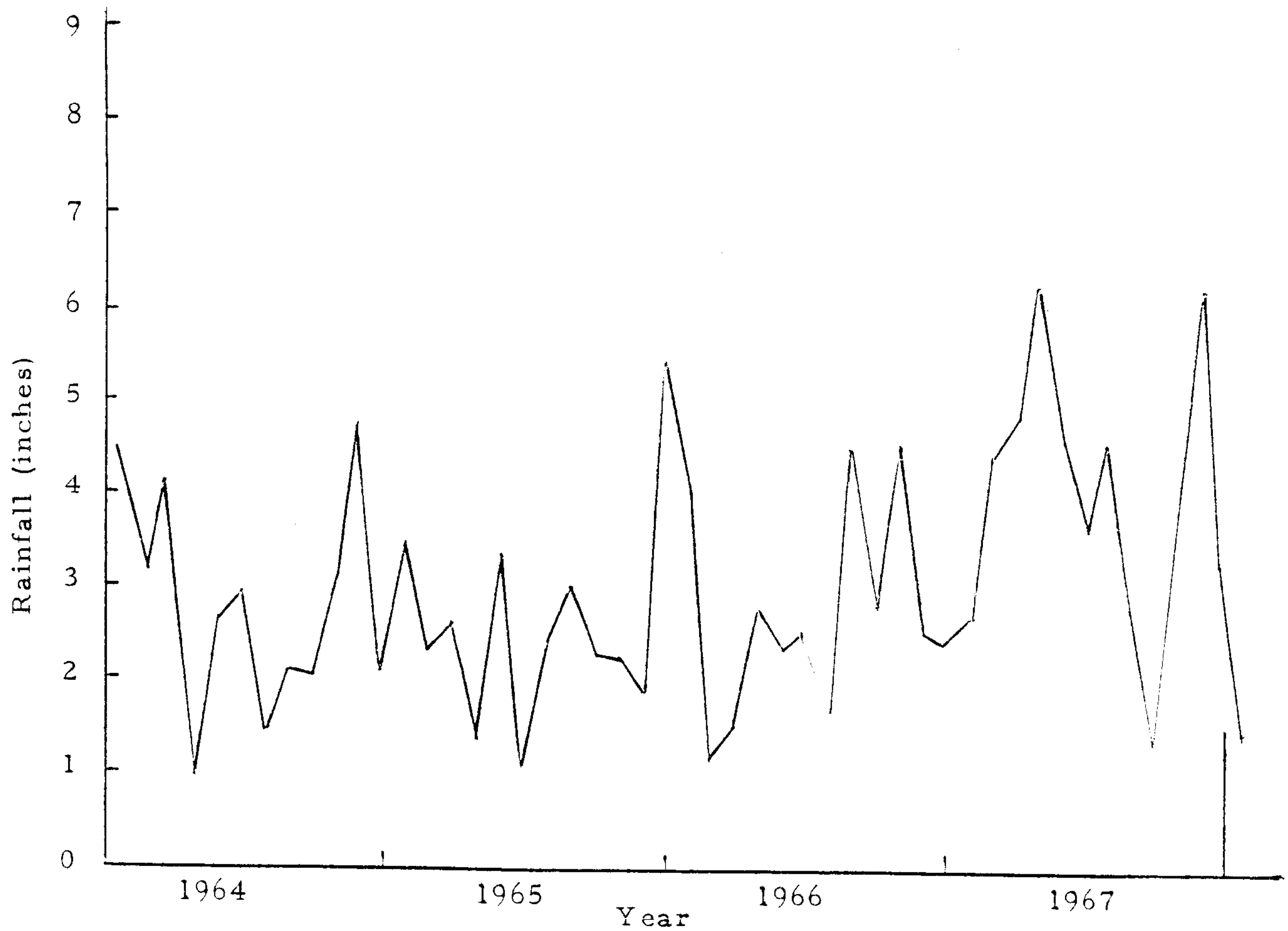


Figure VI:
Graph showing radial distances for cones of influence related to the time since pumping was started based on aquifer test data in the Meadow View and Campbell Road wells.



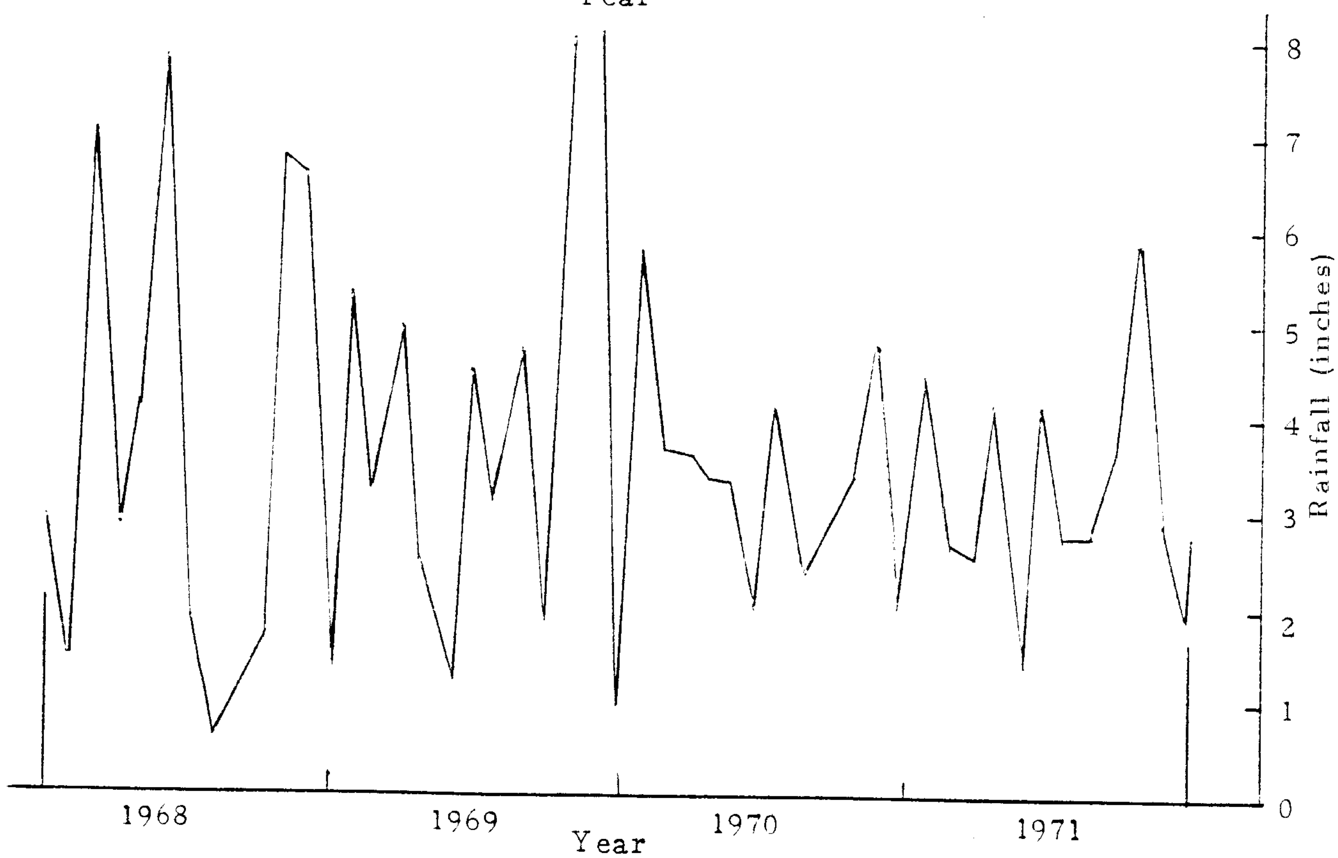
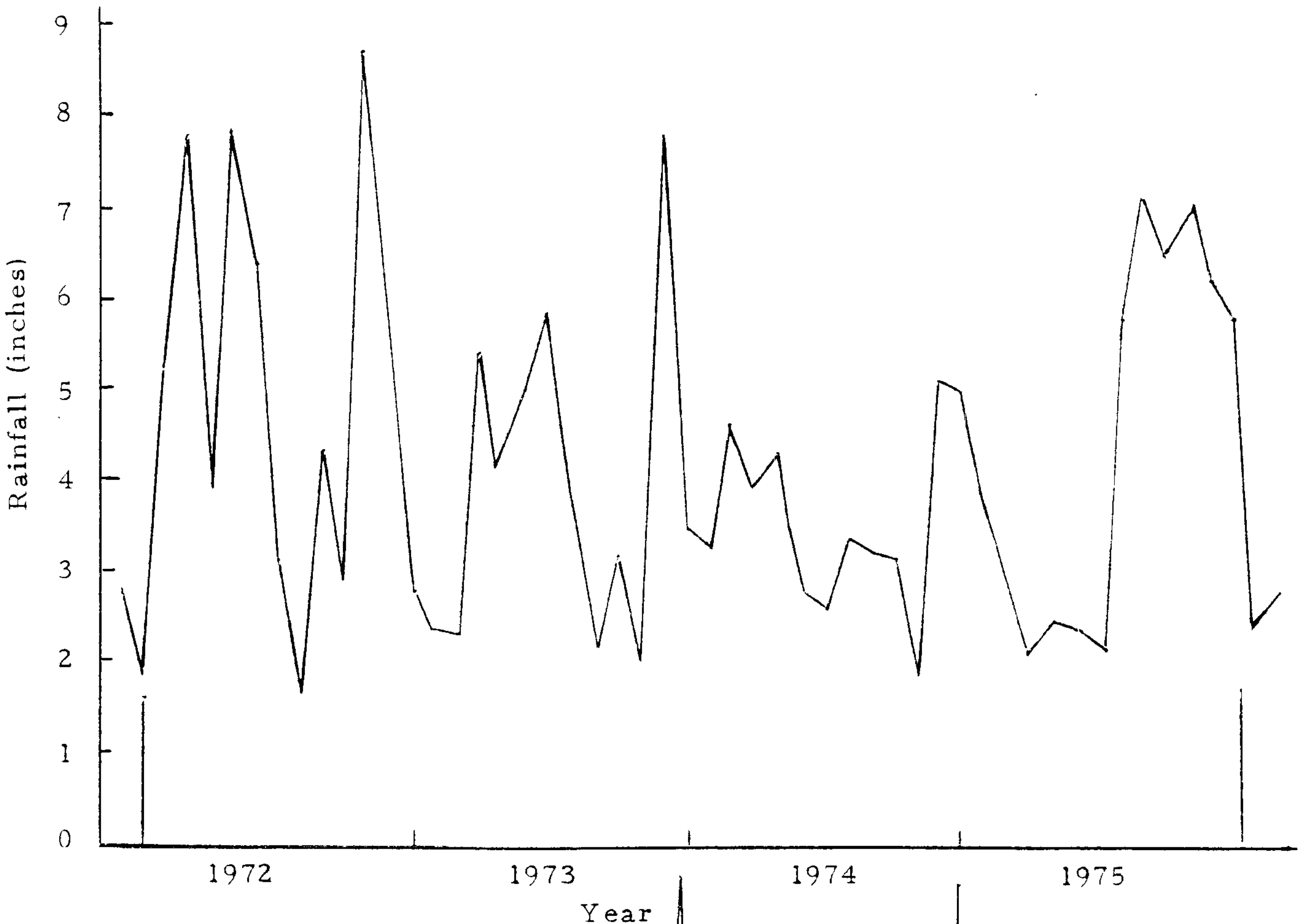


Figure VII (part 1):

Graph of rainfall from records collected at Framingham, Massachusetts and published by the USGS.



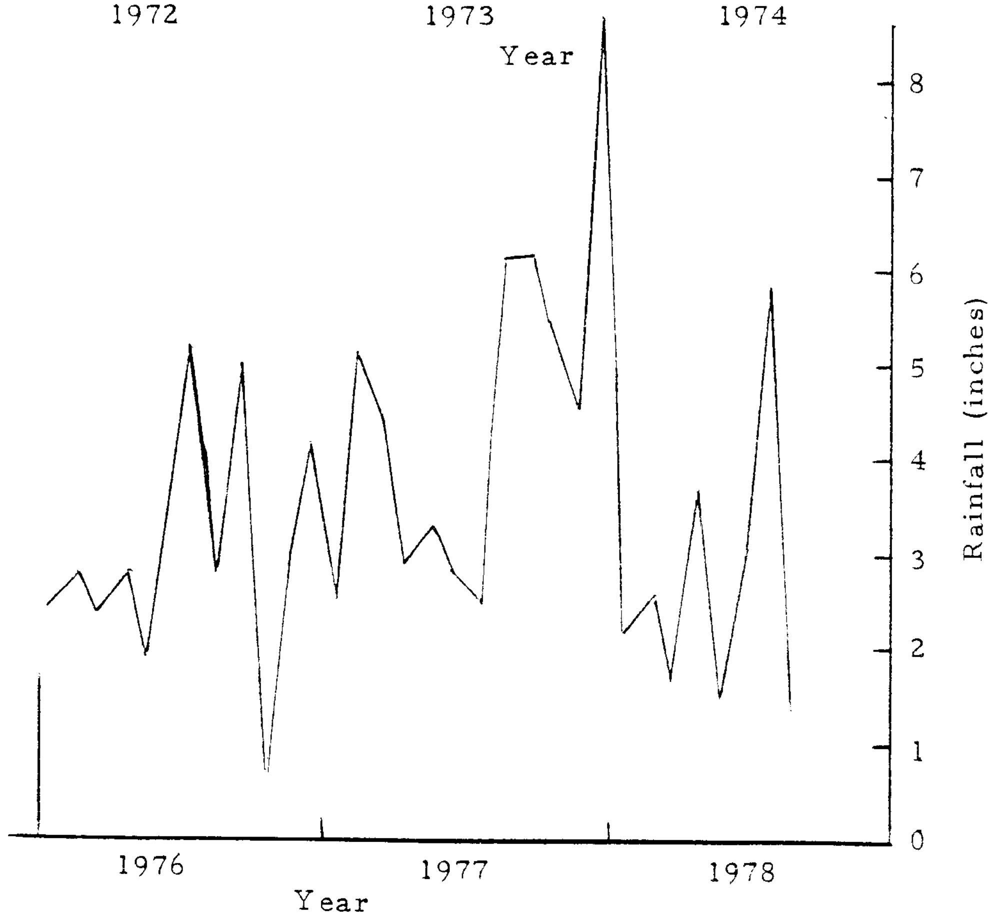


Figure VII (part 2):
Graph of rainfall from records collected at Framingham, Massachusetts and published by the USGS.

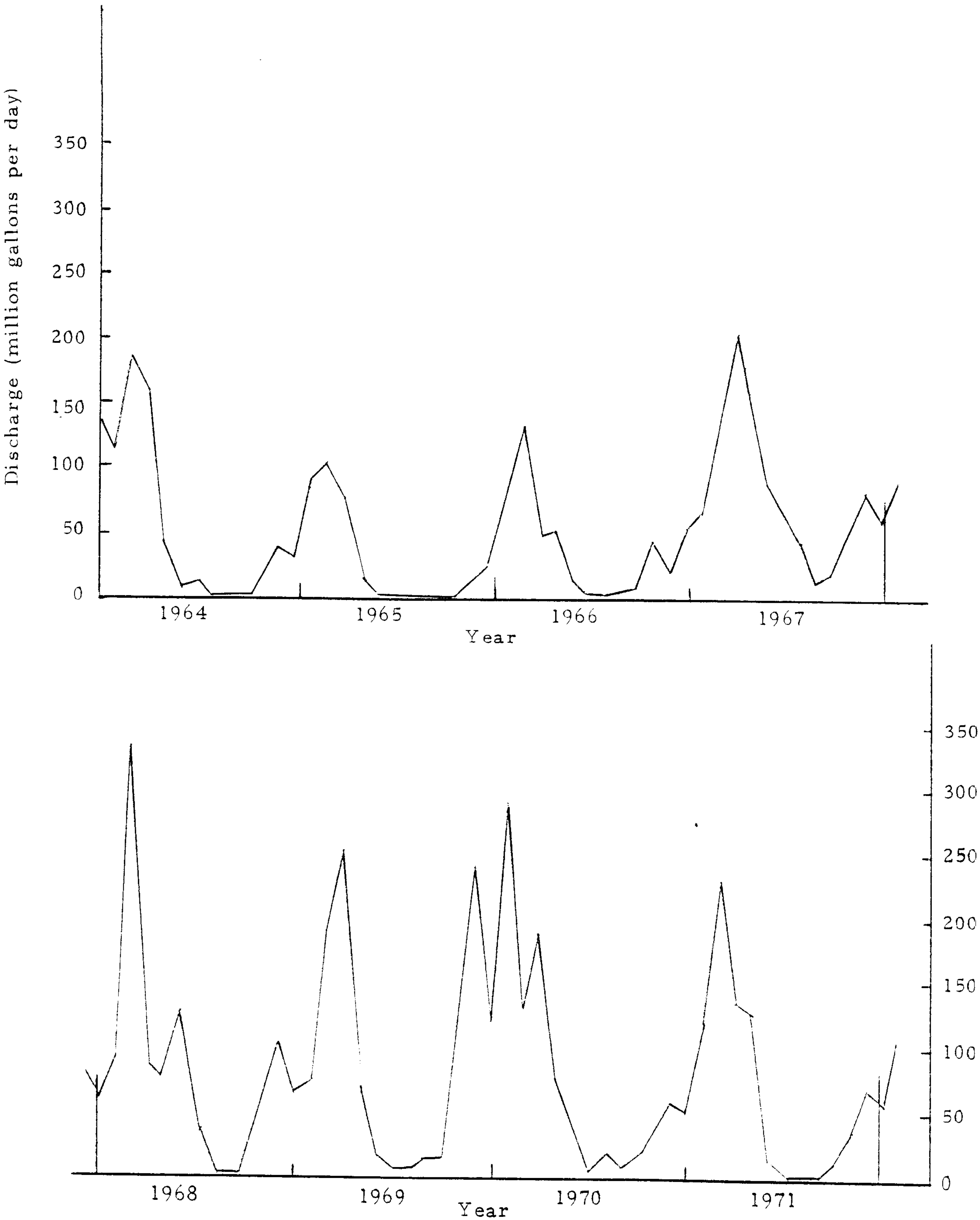
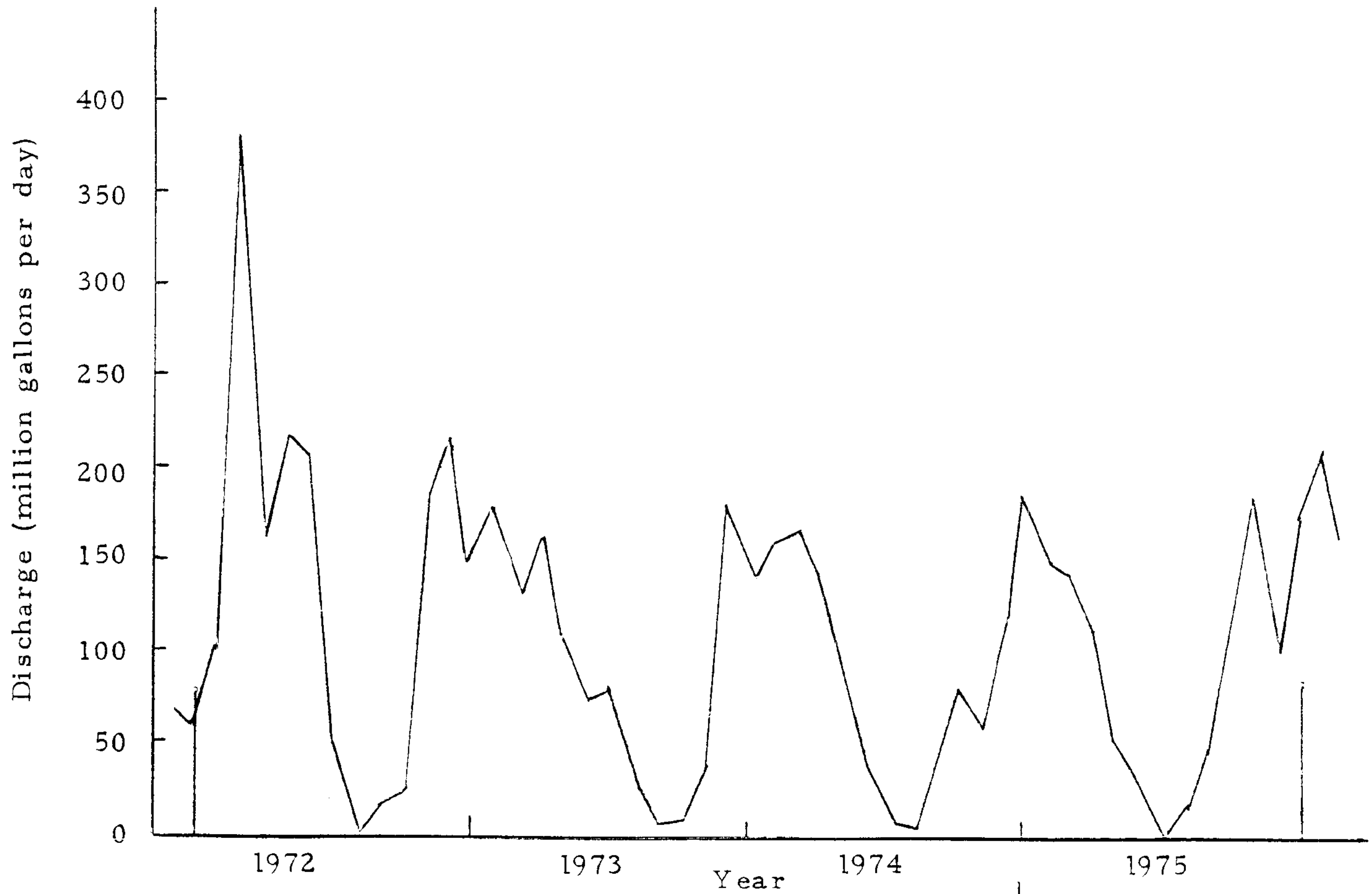


Figure VIII (part 1):
Graph of Sudbury River discharge from records collected at Framingham, Massachusetts and published by the USGS.



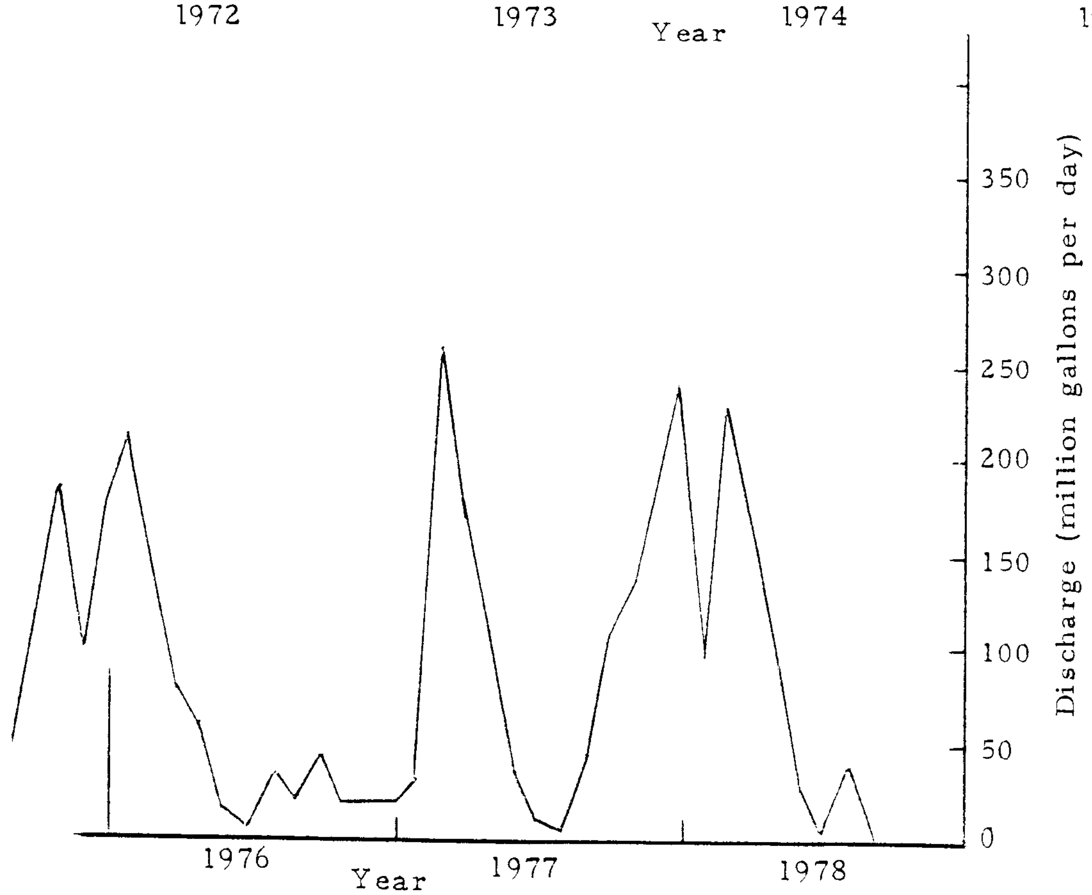


Figure VIII (part 2):
Graph of Sudbury River discharge from records collected at Framingham, Massachusetts and published by the USGS.

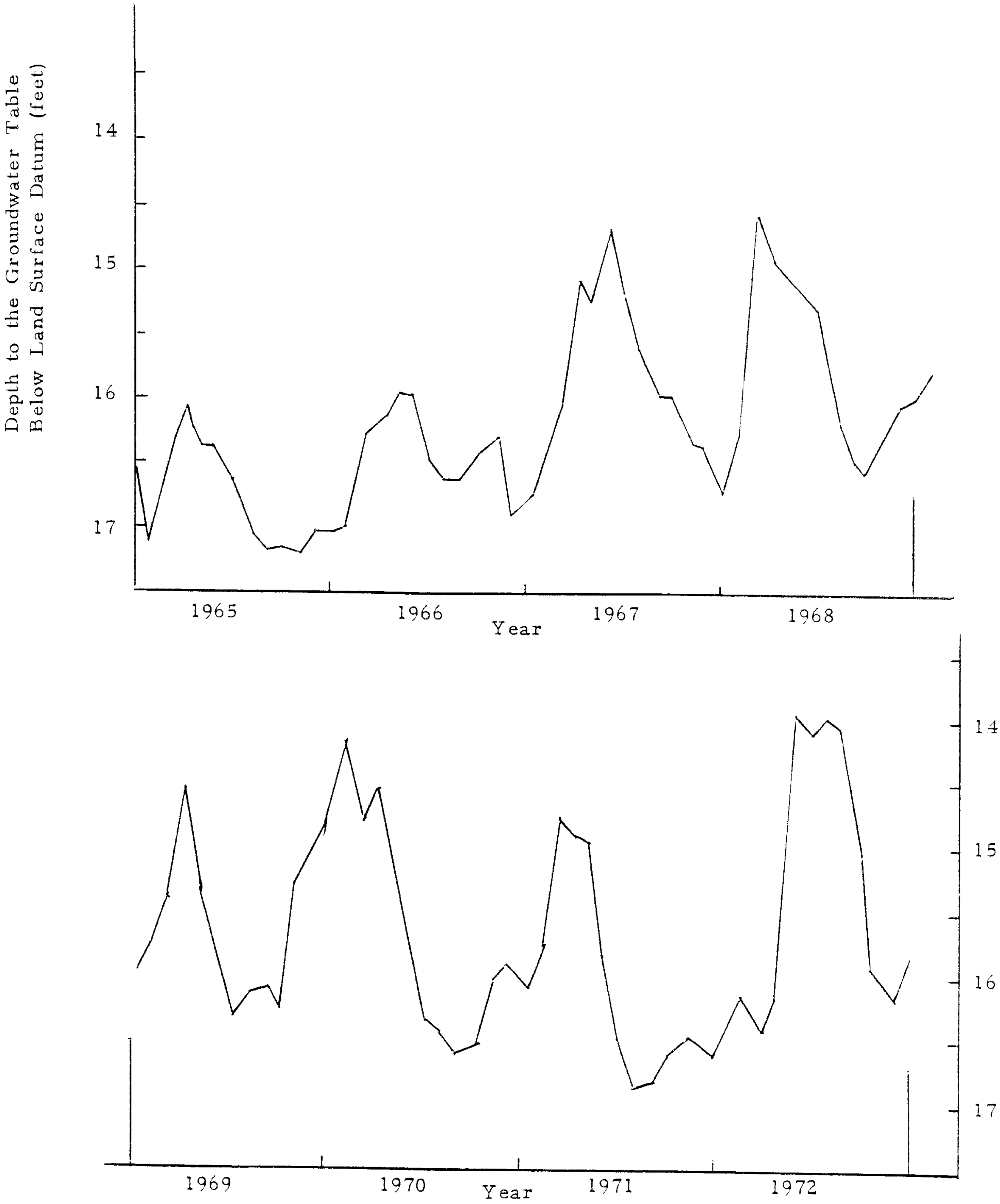
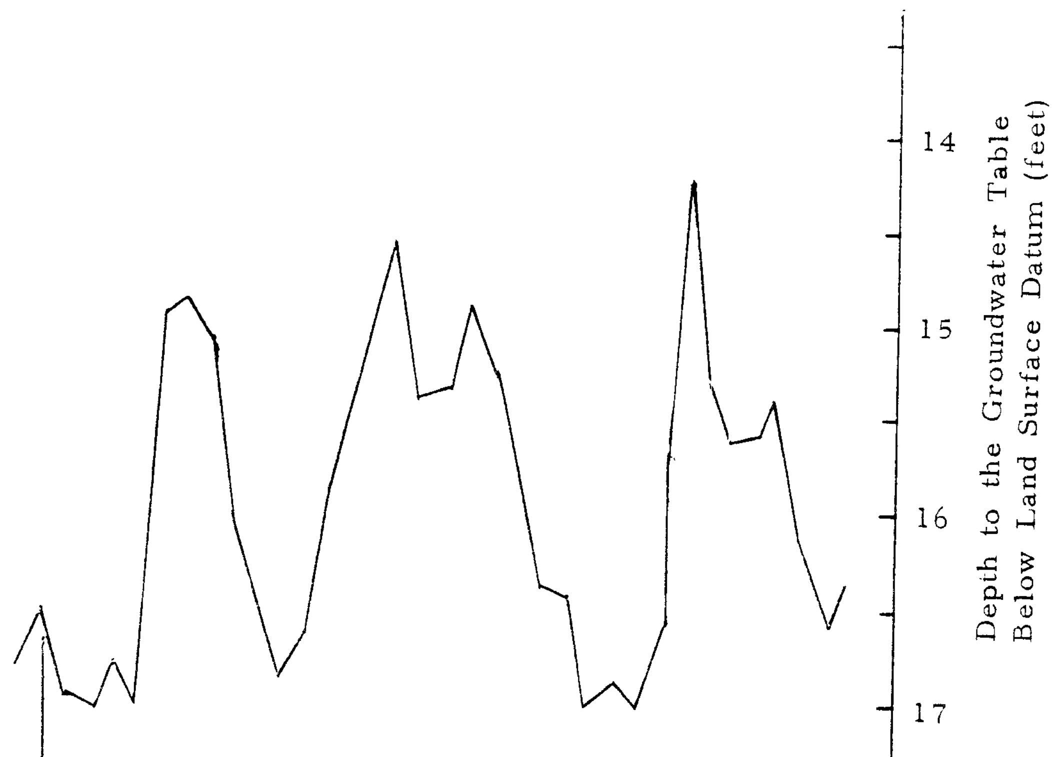


Figure IX (part 1):
Graph of water table level below land surface datum from records collected at #2 well, Cochituate State Park, Wayland, Massachusetts.



<u>Figure IX (part 2):</u>
Graph of water table level below land surface datum from records collected at #2 well, Cochituate State Park, Wayland, Massachusetts.

NORTH SIDE [illegible]

SHERMAN BRIDGE

1984		
JUNE	18	114.8
	19	114.5
	20	114.3
	22	113.7
	26	112.7
	28	112.7
JULY	2	112.3
	3	112.3
	5	112.0
	9	113.7
	10	114.1
	11	114.2
	13	114.2
	18	113.3
	23	112.7
	24	112.5
	25	112.3
	30	112.1
AUGUST	2	111.9
	6	111.1
	8	111.0 +/-
	27	110.8
SEPTEMBER	4	110.5
	11	110.5
	18	110.5
	26	110.5
OCTOBER	17	110.0
	23	110.4
	30	110.5
NOVEMBER	5	110.0
	9	110.0
	13	112.4
	19	111.7
	30	111.0

1984		
DECEMBER	4	111.0 +/-
	12	111.7
	31	112.1
1985		
JANUARY	ALL MONTH	112.0
FEBRUARY	14	113.2
	21	112.8
	25	112.4
MARCH	20	112.4
	26	112.2
APRIL	4	112.0
	11	112.0
	23	111.6
	26	111.2
MAY	1	110.9
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]

SUDBURY RIVER WATER ELEVATIONS

October	11	109.8
	14	109.8
	17	110.5
	19	111.0
	21	111.5
	25	112.0
	27	111.8
	28	111.7
November	1	111.0
	2	110.9
	3	110.8
	4	110.8
	8	111.4
	9	111.2
	14	112.0
	15	111.9
	16	112.2
	17	112.9
	18	113.3
	21	113.5
	22	113.4
December	1	115.3
	11	116.3
	16	116.6
	19	116.5
1984 January	3	114.8
	5	114.5
	18	113.2
	27	113.0
February	6	114.0
	10	114.4
	16	114.9
	17	115.7 AM
	17	116.1 PM
	21	116.6
	24	116.9
	27	116.5
	29	116.6 AM
	29	116.8 Noon
March	2	116.8
	7	116.1
	20	115.8
	21	116.1
	22	116.5
	26	117.1
April	3	116.8
	4	116.8
	5	117.1
	6	117.4
	9	118.1
	10	118.1
	11	117.9
	12	117.7
	13	117.4
	23	115.9
	25	115.9
	26	115.9
	30	115.3
May	3	114.6
	9	115.3
	11	115.0
	21	115.1
	23	113.9
	24	113.7
	25	113.7
	30	113.9
	31	114.8
June	1	116.5
	4	119.1 AM
	4	119.2 PM
	5	119.4
	6	119.2
	7	119.1
	8	118.5 AM
	8	118.0 PM
	11	117.5
	13	116.6
	14	116.3
	15	115.8

	14	118.2
	15	118.2
	16	118.0
	17	117.8
	21	117.4
	28	117.0
	29	116.9
	30	116.3
	31	116.0
April	1	116.0
	7	115.6
	8	115.5
	12	116.2
	13	116.5
	14	116.5
	20	116.5
	22	116.2
	25	116.5
	26	116.9
	27	117.2
	28	117.2
	29	117.1
May	2	116.4
	3	116.4
	5	115.8
	9	115.1
	10	114.9
	11	114.7
	12	114.5
	13	114.3
	25	113.5
	26	113.5
	31	113.9
June	1	114.2
	2	114.3
	3	114.3
	6	114.2
	7	114.1
	9	113.9
	10	113.7
	13	113.1
	14	112.9
	16	112.4
	21	111.5
	23	111.2
	24	111.1
	27	111.1
	28	111.1
	29	111.3
	30	111.4
July	1	111.1
	5	111.0
	6	111.2
	7	111.3
	8	111.1
	11	110.7
	12	110.7
	13	110.5
	14	110.5
	15	110.4
	18	110.4
	19	110.4
	20	110.3
	21	110.4
	25	110.3
	26	110.3
	28	110.0
	29	110.0 ±
August	1	109.8
	2	110.0 ±
	3	110.0 ±
	30	111.0
	31	111.1
September	1	111.4
	2	111.4
	6	110.3
	7	110.1
	20	109.8
	26	109.8
	27	109.8

May	3	112.8
	7	112.2
	10	112.2
	11	112.5
	12	112.7
	13	112.7
	14	112.6
	17	112.2
	20	111.7
	25	111.8
	28	112.0
June	3	114.2
	4	115.2
	6	116.7
	7	118.5
	8	119.6
	9	120.0
	10	120.15
	12	119.7
	14	119.0
	15	118.65
	16	118.3
	17	118.0
	22	116.8
	23	116.5
	24	116.3
	25	116.0
	28	115.1
	30	114.5
July	1	114.4
	2	114.3
	7	113.0
	12	111.5
	13	111.3
	15	111.0
	16	111.0
	19	110.7
	20	110.8
	21	112.0
	23	Stonebridge 114.1
		Shermans Bridge 113.3
	26	112.3
	27	112.1
	28	111.9
August	3	112.0
	4	111.5
	26	Stonebridge 113.8
		Shermans Bridge 110.0
Sept.	3	110.8
	7	110.5
	16	110 ±
	17	110 ±
	20	110 ±
	23	110.3 ±
Oct.	4	110 ±
	13	112.2
	18	112.0
	19	111.7
	20	111.5
	25 - 29	110.5 to 111.5
Nov.	1 - 5	110.5 to 111.5
	8	111.5
	12	111.5
	16	112.5
	19	112.5
Dec.	Month	111.3 to 111.8
Jan.	No Record	
Feb.	3	114.0
	4	114.5
	9	115.5
	15	115.0
	17	115.2
	18	114.8
	25	115.3
	28	114.4
March	1	114.4
	2	114.8
	3	115.5
	[illegible]	116.6

SUDBURY RIVER WATER ELEVATION AT ROUTE 27

1981

October	20	110.6
	22	110.8
	23	110.8
	26	111.5
	27	111.8
Nov.	3	112.0
	5	111.8
	6	111.6
	9	111.4
	10	111.2
	12	111.0
	13	111.0
	17	112.3
	18	112.8
	23	114.0
	27	113.7
Dec.	4	113.8
	8	114.0
	9	113.9
	14	113.5
	17	114.1
	21	114.6
	23	114.3

1982

Jan.	5	115.7
	6	116.6
	7	116.9
	8	117.1
	11	117.1
	18	116 ± ice on road
	20	115.5 ± ice on road
	25	114.5
	28	114.4
Feb.	3	114.5
	4	115.5
	5	116.4 (117.8 Stonbridge)(116.2Sherma Bridge)
	8	116.9
	9	116.5
	10	116.7
	11	116.7
	12	116.5
	16	115.6
	17	115.3
	18	115.2
	22	114.8
	24	114.4
March	1	113.0
	8	113.5
	10	113.6
	15	114.4
	16	114.5
	17	114.6
	18	114.7 (115.9 Stonebridge)
	22	114.6
	23	114.6
	24	114.5
	30	114.2
	31	114.1
April	1	114.1
	2	114.1
	5	114.5
	8	114.8
	12	114.6
	15	114.4
	21	114.2
	23	113.8
	26	113.1
	27	113.2
	28	113.2