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10/18/94

Sudden Gate Opening Analysis
Town Lake
Tempe Rio Salado Project

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Sudden Gate Opening Analysis
Town Lake
Tempe Rio Salado Project

INTRODUCTION

The Town Lake is created by the impoundment of water within the Salt River channel through the use of a series of four air-inflatable gates. The Town Lake has capacity of approximately 3170 acre-feet (3.9 million cubic meters) with a maximum depth from the base to crest of gate of 18 feet (5.5 meters). When full Town Lake has a water surface area of 240 acres (97 hactares) that is approximately 1000 feet in width and 10,450 feet long (300 meters and 3200 meters, respectively). The upstream limit of the lake is a second low-height gate structure that is located just below the confluence with the Indian Bend Wash. The downstream limit of the lake is located about 200 feet (60 meters) downstream of the existing Grade Control Structure No. 4, or about 1750 feet (530 meters) downstream of the railroad crossing of the Salt River.

above

The Salt River channel downstream of Town Lake is a stabilized floodway, consisting of soil cement and gabion stabilized river banks, and a grade stabilized channel invert. The average width of the floodway for 3200 feet (1000 meters) downstream of the gates is 960 feet (290 meters). The channel gradient is 0.1717 percent. The channel section is essentially trapezoidal with a series of small terraces on each channel bank. The channel invert is depressed 3.0 feet (0.9 meters) below the channel bed elevation at the bank line.

Analysis of the sudden gate opening was conducted using an unsteady flow procedure commonly referred to as diffusion wave routing. This type of analysis is suitable to flow conditions where friction and pressure forces are dominant, and the local and convective acceleration forces are relatively small. This form of routing was choosen for the Town Lake gate opening analysis for several reasons:

- near the wave front, pressure and friction forces are of primary importance,
- using an explicit routing scheme, the analysis is computationally stable, and
- the procedure is easily configured to a variety of gate opening patterns.

The analysis was accomplished through the programming of Excel (Microsoft Version 4.0) worksheet software. An explicit finite difference scheme was used which is described in more detail in the section on methodology.

METHODOLOGY

Model Development

The routing of flow released from the Town Lake reservoir by a sudden opening of a gate was modeled by a one-dimensional unsteady flow equations. The one dimensional flow equations consist of the equation of continuity

$$\frac{\delta Q_x}{\delta x} + \frac{\delta A_x}{\delta t} = 0 \tag{1}$$

and the equation of motion

$$\frac{\delta Q_x}{\delta t} + \frac{\delta}{\delta x}\left(\frac{Q_x^2}{A_x}\right) + gA_x\left(S_{fx} + \frac{\delta y}{\delta x}\right) = 0 \tag{2}$$

in which t is time, x is the horizontal direction, Q_x is the total flow rate in the x direction, y is the water surface elevation measured vertically from a horizontal datum, g is the acceleration of gravity, A_x is the cross-sectional area of the flow, and S_{fx} is the friction slope in the x direction.

The friction slope, S_{fx} is estimated using the Manning formula

$$S_{fx} = \left(\frac{n}{1.486}\right)^2 \left(\frac{Q_x}{A_x\, h^{2/3}}\right)^2 \tag{3.a}$$

in which h is the depth of flow.

Near the gate opening and through the expansion zone, the friction slope is assumed to be near minimum energy giving the following estimate for friction slope based on critical depth

$$S_{fx} = \left(\frac{n}{1.486}\right)^2 \left(\frac{g}{h^{1/3}}\right) \tag{3.b}$$

In the computation, the local and convective acceleration terms in the equation of motion (the first two terms of (2) are neglected, which simplifies to the so-called diffusion form

$$S_{fx} = -\frac{\delta y}{\delta x} \tag{4}$$

Combining equation 3 and 4 yields

$$Q_x = \frac{1.486}{n} A_x\, h^{2/3} \frac{-\frac{\delta y}{\delta x}}{\left|\frac{\delta y}{\delta x}\right|^{1/2}} \tag{5}$$

or

$$Q_x = K_x\, S_{fx} \tag{6}$$

where

$$K_x = \left(\frac{1.486}{n}\right) A_x h^{2/3} \Big/ \left|\frac{\delta y}{\delta x}\right|^{1/2} \tag{7}$$

The flow released from the gate will gradually expand to fill the entire channel section. In the model development, it was assumed that the core of the flow expansion will occur at a rate of 4 to 1, that is: 4 units in the longitudinal direction for every one unit in the lateral direction. The flow expansion ceased when a channel bank was encountered. Since the bankline is not symetric to the gate location, the flow will the channel banks at different location. It was assumed that there would be no effect of one bank on the expansion rate approaching the opposite bank. This was considered to be a reasonable assumption since the Salt River channel is relatively wide compared to the flow depths.

Numerical Approximation

The river channel is approximated by a set of nearly uniform spaced cross-section elements, located downstream of the gate. The propagation of the water release after the sudden gate opening is computed by an explicit finite difference procedure at uniform time interval. Flow rates are estimated based on (3) and (5). The net volume of water in each element between time step i and i+1 is

$$\Delta Q_j^i = Q|_{\Gamma_{j-1}} - Q|_{\Gamma_{j+1}} \tag{8}$$

and the change in the depth of water is

$$\Delta h_j^i = \frac{\Delta Q_j^i * \Delta t}{(b_{i-1} + b_i)/2 * \Delta x} \tag{9}$$

for timestep i and i+1 with Δt interval. Then the model advances explicitly in time by

$$h_j^{i+1} = \Delta h_j^i + h_j^i \tag{10}$$

where the assumed input flows are added to the specified cross sections at each timestep. After each timestep, the hydraulic conductivity parameters of equation 6 are reevaluated, and the solution of equation 10 reinitiated.

Time Step Selection

As with all explicit schemes, the time step is very sensitive to the slope of the discharge hydrograph and the spacing of the cross-sections. Large changes in flow depth at any cross section can cause the computation to become unstable, or create an unacceptable error.

In the case of the sudden gate opening condition, the slope of the hydrograph is large and a small time step is required to avoid a large accumation of flow volume near the wave front. Trial and error found that a time step of 0.2 seconds provide for a smooth variation in flow depths over the simulation time.

Computer Program

The numerical procedure was executed using an Excel for Windows (Version 4.0) worksheet. The worksheet consists of two parts: the first part contains the hydraulic parameters for the current time step; and the second part is the computed hydraulic parameters for the next time step. New water levels in the reservoir are computed by a table look up procedure, using the tabular data on reservoir stage-storage relationship provided by the CH2M Hill design team.

The computation proceeds through a series of time steps using commands written in the Excel macro script. The macro overwrites the current time step hydraulic information with the hydraulic information computed for the next time step. The macro repeats the process for a specified number of time steps. After the macro completes, the worksheet can be printed out, the time interval in the macro reset, and the computation progressed for an additional interval of time.

The worksheet contains both tabular and graphical output. The tabular output contains data for the current time step, and the compute results for the next time step. Graphical information includes the computed depth and discharge for the next time step.

For the analysis of the Town Lake facility, the worksheet was executed on a 90 megahertz, Pentium computer. This allowed the computation to proceed at the rate of about one worksheet computation per second. (The full simulation was took 2500 time steps to simulate 500 seconds of flood wave propagation, or about 40 minutes of computer time.)

RESULTS

The Town Lake is configured with four gates controlling the pool level in the reservoir. There are two possible cases for a single gate failure for the town lake: Case 1, a gate near the center of the channel fails; or Case 2, a gate near the bank of the channel fails. The major difference between these two possible gate failure modes is the distance that the expanding flow requires to reach the channel bank. For case one, the flow will expand to the full channel width at 1,920 feet down stream of the gate opening, where:

Expansion Length = 4 * (Half the channel width)

= 4 * (960/2) = 1920 feet

For case two, the flow will expand to the full channel width in 3,000 feet down stream of the gate opening, where:

Expansion Length = 4 * (Channel width - Gate width)

= 4 * (960 - 210) = 3000 feet

Channel and gate dimensions are as follows:

Channel width = 960 feet
Gate width = 210 feet

CASE ONE

The flow expands to the full channel width about 100 seconds after the gate opening. During this initial release period the release rate from the gate had an instantaneous peak rate of 49,500 cfs at the moment of gate opening, and gradually drops to 47,600 cfs at 100 seconds after opening. The wave front advanced at the average speed of 19.2 fps. Behind the wave front the flow depth increases rapidly and reaches a depth of 5.2 feet 840 feet upstream of the wave front, and 9.0 feet 1440 feet upstream of the wave front (or 480 feet downstream of the gate).

For an individual standing in place 1920 feet downstream of the gate (at the location of the fully expanded flow), the flow depth will increase from nearly zero depth at 100 seconds to 4.1 feet at 200 seconds. Flow velocity will increase from zero to 11.4 fps during this same time period. For safe movement across a flooded area, FEMA advises a maximum velocity/depth product of 10 cfs/ft. In the Salt River channel, this condition will be exceeded about two minutes after the gate opening at the 1920 foot location, and about 3 minutes 20 seconds after gate opening at a location 2800 feet downstream of the gate. Movement of the floodwave on this basis is about 11.0 fps.

In the expansion zone flow velocity gradually varies from 16.7 fps just downstream of the gate opening to about 11.0 fps just upstream of the wave front. Full channel velocity is about 11.2 fps. As the expanding flow reaches the channel banks, the flow will impinge on the bank at the flow expansion angle of 14 degrees. Bed shear stresses will be on the order of 2.9 psf in the expansion zone as it reaches the bank line. This shear stress is roughly double the computed mean boundary shear stress computed for the design flood event (see Salt River Channelization Technical Data Notebook, CRSS Civil Engineers, November 1993). Significant erosion of the channel bed would occur under these conditions, and could locally undermine the channel bank protection as a result. However because of the short duration of the release, the volume of sediment transport will be limited. Also because the high bed shear conditions are localize to the expansion zone, there would be deposition immediately below expansion zone. This deposition might also decrease the extent of the expansion zone, and force a higher expansion rate.

The flow duration is equivalent to the reservoir drain time. Using the FEMA criteria of 10 cfs/ft the following conditions are noted at various times:

1. At 4,630 seconds (1-hr 17-min) after the gate opening, the discharge from the reservoir will be 9600 cfs or 10 cfs/ft at 1920 feet downstream of the gate. At that time, the reservoir volume will be 19.1 percent of the initial volume.

2. At 8,600 seconds (2-hr 23-min) after the gate opening, the discharge from the reservoir will be 2100 cfs or 10 cfs/ft at the gate. At that time, the reservoir volume will be 4.5 percent of the initial volume.

The flow from the reservoir exponentially tapers off (see Chart, Appendix C, Town Lake -- Reservoir Drain Time). The reservoir will be 99 percent drained 13,900 second (3-hr 52-min) after the gate opening. At that time the discharge over the sill will be under 300 cfs and less than 0.5 foot deep.

Model output for Case One is contained in Appendix A and drain time computation is contained in Appendix C.

CASE TWO

The results for the second scenario for gate failure are quite similar to the results for the first. Release rates from the Town Lake Reservoir, drain times, and flood wave propagation are in nearly identical. The only significant difference, one that is imposed by the geometrical definition of the expansion rate, is the size of the expansion zone which is 1080 feet longer compared to Case One.

Model output for Case Two is contained in Appendix B.

SUMMARY

Results of the analysis indicate that a gate failure leading to a sudden water release would create severe in-channel conditions, for a period of about two and one-half hours. The release of water from Town Lake would be essentially end within four hours. The flood wave would travel down the Salt River channel at the rate of about eleven feet per second, and would gradually attenuate as the result of in-channel storage. The presence of in-stream mining excavations to the west of 19th Avenue may cause significant attenuation of the flow. However, this is a temporary land use and may not exist at the future time when the gate failure might occur.

It is expected that should a rapid gate release occur, channel-bed users would be at risk for many miles downstream of the project. The rate of rise at the wave front would be rapid, with flow depths increasing from near zero depth to a five to six foot depth in about two minutes. This rapid rise rate would give channel-bed users with no previous warning very little time to exit the channel safely. Such a release would not be a hazard to users located on in-channel terraces that are more than eight feet above the channel bed elevation, or to users outside of the channel area.

The hazard to channel bed users could be mitigated by providing a downstreeam flood warning. Because the travel time for the flood wave is on the order of eight miles per hour, warning times of one-half hour to two hours could theoretically be developed for channel-bed users located four to sixteen miles below Town Lake, respectively. The logistical requirements of such a warning and other factors would reduce the theoretical warning time.

There is a potential for damage to the channel bed and banks immediately downstream of the gate, in the flow expansion zone. The main reason for the increased hazard is the higher shear stress on the channel bed caused by the rapidly expanding flow field. The brief flow duration may limit the potential damage in this zone. This hazard could be mitigated by providing an additional source of armoring material in the channel bed near the channel bank that is sized to resist the additional shear and impingment forces.

REFERENCES

Hromadka II, T.V., T.R. Walker, C.C. Yen, and J.J. DeVries, *"Application of the U.S.G.S. Diffusion Hydrodynamic Model for Urban Floodplain Management"*, Water Resources Bulletin, Vol. 25, No. 5, October 1989.

Hromadka II, T.V. and C.C. Yen, *"A Diffusion Hydrodynamic Model"*, U.S. Geologic Survey, Water-Resources Investigations Report 87-4137.

CRSS Civil Engineers, *"Technical Data Notebook, Salt River Channelization, Floodplain Delineation Study"*, prepared for the Rio Salado Task Force, November 1993.

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last revised: 7/21/94 10:40 AM

Data:

Location: Salt River -- Town Lake, Tempe, Arizona

Init. Pool Elev.. =	1150 msl	dt =	0.2 sec
Gate Base Elev.. =	1132 msl	dx =	varies
Channel Slope =	0.1717%	units:	US Customary
Manning Coef. =	0.035		

Reservoir:		
	49,536	cfs (init.)
	3,165.59	ac-ft (init)
Volume =	3,154.24	ac-ft.
Stage =	1,149.95	ft.
Time Step =	50	
t=	10.0	sec

Section Number	Cum.Length (ft.)	Width (ft.)	Invert Elev.. (msl)	Discharge (cfs)	Depth (ft.)	Velocity (fps)	Sc (ft./ft.)	Sf (ft./ft.)
1	0	210	1.00	49,338	11.97	19.63	0.0078	0.0078
2	80	250	0.35	45,095	11.67	16.79	0.0079	0.0004
3	180	300	0.11	25,704	7.05	13.26	0.0093	0.0005
4	280	350	0.00	6,460	2.27	8.76	0.0136	0.0009
5	480	450	0.00	145	0.15	2.46	0.0338	0.0027
6	680	550	0.00	0	0.00	0.24	0.1564	0.0119
7	880	650	0.00	0	0.00	0.00	0.0017	0.0017
8	1080	750	0.00	0	0.00	0.00	0.0017	0.0017
9	1280	800	0.00	0	0.00	0.00	0.0017	0.0017
10	1480	900	0.00	0	0.00	0.00	0.0017	0.0017
11	1680	960	0.00	0	0.00	0.00	0.0017	0.0017
12	1920	960	0.00	0	0.00	0.00	0.0017	0.0017
13	2200	960	0.00	0	0.00	0.00	0.0017	0.0017
14	2450	960	0.00	0	0.00	0.00	0.0017	0.0017
15	2700	960	0.00	0	0.00	0.00	0.0017	0.0017
16	2950	960	0.00	0	0.00	0.00	0.0017	0.0017
17	3200	960	0.00	0	0.00	0.00	0.0017	0.0017
18	3450	960	0.00	0	0.00	0.00	0.0017	0.0017
19	3700	960	0.00	0	0.00	0.00	0.0017	0.0017
20	3950	960	0.00	0	0.00	0.00	0.0017	0.0017
21	4200	960	0.00	0	0.00	0.00	0.0017	0.0017

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

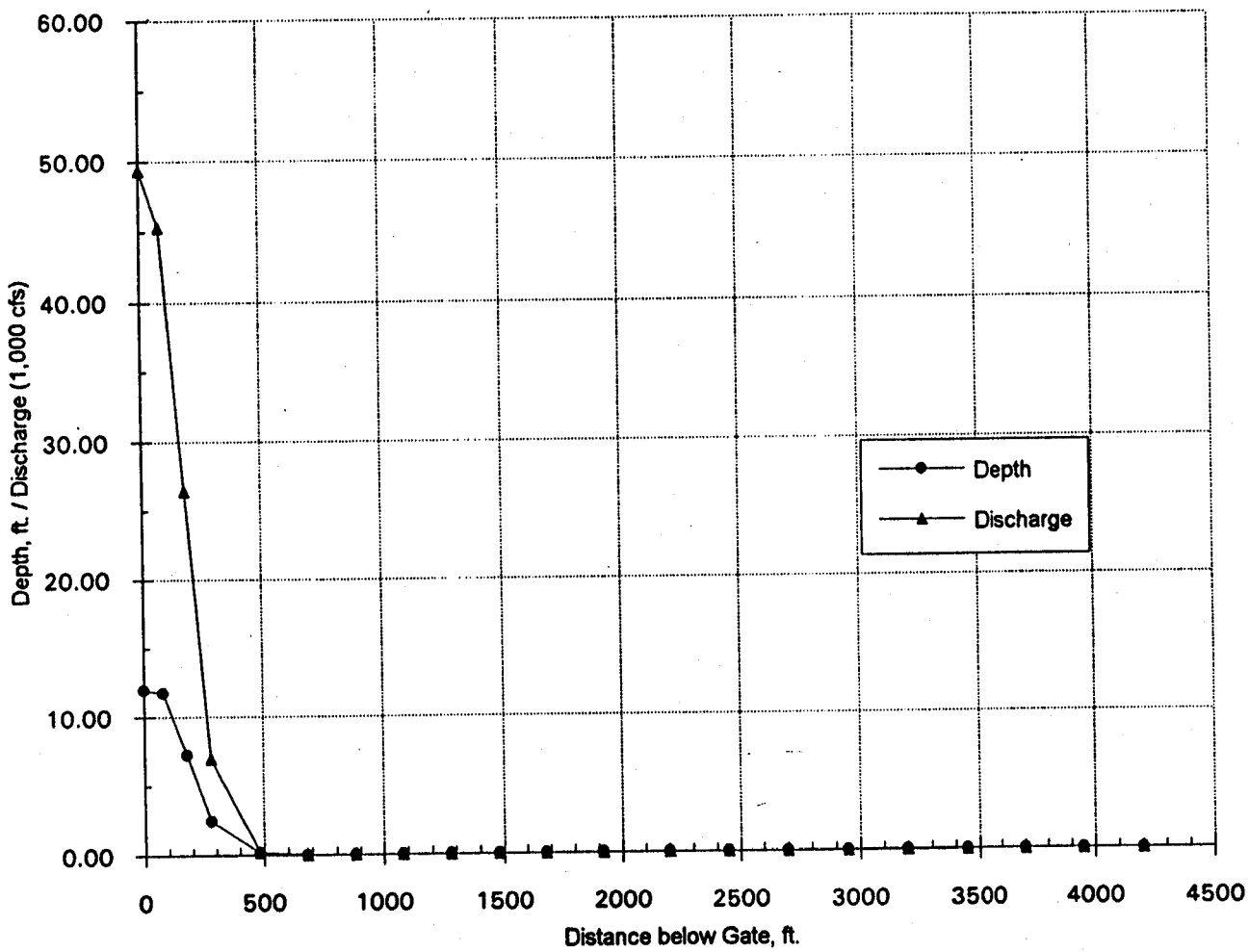
Template by: George K. Cotton, PE

Last revised: 7/21/94

			13
Release Volume:	0.23	acre-ft.	2,692.99
New Volume:	3,154.01	acre-ft.	3,165.59
Reservoir Stage:	1,149.95	ft.	1,148.00
Next Time Step =	51		1,150.00
Cumulative time =	10.2	sec	1,149.95

Sx		Diffusion Calc.				Raw Values		Plotted Values	
(ft./ft.)	Kx	q	dh	Vel	Fr	Discharge	Depth	Q(n+1)	y(n+1)
0.0078	3.01E+04	235	-6.40E-04	19.63	1.00	49,334	11.97	49.334	11.97
0.0083	2.81E+04	197	4.61E-02	16.81	0.87	45,324	11.72	45.324	11.72
0.0103	1.12E+04	96	1.41E-01	13.36	0.88	26,431	7.19	26.431	7.19
0.0189	1.32E+03	21	1.18E-01	8.94	1.02	6,940	2.39	6.940	2.39
0.0680	7.92E+00	0	1.58E-02	2.57	1.12	167	0.16	0.167	0.16
0.0640	0.00E+00	0	2.90E-04	0.00	0.00	0	0.00	0.000	0.00
0.0533	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00

Depth Profiles -- Town Lake, Sudden Gate Release



Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last revised: 7/21/94 10:40 AM

Data:

Location: Salt River -- Town Lake, Tempe, Arizona

Init. Pool Elev.. =	1150 msl	dt =	0.2 sec	Volume =	3,142.94 ac-ft.
Gate Base Elev.. =	1132 msl	dx =	varies	Stage =	1,149.90 ft.
Channel Slope =	0.1717%	units:	US Customary	Time Step =	100
Manning Coef. =	0.035			t =	20.0 sec

Reservoir: 49,536 cfs (init.)
3,165.59 ac-ft (init)

Section Number	Cum.Length (ft.)	Width (ft.)	Invert Elev.. (msl)	Discharge (cfs)	Depth (ft.)	Velocity (fps)	Sc (ft./ft.)	Sf (ft./ft.)
1	0	210	1.00	49,141	11.94	19.60	0.0078	0.0078
2	80	250	0.35	48,886	12.47	17.05	0.0077	0.0003
3	180	300	0.11	45,557	10.62	15.60	0.0081	0.0004
4	280	350	0.00	34,833	7.56	14.18	0.0091	0.0005
5	480	450	0.00	7,596	2.43	7.82	0.0133	0.0006
6	680	550	0.00	373	0.25	3.00	0.0284	0.0020
7	880	650	0.00	1	0.01	0.25	0.0982	0.0019
8	1080	750	0.00	0	0.00	0.00	0.0017	0.0017
9	1280	800	0.00	0	0.00	0.00	0.0017	0.0017
10	1480	900	0.00	0	0.00	0.00	0.0017	0.0017
11	1680	960	0.00	0	0.00	0.00	0.0017	0.0017
12	1920	960	0.00	0	0.00	0.00	0.0017	0.0017
13	2200	960	0.00	0	0.00	0.00	0.0017	0.0017
14	2450	960	0.00	0	0.00	0.00	0.0017	0.0017
15	2700	960	0.00	0	0.00	0.00	0.0017	0.0017
16	2950	960	0.00	0	0.00	0.00	0.0017	0.0017
17	3200	960	0.00	0	0.00	0.00	0.0017	0.0017
18	3450	960	0.00	0	0.00	0.00	0.0017	0.0017
19	3700	960	0.00	0	0.00	0.00	0.0017	0.0017
20	3950	960	0.00	0	0.00	0.00	0.0017	0.0017
21	4200	960	0.00	0	0.00	0.00	0.0017	0.0017

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			13
Release Volume:	0.23	acre-ft.	2,692.99
New Volume:	3,142.71	acre-ft.	3,165.59
Reservoir Stage:	1,149.90	ft.	1,148.00
Next Time Step =	101		1,150.00
Cumulative time =	20.2	sec	1,149.90

Sx		Diffusion Calc.				Raw Values		Plotted Values	
(ft./ft.)	Kx	q	dh	Vel	Fr	Discharge	Depth	Q(n+1)	y(n+1)
0.0078	3.00E+04	234	-6.40E-04	19.60	1.00	49,137	11.94	49.137	11.94
0.0079	3.21E+04	213	2.77E-03	17.05	0.85	48,897	12.47	48.897	12.47
0.0083	2.40E+04	166	2.42E-02	15.62	0.84	45,699	10.64	45.699	10.64
0.0102	1.24E+04	108	6.60E-02	14.23	0.91	35,250	7.62	35.250	7.62
0.0169	1.50E+03	20	6.81E-02	7.91	0.88	7,900	2.50	7.900	2.50
0.0466	2.12E+01	1	1.45E-02	3.08	1.06	404	0.26	0.404	0.26
0.0428	5.00E-02	0	6.20E-04	0.27	0.59	1	0.01	0.001	0.01
0.0339	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
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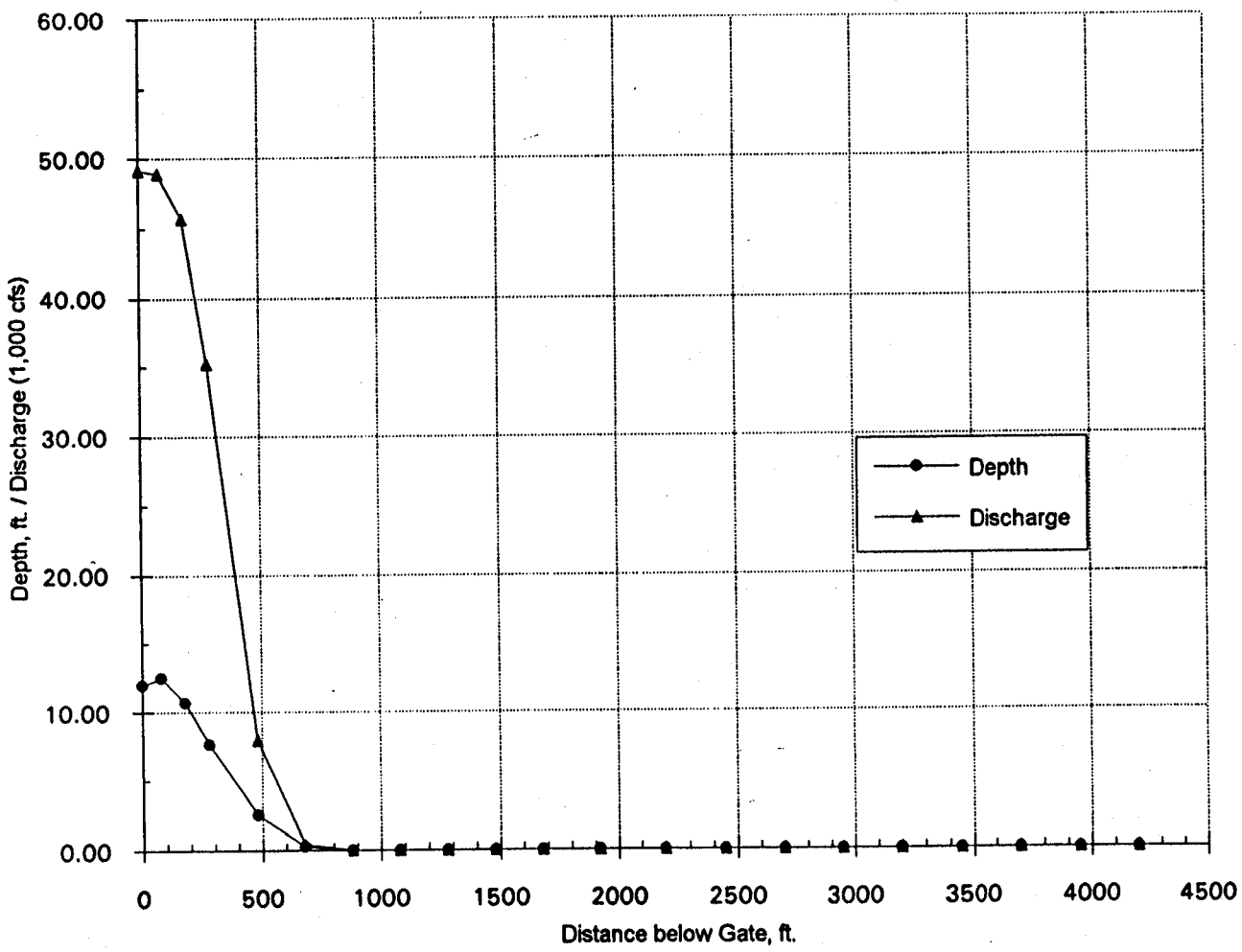
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00

Depth Profiles -- Town Lake, Sudden Gate Release



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Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last revised: 7/21/94 10:42 AM

Data:

Location: Salt River -- Town Lake, Tempe, Arizona

Init. Pool Elev.. =	1150 msl	dt =	0.2 sec	Volume =	3,109.30 ac-ft.
Gate Base Elev.. =	1132 msl	dx =	varies	Stage =	1,149.76 ft.
Channel Slope =	0.1717%	units:	US Customary	Time Step =	250
Manning Coef. =	0.035			t =	50.0 sec

Reservoir: 49,536 cfs (init.)
3,165.59 ac-ft (init)

Section Number	Cum.Length (ft.)	Width (ft.)	Invert Elev.. (msl)	Discharge (cfs)	Depth (ft.)	Velocity (fps)	Sc (ft./ft.)	Sf (ft./ft.)
1	0	210	1.00	48,556	11.84	19.53	0.0078	0.0078
2	80	250	0.35	48,616	12.45	16.98	0.0077	0.0003
3	180	300	0.11	48,682	11.17	15.84	0.0080	0.0003
4	280	350	0.00	48,601	9.80	15.26	0.0083	0.0004
5	480	450	0.00	44,224	8.45	13.08	0.0088	0.0003
6	680	550	0.00	30,485	5.46	11.17	0.0101	0.0005
7	880	650	0.00	11,700	2.43	8.01	0.0133	0.0007
8	1080	750	0.00	1,610	0.55	4.20	0.0218	0.0014
9	1280	800	0.00	50	0.04	1.50	0.0510	0.0051
10	1480	900	0.00	0	0.00	0.16	0.2022	0.0142
11	1680	960	0.00	0	0.00	0.00	0.0017	0.0017
12	1920	960	0.00	0	0.00	0.00	0.0017	0.0017
13	2200	960	0.00	0	0.00	0.00	0.0017	0.0017
14	2450	960	0.00	0	0.00	0.00	0.0017	0.0017
15	2700	960	0.00	0	0.00	0.00	0.0017	0.0017
16	2950	960	0.00	0	0.00	0.00	0.0017	0.0017
17	3200	960	0.00	0	0.00	0.00	0.0017	0.0017
18	3450	960	0.00	0	0.00	0.00	0.0017	0.0017
19	3700	960	0.00	0	0.00	0.00	0.0017	0.0017
20	3950	960	0.00	0	0.00	0.00	0.0017	0.0017
21	4200	960	0.00	0	0.00	0.00	0.0017	0.0017

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last revised: 7/21/94

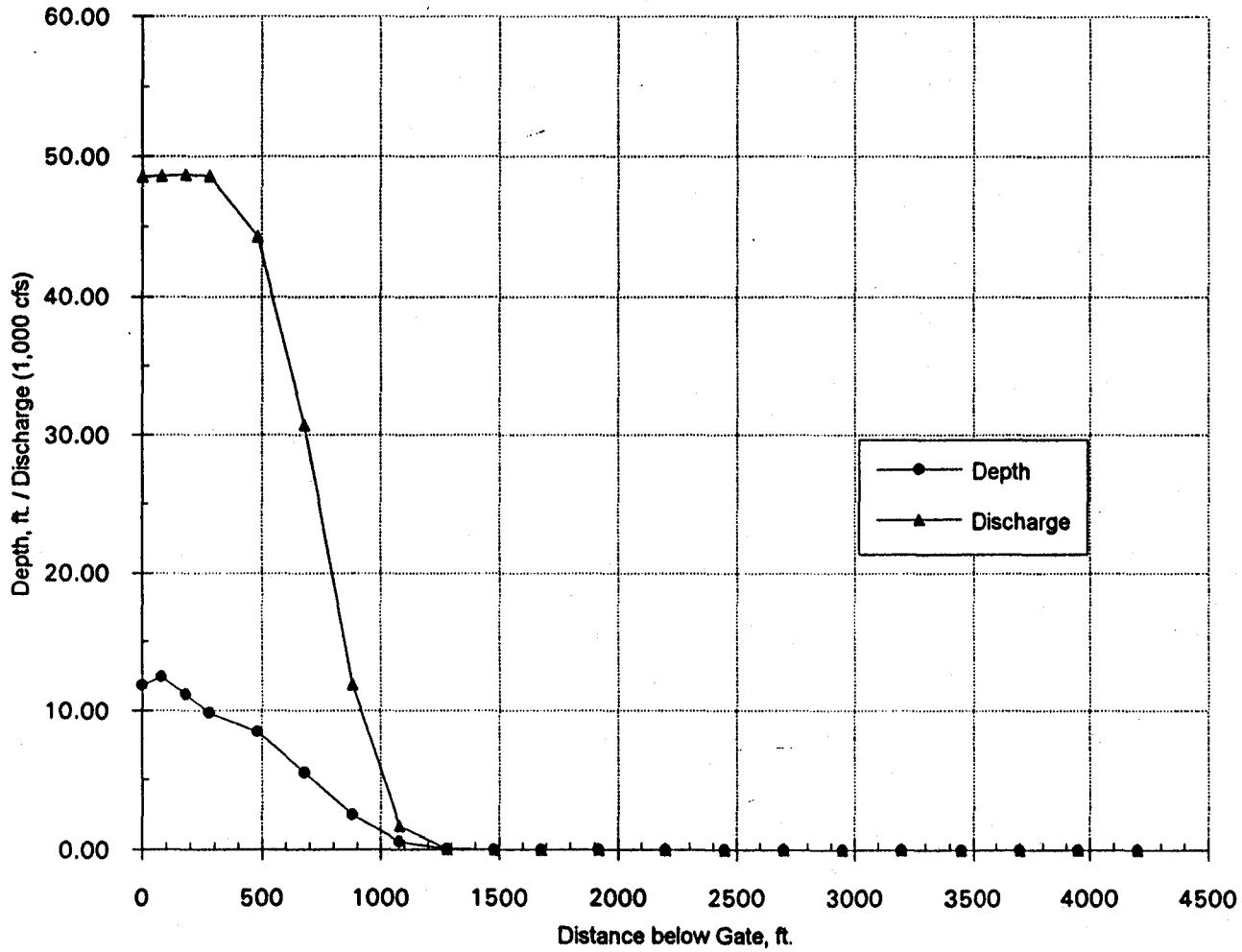
			13
Release Volume:	0.22	acre-ft.	2,692.99
New Volume:	3,109.08	acre-ft.	3,165.59
Reservoir Stage:	1,149.76	ft.	1,148.00
Next Time Step =	251		1,150.00
Cumulative time =	50.2	sec	1,149.76

Sx		Diffusion Calc.				Raw Values		Plotted Values	
(ft./ft.)	Kx	q	dh	Vel	Fr	Discharge	Depth	Q(n+1)	y(n+1)
0.0078	2.95E+04	231	-6.30E-04	19.53	1.00	48,552	11.84	48.552	11.84
0.0078	3.21E+04	211	-6.50E-04	16.98	0.85	48,612	12.45	48.612	12.45
0.0080	2.65E+04	177	-4.90E-04	15.84	0.84	48,679	11.17	48.679	11.17
0.0084	2.08E+04	150	5.00E-04	15.26	0.86	48,602	9.80	48.602	9.80
0.0091	1.57E+04	111	1.09E-02	13.09	0.79	44,302	8.46	44.302	8.46
0.0107	6.99E+03	61	2.75E-02	11.20	0.84	30,704	5.48	30.704	5.48
0.0151	1.56E+03	20	3.13E-02	8.06	0.90	11,917	2.47	11.917	2.47
0.0287	9.60E+01	2	1.44E-02	4.25	1.00	1,671	0.56	1.671	0.56
0.0917	8.00E-01	0	2.01E-03	1.53	1.27	53	0.05	0.053	0.05
0.0850	0.00E+00	0	6.00E-05	0.00	0.00	0	0.00	0.000	0.00
0.0685	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00

Appendix A

Case One
Central Gate Failure
1920 ft. Downstream Diffusion Length

Depth Profiles -- Town Lake, Sudden Gate Release



Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last revised: 7/21/94 10:45 AM

Data:

Location: Salt River -- Town Lake, Tempe, Arizona

Init. Pool Elev.. =	1150 msl	dt =	0.2 sec	Volume =	3,054.12 ac-ft.
Gate Base Elev.. =	1132 msl	dx =	varies	Stage =	1,149.53 ft.
Channel Slope =	0.1717%	units:	US Customary	Time Step =	500
Manning Coef. =	0.035			t =	100.0 sec

Reservoir:

	49,536	cfs (init.)
	3,165.59	ac-ft (init)

Section Number	Cum.Length (ft.)	Width (ft.)	Invert Elev.. (msl)	Discharge (cfs)	Depth (ft.)	Velocity (fps)	Sc (ft./ft.)	Sf (ft./ft.)
1	0	210	1.00	47,601	11.69	19.40	0.0079	0.0079
2	80	250	0.35	47,661	12.28	16.87	0.0077	0.0003
3	180	300	0.11	47,741	11.03	15.74	0.0080	0.0003
4	280	350	0.00	47,823	9.72	15.14	0.0084	0.0004
5	480	450	0.00	47,946	8.99	13.33	0.0086	0.0003
6	680	550	0.00	47,702	7.50	12.72	0.0091	0.0004
7	880	650	0.00	46,045	6.33	12.12	0.0097	0.0004
8	1080	750	0.00	40,641	5.15	11.27	0.0103	0.0005
9	1280	800	0.00	29,514	3.67	10.38	0.0116	0.0007
10	1480	900	0.00	13,594	2.09	7.67	0.0140	0.0008
11	1680	960	0.00	2,863	0.64	4.78	0.0207	0.0014
12	1920	960	0.00	140	0.07	1.98	0.0426	0.0044
13	2200	960	0.00	0	0.00	0.25	0.1450	0.0091
14	2450	960	0.00	0	0.00	0.00	0.0017	0.0017
15	2700	960	0.00	0	0.00	0.00	0.0017	0.0017
16	2950	960	0.00	0	0.00	0.00	0.0017	0.0017
17	3200	960	0.00	0	0.00	0.00	0.0017	0.0017
18	3450	960	0.00	0	0.00	0.00	0.0017	0.0017
19	3700	960	0.00	0	0.00	0.00	0.0017	0.0017
20	3950	960	0.00	0	0.00	0.00	0.0017	0.0017
21	4200	960	0.00	0	0.00	0.00	0.0017	0.0017

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

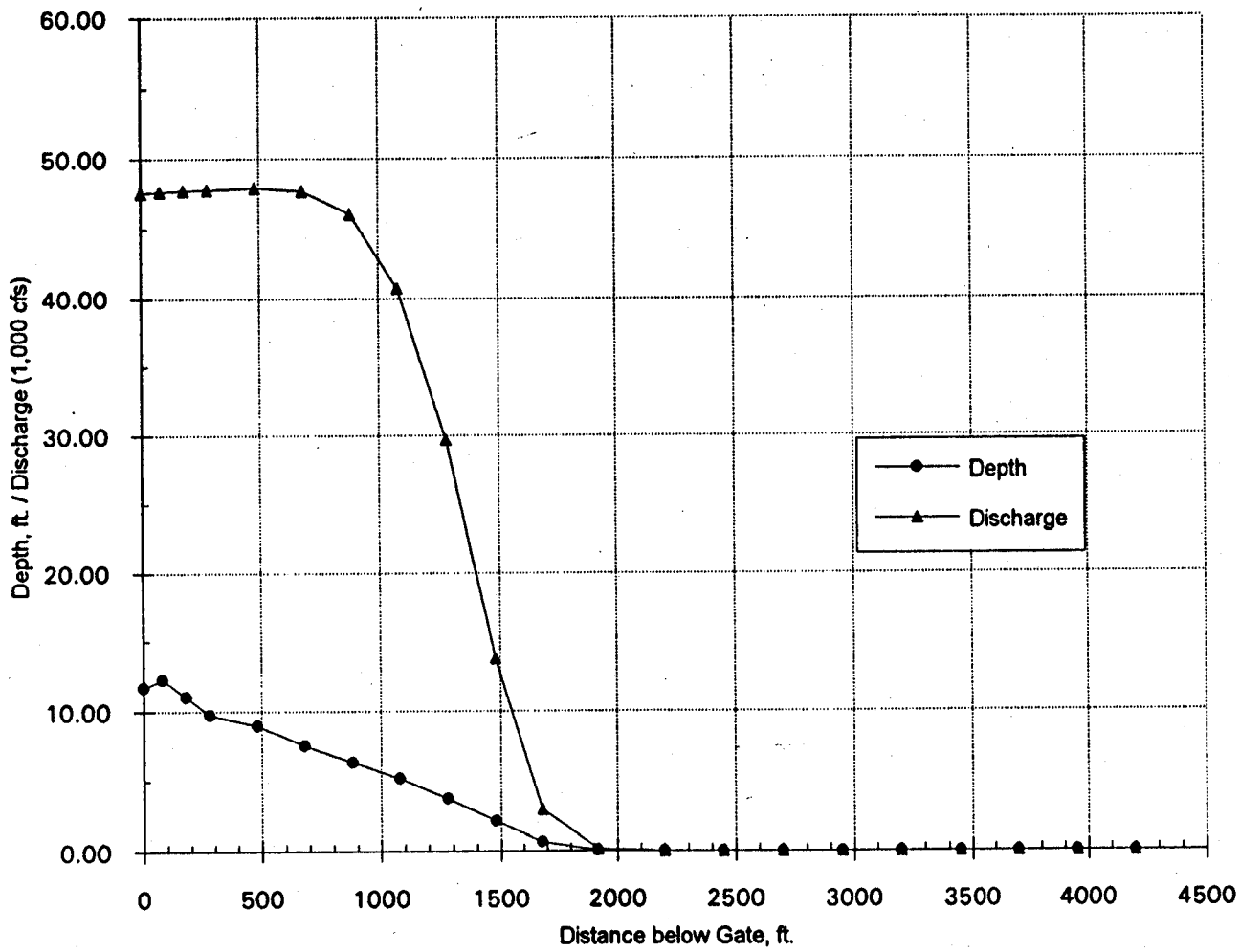
Template by: George K. Cotton, PE

Last revised: 7/21/94

			13
Release Volume:	0.22	acre-ft.	2,692.99
New Volume:	3,053.90	acre-ft.	3,165.59
Reservoir Stage:	1,149.53	ft.	1,148.00
Next Time Step =	501		1,150.00
Cumulative time =	100.2	sec	1,149.53

Sx		Diffusion Calc.				Raw Values		Plotted Values	
(ft./ft.)	Kx	q	dh	Vel	Fr	Discharge	Depth	Q(n+1)	y(n+1)
0.0079	2.88E+04	227	-6.20E-04	19.40	1.00	47,597	11.68	47.597	11.68
0.0079	3.13E+04	207	-6.50E-04	16.87	0.85	47,657	12.28	47.657	12.28
0.0080	2.59E+04	174	-5.80E-04	15.74	0.84	47,738	11.03	47.738	11.03
0.0083	2.06E+04	147	-5.00E-04	15.14	0.86	47,819	9.72	47.819	9.72
0.0087	1.77E+04	120	-3.10E-04	13.33	0.78	47,943	8.99	47.943	8.99
0.0091	1.28E+04	95	4.90E-04	12.72	0.82	47,706	7.50	47.706	7.50
0.0097	9.35E+03	77	2.76E-03	12.13	0.85	46,073	6.33	46.073	6.33
0.0105	6.38E+03	58	7.72E-03	11.28	0.88	40,729	5.16	40.729	5.16
0.0120	3.41E+03	38	1.44E-02	10.39	0.95	29,681	3.68	29.681	3.68
0.0154	1.18E+03	16	1.87E-02	7.70	0.94	13,771	2.10	13.771	2.10
0.0258	1.31E+02	3	1.15E-02	4.82	1.05	2,938	0.66	2.938	0.66
0.0694	2.20E+00	0	2.36E-03	2.01	1.28	147	0.08	0.147	0.08
0.0631	1.00E-02	0	1.00E-04	0.32	1.27	1	0.00	0.001	0.00
0.0495	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00

Depth Profiles -- Town Lake, Sudden Gate Release



Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last revised: 7/21/94 10:50 AM

Data:

Location: Salt River -- Town Lake, Tempe, Arizona

Init. Pool Elev.. =	1150 msl	dt =	0.2 sec	Volume =	2,946.97	ac-ft.
Gate Base Elev.. =	1132 msl	dx =	varies	Stage =	1,149.07	ft.
Channel Slope =	0.1717%	units:	US Customary	Time Step =	1000	
Manning Coef. =	0.035			t =	200.0	sec

Reservoir:

	49,536	cfs (init.)
	3,165.59	ac-ft (init)

Section Number	Cum.Length (ft.)	Width (ft.)	Invert Elev.. (msl)	Discharge (cfs)	Depth (ft.)	Velocity (fps)	Sc (ft./ft.)	Sf (ft./ft.)
1	0	210	1.00	45,766	11.38	19.15	0.0079	0.0079
2	80	250	0.35	45,824	11.97	16.65	0.0078	0.0004
3	180	300	0.11	45,901	10.74	15.53	0.0081	0.0004
4	280	350	0.00	45,981	9.47	14.94	0.0084	0.0004
5	480	450	0.00	46,163	8.77	13.16	0.0087	0.0003
6	680	550	0.00	46,356	7.36	12.59	0.0092	0.0004
7	880	650	0.00	46,552	6.39	12.14	0.0096	0.0004
8	1080	750	0.00	46,749	5.69	11.74	0.0100	0.0005
9	1280	800	0.00	46,914	5.07	11.93	0.0104	0.0006
10	1480	900	0.00	46,973	4.92	11.24	0.0105	0.0005
11	1680	960	0.00	46,681	4.46	11.24	0.0109	0.0006
12	1920	960	0.00	44,977	4.08	11.48	0.0112	0.0007
13	2200	960	0.00	38,755	3.68	10.97	0.0116	0.0007
14	2450	960	0.00	27,930	2.94	9.91	0.0125	0.0008
15	2700	960	0.00	13,552	1.79	7.90	0.0147	0.0010
16	2950	960	0.00	3,160	0.66	5.02	0.0206	0.0015
17	3200	960	0.00	221	0.10	2.22	0.0380	0.0035
18	3450	960	0.00	1	0.00	0.21	0.1073	0.0021
19	3700	960	0.00	0	0.00	0.00	0.0017	0.0017
20	3950	960	0.00	0	0.00	0.00	0.0017	0.0017
21	4200	960	0.00	0	0.00	0.00	0.0017	0.0017

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

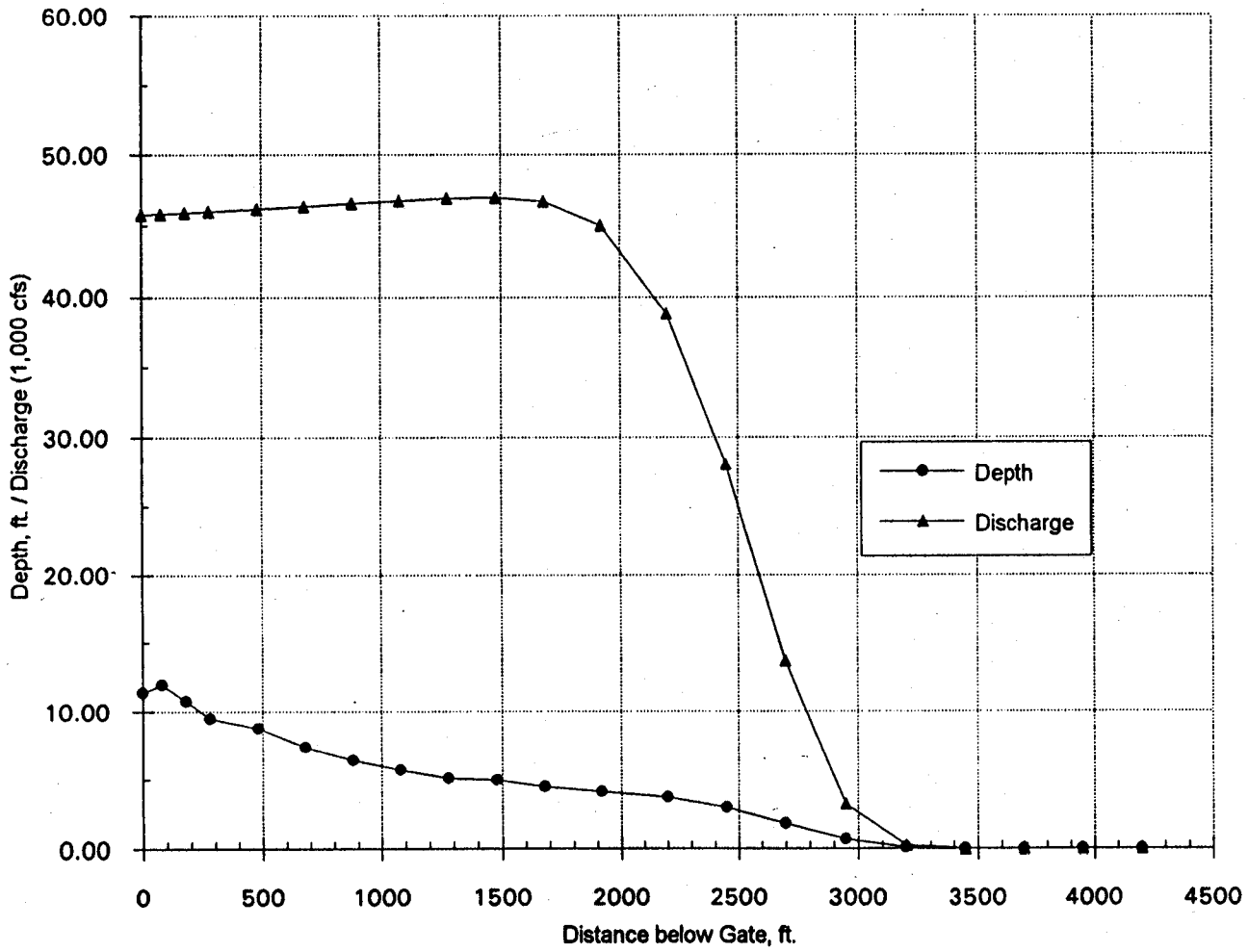
Template by: George K. Cotton, PE

Last revised: 7/21/94

			13
Release Volume:	0.21	acre-ft.	2,692.99
New Volume:	2,946.76	acre-ft.	3,165.59
Reservoir Stage:	1,149.07	ft.	1,148.00
Next Time Step =	1001		1,150.00
Cumulative time =	200.2	sec	1,149.07

Sx		Diffusion Calc.				Raw Values		Plotted Values	
(ft./ft.)	Kx	q	dh	Vel	Fr	Discharge	Depth	Q(n+1)	y(n+1)
0.0079	2.75E+04	218	-5.90E-04	19.14	1.00	45,762	11.38	45.762	11.38
0.0080	2.98E+04	199	-6.20E-04	16.65	0.85	45,820	11.97	45.820	11.97
0.0081	2.47E+04	167	-5.60E-04	15.53	0.84	45,897	10.74	45.897	10.74
0.0084	1.96E+04	141	-4.90E-04	14.94	0.86	45,978	9.47	45.978	9.47
0.0088	1.69E+04	115	-4.60E-04	13.16	0.78	46,160	8.77	46.160	8.77
0.0092	1.24E+04	93	-3.80E-04	12.59	0.82	46,352	7.36	46.352	7.36
0.0096	9.54E+03	78	-3.30E-04	12.14	0.85	46,549	6.39	46.549	6.39
0.0100	7.70E+03	67	-2.80E-04	11.74	0.87	46,746	5.69	46.746	5.69
0.0103	6.27E+03	61	-2.10E-04	11.93	0.93	46,911	5.07	46.911	5.07
0.0106	5.87E+03	55	-7.00E-05	11.24	0.89	46,972	4.92	46.972	4.92
0.0108	4.94E+03	50	3.10E-04	11.24	0.94	46,685	4.46	46.685	4.46
0.0112	4.18E+03	47	1.48E-03	11.48	1.00	45,000	4.08	45.000	4.08
0.0117	3.44E+03	40	4.63E-03	10.98	1.01	38,826	3.68	38.826	3.68
0.0129	2.26E+03	29	9.02E-03	9.92	1.02	28,055	2.95	28.055	2.95
0.0159	8.95E+02	14	1.20E-02	7.93	1.04	13,684	1.80	13.684	1.80
0.0244	1.37E+02	3	8.66E-03	5.05	1.09	3,221	0.66	3.221	0.66
0.0553	4.31E+00	0	2.45E-03	2.24	1.21	229	0.11	0.229	0.11
0.0490	3.00E-02	0	1.80E-04	0.31	0.78	1	0.00	0.001	0.00
0.0369	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00

Depth Profiles -- Town Lake, Sudden Gate Release



Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last revised: 7/21/94 10:58 AM

Data:

Location: Salt River -- Town Lake, Tempe, Arizona

Init. Pool Elev.. =	1150 msl	dt =	0.2 sec	Volume =	2,783.98	ac-ft.
Gate Base Elev.. =	1132 msl	dx =	varies	Stage =	1,148.39	ft.
Channel Slope =	0.1717%	units:	US Customary	Time Step =	1800	
Manning Coef. =	0.035			t =	360.0	sec

Reservoir: 49,536 cfs (init.)
3,165.59 ac-ft (init)

Section Number	Cum.Length (ft.)	Width (ft.)	Invert Elev.. (msl)	Discharge (cfs)	Depth (ft.)	Velocity (fps)	Sc (ft./ft.)	Sf (ft./ft.)
1	0	210	1.00	43,021	10.92	18.75	0.0081	0.0081
2	80	250	0.35	43,075	11.48	16.31	0.0079	0.0004
3	180	300	0.11	43,147	10.31	15.22	0.0082	0.0004
4	280	350	0.00	43,223	9.09	14.64	0.0086	0.0004
5	480	450	0.00	43,396	8.42	12.89	0.0088	0.0003
6	680	550	0.00	43,578	7.07	12.33	0.0093	0.0004
7	880	650	0.00	43,767	6.14	11.89	0.0098	0.0004
8	1080	750	0.00	43,961	5.46	11.50	0.0101	0.0005
9	1280	800	0.00	44,156	4.87	11.69	0.0105	0.0006
10	1480	900	0.00	44,364	4.74	11.02	0.0106	0.0005
11	1680	960	0.00	44,573	4.33	11.06	0.0110	0.0006
12	1920	960	0.00	44,809	4.08	11.43	0.0112	0.0007
13	2200	960	0.00	45,085	4.09	11.48	0.0112	0.0007
14	2450	960	0.00	45,320	4.10	11.50	0.0112	0.0007
15	2700	960	0.00	45,530	4.12	11.52	0.0111	0.0007
16	2950	960	0.00	45,668	4.12	11.53	0.0111	0.0007
17	3200	960	0.00	45,619	4.12	11.53	0.0111	0.0007
18	3450	960	0.00	45,115	4.09	11.49	0.0112	0.0007
19	3700	960	0.00	43,576	3.99	11.36	0.0113	0.0007
20	3950	960	0.00	39,728	3.80	10.89	0.0114	0.0007
21	4200	960	0.00	23,891	4.90	5.08	0.0105	0.0001

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

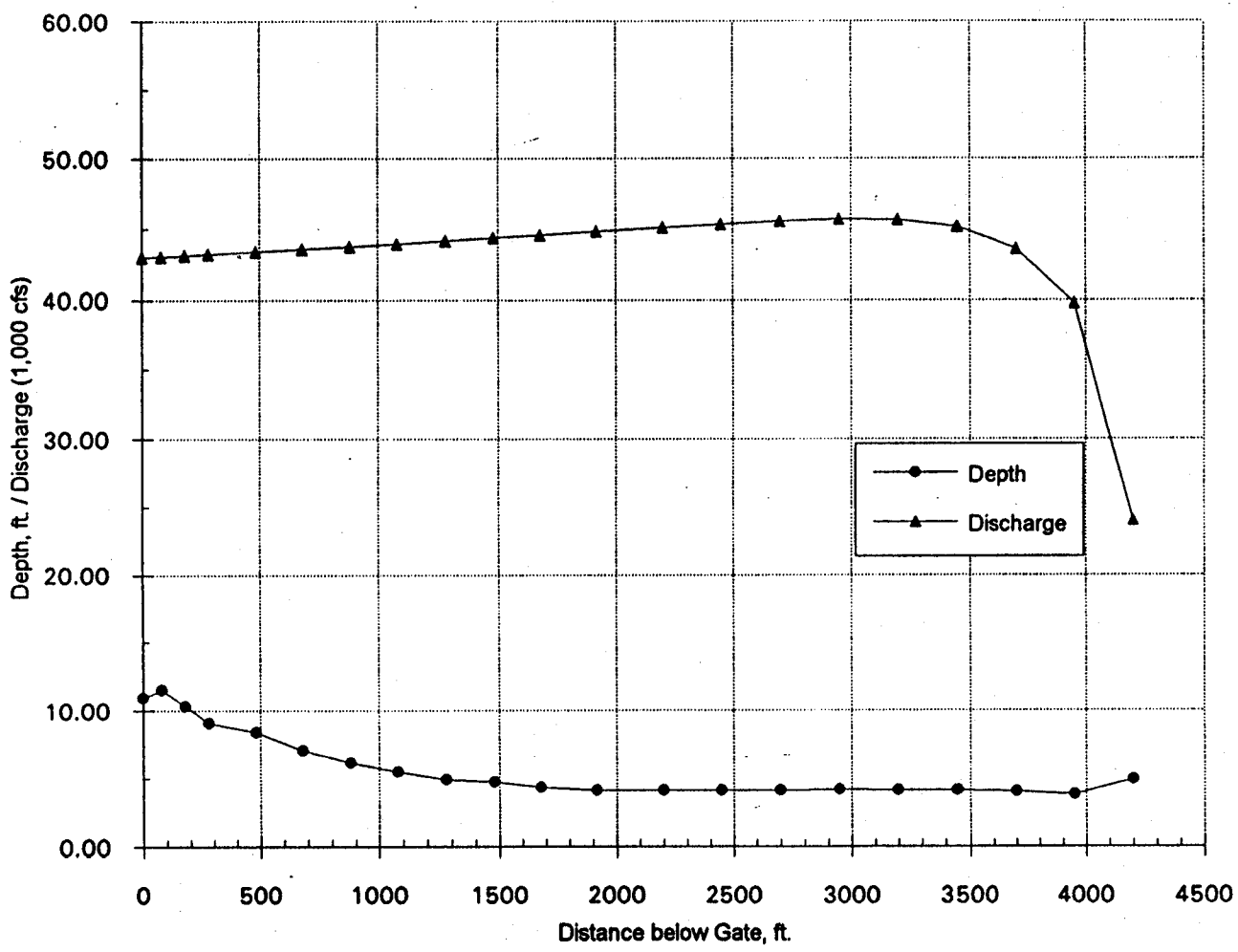
Template by: George K. Cotton, PE

Last revised: 7/21/94

			13
Release Volume:	0.20	acre-ft.	2,692.99
New Volume:	2,783.78	acre-ft.	3,165.59
Reservoir Stage:	1,148.38	ft.	1,148.00
Next Time Step =	1801		1,150.00
Cumulative time =	360.2	sec	1,148.38

Sx		Diffusion Calc.				Raw Values		Plotted Values	
(ft./ft.)	Kx	q	dh	Vel	Fr	Discharge	Depth	Q(n+1)	y(n+1)
0.0081	2.55E+04	205	-5.60E-04	18.75	1.00	43,018	10.92	43.018	10.92
0.0081	2.77E+04	187	-5.90E-04	16.31	0.85	43,072	11.48	43.072	11.48
0.0082	2.29E+04	157	-5.20E-04	15.22	0.84	43,144	10.31	43.144	10.31
0.0085	1.82E+04	133	-4.60E-04	14.64	0.86	43,219	9.09	43.219	9.09
0.0089	1.57E+04	108	-4.30E-04	12.89	0.78	43,393	8.42	43.393	8.42
0.0093	1.15E+04	87	-3.60E-04	12.33	0.82	43,575	7.07	43.575	7.07
0.0097	8.85E+03	73	-3.10E-04	11.89	0.85	43,764	6.14	43.764	6.14
0.0101	7.14E+03	63	-2.80E-04	11.50	0.87	43,957	5.46	43.957	5.46
0.0104	5.82E+03	57	-2.50E-04	11.69	0.93	44,153	4.87	44.153	4.87
0.0107	5.48E+03	52	-2.40E-04	11.02	0.89	44,361	4.74	44.361	4.74
0.0109	4.68E+03	48	-2.20E-04	11.06	0.94	44,570	4.33	44.570	4.33
0.0111	4.20E+03	47	-2.00E-04	11.43	1.00	44,806	4.08	44.806	4.08
0.0112	4.20E+03	47	-2.10E-04	11.48	1.00	45,082	4.09	45.082	4.09
0.0112	4.23E+03	47	-2.00E-04	11.50	1.00	45,317	4.10	45.317	4.10
0.0111	4.25E+03	47	-1.80E-04	11.52	1.00	45,527	4.12	45.527	4.12
0.0111	4.27E+03	48	-1.20E-04	11.53	1.00	45,666	4.12	45.666	4.12
0.0112	4.26E+03	48	4.00E-05	11.53	1.00	45,619	4.12	45.619	4.12
0.0112	4.20E+03	47	4.20E-04	11.49	1.00	45,121	4.09	45.121	4.09
0.0113	4.02E+03	45	1.28E-03	11.37	1.00	43,596	4.00	43.596	4.00
0.0111	3.74E+03	41	3.21E-03	10.89	0.98	39,776	3.80	39.776	3.80
0.0017	1.46E+04	25	1.32E-02	5.09	0.40	23,998	4.91	23.998	4.91

Depth Profiles -- Town Lake, Sudden Gate Release



Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last revised: 7/21/94 11:05 AM

Data:

Location: Salt River -- Town Lake, Tempe, Arizona

Init. Pool Elev.. =	1150 msl	dt =	0.2 sec	Volume =	2,649.35	ac-ft.
Gate Base Elev.. =	1132 msl	dx =	varies	Stage =	1,147.81	ft.
Channel Slope =	0.1717%	units:	US Customary	Time Step =	2500	
Manning Coef. =	0.035			t=	500.0	sec

Reservoir: 49,536 cfs (init.)
3,165.59 ac-ft (init)

Section Number	Cum.Length (ft.)	Width (ft.)	Invert Elev.. (msl)	Discharge (cfs)	Depth (ft.)	Velocity (fps)	Sc (ft./ft.)	Sf (ft./ft.)
1	0	210	1.00	40,774	10.54	18.42	0.0081	0.0081
2	80	250	0.35	40,827	11.08	16.02	0.0080	0.0004
3	180	300	0.11	40,898	9.95	14.95	0.0083	0.0004
4	280	350	0.00	40,972	8.77	14.38	0.0087	0.0004
5	480	450	0.00	41,138	8.12	12.66	0.0089	0.0003
6	680	550	0.00	41,312	6.82	12.12	0.0094	0.0004
7	880	650	0.00	41,495	5.92	11.68	0.0099	0.0004
8	1080	750	0.00	41,681	5.27	11.30	0.0103	0.0005
9	1280	800	0.00	41,868	4.70	11.49	0.0107	0.0006
10	1480	900	0.00	42,067	4.57	10.83	0.0108	0.0005
11	1680	960	0.00	42,267	4.18	10.87	0.0111	0.0006
12	1920	960	0.00	42,492	3.94	11.23	0.0113	0.0007
13	2200	960	0.00	42,762	3.95	11.28	0.0113	0.0007
14	2450	960	0.00	43,005	3.96	11.30	0.0113	0.0007
15	2700	960	0.00	43,249	3.98	11.32	0.0113	0.0007
16	2950	960	0.00	43,483	3.99	11.34	0.0113	0.0007
17	3200	960	0.00	43,717	4.01	11.37	0.0112	0.0007
18	3450	960	0.00	43,951	4.02	11.39	0.0112	0.0007
19	3700	960	0.00	44,185	4.04	11.40	0.0112	0.0007
20	3950	960	0.00	44,414	4.12	11.22	0.0111	0.0007
21	4200	960	0.00	44,630	7.13	6.52	0.0093	0.0001

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

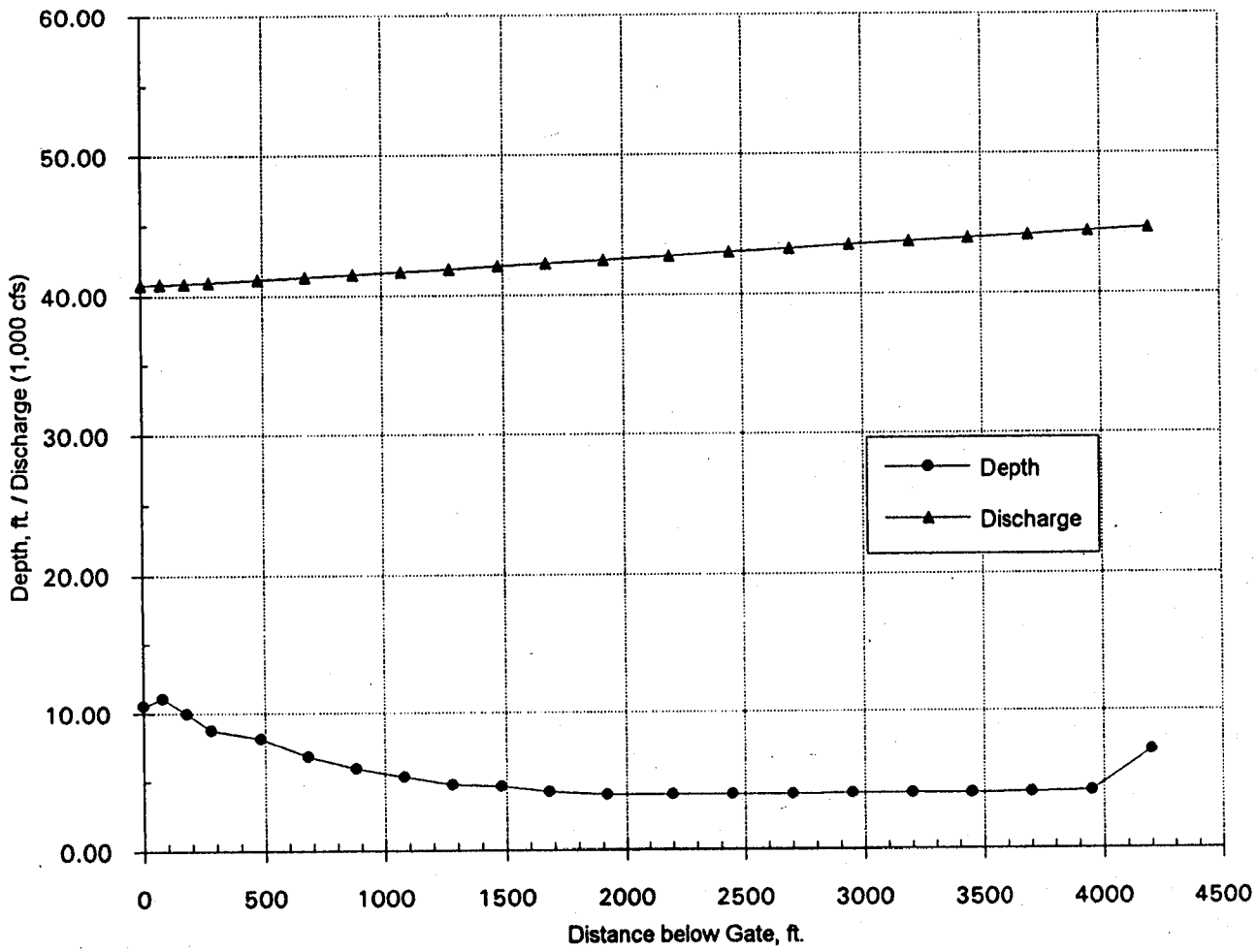
Template by: George K. Cotton, PE

Last revised: 7/21/94

			12
Release Volume:	0.19	acre-ft.	2,234.79
New Volume:	2,649.16	acre-ft.	2,692.99
Reservoir Stage:	1,147.81	ft.	1,146.00
Next Time Step =	2501		1,148.00
Cumulative time =	500.2	sec	1,147.81

Sx		Diffusion Calc.				Raw Values		Plotted Values	
(ft./ft.)	Kx	q	dh	Vel	Fr	Discharge	Depth	Q(n+1)	y(n+1)
0.0081	2.38E+04	194	-5.40E-04	18.42	1.00	40,771	10.54	40.771	10.54
0.0082	2.59E+04	177	-5.70E-04	16.02	0.85	40,824	11.08	40.824	11.08
0.0083	2.14E+04	149	-5.10E-04	14.95	0.84	40,895	9.95	40.895	9.95
0.0086	1.71E+04	126	-4.50E-04	14.38	0.86	40,969	8.77	40.969	8.77
0.0090	1.47E+04	103	-4.10E-04	12.66	0.78	41,135	8.12	41.135	8.12
0.0094	1.07E+04	83	-3.50E-04	12.12	0.82	41,309	6.82	41.309	6.82
0.0099	8.29E+03	69	-3.00E-04	11.68	0.85	41,492	5.92	41.492	5.92
0.0103	6.69E+03	60	-2.70E-04	11.30	0.87	41,677	5.27	41.677	5.27
0.0106	5.45E+03	54	-2.40E-04	11.49	0.93	41,865	4.70	41.865	4.70
0.0108	5.14E+03	49	-2.40E-04	10.83	0.89	42,064	4.57	42.064	4.57
0.0111	4.38E+03	45	-2.10E-04	10.87	0.94	42,264	4.18	42.264	4.18
0.0112	3.94E+03	44	-1.90E-04	11.23	1.00	42,489	3.94	42.489	3.94
0.0113	3.94E+03	45	-2.00E-04	11.28	1.00	42,758	3.95	42.758	3.95
0.0113	3.97E+03	45	-2.00E-04	11.30	1.00	43,002	3.96	43.002	3.96
0.0113	4.00E+03	45	-2.00E-04	11.32	1.00	43,245	3.98	43.245	3.98
0.0113	4.02E+03	45	-2.00E-04	11.34	1.00	43,480	3.99	43.480	3.99
0.0112	4.05E+03	46	-2.00E-04	11.36	1.00	43,714	4.01	43.714	4.01
0.0112	4.07E+03	46	-2.00E-04	11.38	1.00	43,948	4.02	43.948	4.02
0.0112	4.11E+03	46	-2.00E-04	11.40	1.00	44,182	4.04	44.182	4.04
0.0105	4.39E+03	46	-1.90E-04	11.22	0.97	44,411	4.12	44.411	4.12
0.0017	2.71E+04	46	-1.80E-04	6.52	0.43	44,628	7.13	44.628	7.13

Depth Profiles -- Town Lake, Sudden Gate Release



Appendix B

Case Two
Near Bank Gate Failure
3000 ft. Downstream Diffusion Length

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last run: 8/19/94 2:32 PM

Data:				**Reservoir:**	49,536 cfs (init.)
Location:	Salt River -- Town Lake, Tempe, Arizona				3,165.59 ac-ft (init)
Init. Pool Elev.. =	1150 msl	dt =	0.2 sec	Volume =	3,154.24 ac-ft.
Gate Base Elev.. =	1132 msl	dx =	varies	Stage =	1149.952 ft.
Channel Slope =	0.1717%	units:	US Customary	Time Step =	50
Manning Coef. =	0.035			t =	10.0 sec

Section Number	Cum.Length (ft.)	Width (ft.)	Invert Elev.. (msl)	Discharge (cfs)	Depth (ft.)	Velocity (fps)	Sc (ft./ft.)	Sf (ft./ft.)
1	0	210	1132.00	49,338	11.97	19.63	0.0078	0.0078
2	100	235	1129.23	42,717	10.86	17.69	0.0081	0.0065
3	300	285	1128.88	11,751	4.20	10.76	0.0111	0.0079
4	500	335	1128.54	745	0.54	4.49	0.0220	0.0220
5	700	385	1128.20	3	0.02	0.42	0.0700	0.0206
6	900	435	1127.85	0	0.00	0.02	0.8293	0.8307
7	1100	485	1127.51	0	0.00	0.00	0.0017	0.0017
8	1300	535	1127.17	0	0.00	0.00	0.0017	0.0017
9	1500	585	1126.82	0	0.00	0.00	0.0017	0.0017
10	1700	635	1126.48	0	0.00	0.00	0.0017	0.0017
11	1900	685	1126.14	0	0.00	0.00	0.0017	0.0017
12	2100	735	1125.79	0	0.00	0.00	0.0017	0.0017
13	2300	785	1125.45	0	0.00	0.00	0.0017	0.0017
14	2500	835	1125.11	0	0.00	0.00	0.0017	0.0017
15	2750	897.5	1124.68	0	0.00	0.00	0.0017	0.0017
16	3000	960	1124.25	0	0.00	0.00	0.0017	0.0017
17	3200	960	1123.91	0	0.00	0.00	0.0017	0.0017
18	3450	960	1123.48	0	0.00	0.00	0.0017	0.0017
19	3700	960	1123.05	0	0.00	0.00	0.0017	0.0017
20	3950	960	1122.62	0	0.00	0.00	0.0017	0.0017
21	4200	960	1122.19	0	0.00	0.00	0.0017	0.0017

Computational Method

Rapid Gate Opening Condition

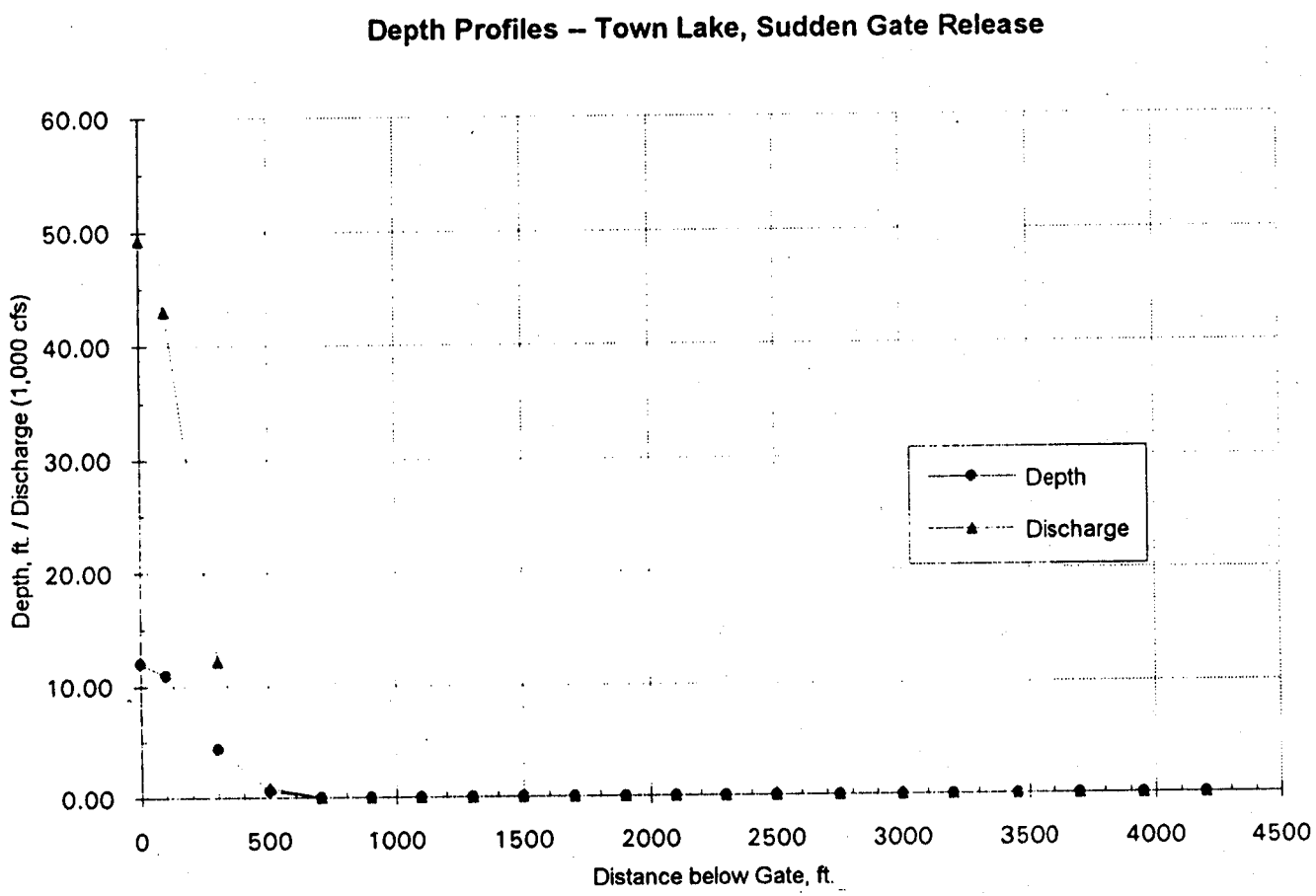
Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last.revised: 8/19/94

			13
Release Volume:	0.23	acre-ft.	2,692.99
New Volume:	3,154.01	acre-ft.	3,165.59
Reservoir Stage:	1,149.95	ft.	1,148.00
Next Time Step =	51		1,150.00
Cumulative time =	10.2	sec	1,149.95

Sx		Diffusion Calc.				Raw Values		Plotted Values	
(ft./ft.)	Kx	q	dh	Vel	Fr	Discharge	Depth	Q(n+1)	y(n+1)
0.0078	3.01E+04	235	-6.40E-04	19.63	1.00	49,334	11.97	49.334	11.97
0.0090	2.41E+04	193	5.95E-02	17.71	0.94	43,011	10.92	43.011	10.92
0.0137	4.16E+03	47	1.19E-01	10.88	0.92	12,221	4.32	12.221	4.32
0.0344	9.00E+01	3	3.55E-02	4.61	1.07	815	0.57	0.815	0.57
0.3071	1.00E-01	0	2.06E-03	1.43	1.85	10	0.02	0.010	0.02
0.3003	0.00E+00	0	1.00E-05	0.00	0.00	0	0.00	0.000	0.00
0.2776	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00


Depth Profiles -- Town Lake, Sudden Gate Release
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Depth, ft. / Discharge (1,000 cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Distance below Gate, ft.
Depth
Discharge

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last run: 8/19/94 2:46 PM

Data:

Location: Salt River -- Town Lake, Tempe, Arizona

Init. Pool Elev.. =	1150 msl	dt =	0.2 sec	Volume =	3,142.94 ac-ft.
Gate Base Elev.. =	1132 msl	dx =	varies	Stage =	1149.9041 ft.
Channel Slope =	0.1717%	units:	US Customary	Time Step =	100
Manning Coef. =	0.035			t =	20.0 sec

Reservoir: 49,536 cfs (init.)
3,165.59 ac-ft (init)

Section Number	Cum.Length (ft.)	Width (ft.)	Invert Elev.. (msl)	Discharge (cfs)	Depth (ft.)	Velocity (fps)	Sc (ft./ft.)	Sf (ft./ft.)
1	0	210	1132.00	49,141	11.94	19.60	0.0078	0.0078
2	100	235	1129.23	48,349	12.08	17.99	0.0078	0.0058
3	300	285	1128.88	32,912	8.75	14.46	0.0087	0.0054
4	500	335	1128.54	10,638	3.49	9.83	0.0118	0.0087
5	700	385	1128.20	1,018	0.61	4.64	0.0211	0.0202
6	900	435	1127.85	17	0.03	1.34	0.0569	0.0915
7	1100	485	1127.51	0	0.00	0.08	0.3055	0.3060
8	1300	535	1127.17	0	0.00	0.00	0.0017	0.0017
9	1500	585	1126.82	0	0.00	0.00	0.0017	0.0017
10	1700	635	1126.48	0	0.00	0.00	0.0017	0.0017
11	1900	685	1126.14	0	0.00	0.00	0.0017	0.0017
12	2100	735	1125.79	0	0.00	0.00	0.0017	0.0017
13	2300	785	1125.45	0	0.00	0.00	0.0017	0.0017
14	2500	835	1125.11	0	0.00	0.00	0.0017	0.0017
15	2750	897.5	1124.68	0	0.00	0.00	0.0017	0.0017
16	3000	960	1124.25	0	0.00	0.00	0.0017	0.0017
17	3200	960	1123.91	0	0.00	0.00	0.0017	0.0017
18	3450	960	1123.48	0	0.00	0.00	0.0017	0.0017
19	3700	960	1123.05	0	0.00	0.00	0.0017	0.0017
20	3950	960	1122.62	0	0.00	0.00	0.0017	0.0017
21	4200	960	1122.19	0	0.00	0.00	0.0017	0.0017

Computational Method

Rapid Gate Opening Condition

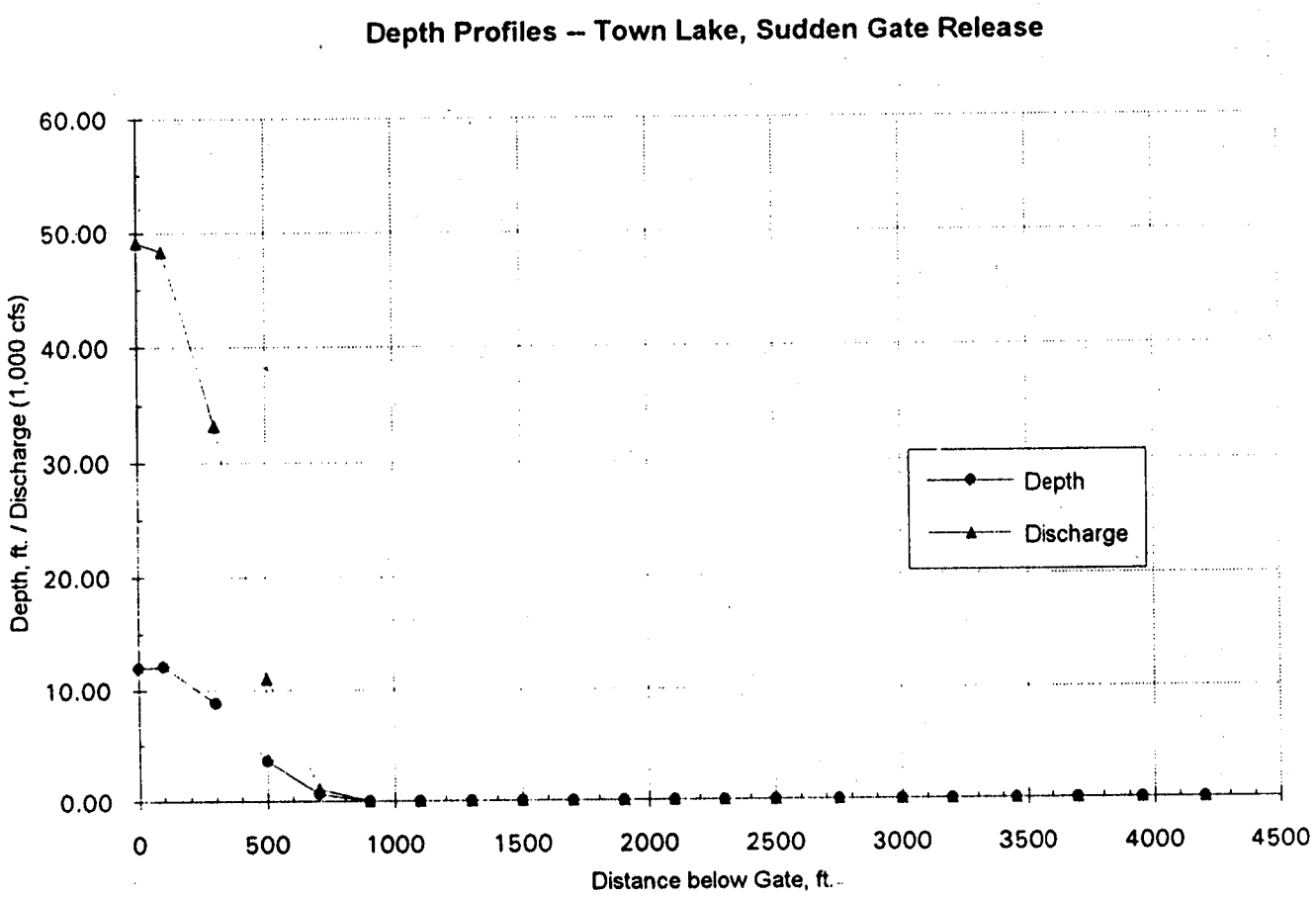
Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last revised: 8/19/94

			13
Release Volume:	0.23	acre-ft.	2,692.99
New Volume:	3,142.71	acre-ft.	3,165.59
Reservoir Stage:	1,149.90	ft.	1,148.00
Next Time Step =	101		1,150.00
Cumulative time =	20.2	sec	1,149.90

Sx		Diffusion Calc.				Raw Values		Plotted Values	
(ft./ft.)	Kx	q	dh	Vel	Fr	Discharge	Depth	Q(n+1)	y(n+1)
0.0078	3.00E+04	234	-6.40E-04	19.60	1.00	49,137	11.94	49.137	11.94
0.0081	3.01E+04	217	7.11E-03	17.99	0.91	48,375	12.09	48.375	12.09
0.0094	1.65E+04	128	5.94E-02	14.50	0.86	33,224	8.81	33.224	8.81
0.0138	3.00E+03	35	7.19E-02	9.92	0.93	10,952	3.56	10.952	3.56
0.0299	1.15E+02	3	2.67E-02	4.73	1.04	1,082	0.64	1.082	0.64
0.1278	4.10E-01	0	2.44E-03	1.39	1.34	19	0.03	0.019	0.03
0.1214	0.00E+00	0	4.00E-05	0.00	0.00	0	0.00	0.000	0.00
0.1030	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00


Depth Profiles -- Town Lake, Sudden Gate Release
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Depth, ft. / Discharge (1,000 cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Distance below Gate, ft.
Depth
Discharge

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last run: 8/19/94 2:49 PM

Data:

Location: Salt River -- Town Lake, Tempe, Arizona

Init. Pool Elev.. =	1150 msl	dt =	0.2 sec	Volume =	3,109.30 ac-ft.
Gate Base Elev.. =	1132 msl	dx =	varies	Stage =	1149.7618 ft.
Channel Slope =	0.1717%	units: US Customary		Time Step =	250
Manning Coef. =	0.035			t =	50.0 sec

Reservoir:

49,536	cfs (init.)
3,165.59	ac-ft (init)

Section Number	Cum.Length (ft.)	Width (ft.)	Invert Elev.. (msl)	Discharge (cfs)	Depth (ft.)	Velocity (fps)	Sc (ft./ft.)	Sf (ft./ft.)
1	0	210	1132.00	48,556	11.84	19.53	0.0078	0.0078
2	100	235	1129.23	48,610	12.24	17.85	0.0078	0.0056
3	300	285	1128.88	48,055	11.53	16.03	0.0079	0.0045
4	500	335	1128.54	44,568	9.55	15.05	0.0084	0.0053
5	700	385	1128.20	34,365	7.11	13.43	0.0093	0.0064
6	900	435	1127.85	17,508	4.04	10.57	0.0112	0.0085
7	1100	485	1127.51	4,081	1.36	6.55	0.0161	0.0143
8	1300	535	1127.17	265	0.19	2.76	0.0312	0.0356
9	1500	585	1126.82	1	0.01	0.28	0.0933	0.0294
10	1700	635	1126.48	0	0.00	0.00	0.0017	0.0017
11	1900	685	1126.14	0	0.00	0.00	0.0017	0.0017
12	2100	735	1125.79	0	0.00	0.00	0.0017	0.0017
13	2300	785	1125.45	0	0.00	0.00	0.0017	0.0017
14	2500	835	1125.11	0	0.00	0.00	0.0017	0.0017
15	2750	897.5	1124.68	0	0.00	0.00	0.0017	0.0017
16	3000	960	1124.25	0	0.00	0.00	0.0017	0.0017
17	3200	960	1123.91	0	0.00	0.00	0.0017	0.0017
18	3450	960	1123.48	0	0.00	0.00	0.0017	0.0017
19	3700	960	1123.05	0	0.00	0.00	0.0017	0.0017
20	3950	960	1122.62	0	0.00	0.00	0.0017	0.0017
21	4200	960	1122.19	0	0.00	0.00	0.0017	0.0017

Computational Method

Rapid Gate Opening Condition

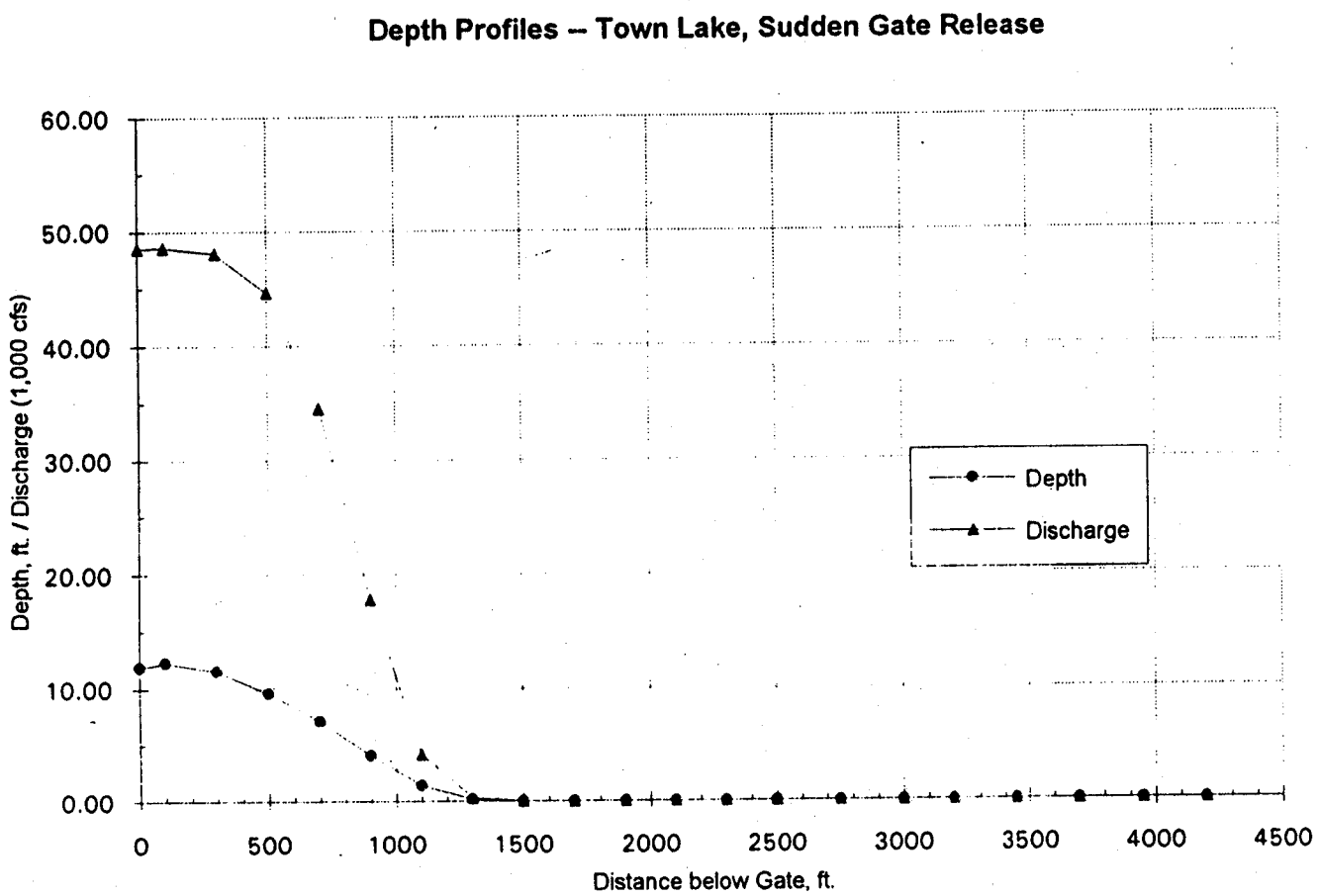
Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last revised: 8/19/94

			13
Release Volume:	0.22	acre-ft.	2,692.99
New Volume:	3,109.08	acre-ft.	3,165.59
Reservoir Stage:	1,149.76	ft.	1,148.00
Next Time Step =	251		1,150.00
Cumulative time =	50.2	sec	1,149.76

Sx		Diffusion Calc.				Raw Values		Plotted Values	
(ft./ft.)	Kx	q	dh	Vel	Fr	Discharge	Depth	Q(n+1)	y(n+1)
0.0078	2.95E+04	231	-6.30E-04	19.53	1.00	48,552	11.84	48.552	11.84
0.0078	3.12E+04	218	-4.90E-04	17.85	0.90	48,606	12.24	48.606	12.24
0.0080	2.79E+04	185	2.13E-03	16.03	0.83	48,066	11.54	48.066	11.54
0.0085	1.98E+04	144	1.13E-02	15.05	0.86	44,641	9.57	44.641	9.57
0.0096	1.14E+04	96	2.83E-02	13.45	0.89	34,561	7.14	34.561	7.14
0.0122	4.01E+03	43	4.11E-02	10.61	0.93	17,765	4.08	17.765	4.08
0.0195	5.23E+02	9	2.92E-02	6.61	0.99	4,208	1.38	4.208	1.38
0.0469	1.30E+01	1	7.48E-03	2.81	1.12	281	0.20	0.281	0.20
0.0420	6.00E-02	0	4.70E-04	0.31	0.63	1	0.01	0.001	0.01
0.0322	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00


Depth Profiles -- Town Lake, Sudden Gate Release
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Depth, ft. / Discharge (1,000 cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Distance below Gate, ft.
Depth
Discharge

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last run: 8/19/94 2:52 PM

Data:

Location: Salt River -- Town Lake, Tempe, Arizona

Init. Pool Elev.. =	1150 msl	dt =	0.2 sec	Volume =	3,054.12 ac-ft.
Gate Base Elev.. =	1132 msl	dx =	varies	Stage =	1149.5282 ft.
Channel Slope =	0.1717%	units:	US Customary	Time Step =	500
Manning Coef. =	0.035			t =	100.0 sec

Reservoir: 49,536 cfs (init.)
3,165.59 ac-ft (init)

Section Number	Cum.Length (ft.)	Width (ft.)	Invert Elev.. (msl)	Discharge (cfs)	Depth (ft.)	Velocity (fps)	Sc (ft./ft.)	Sf (ft./ft.)
1	0	210	1132.00	47,601	11.69	19.40	0.0079	0.0079
2	100	235	1129.23	47,672	12.09	17.73	0.0078	0.0056
3	300	285	1128.88	47,824	11.52	15.97	0.0079	0.0045
4	500	335	1128.54	47,947	10.09	15.33	0.0083	0.0051
5	700	385	1128.20	47,900	8.98	14.81	0.0086	0.0057
6	900	435	1127.85	47,212	8.06	14.29	0.0089	0.0062
7	1100	485	1127.51	44,657	7.12	13.64	0.0093	0.0068
8	1300	535	1127.17	37,947	5.89	12.63	0.0099	0.0076
9	1500	585	1126.82	25,205	4.15	10.85	0.0111	0.0090
10	1700	635	1126.48	10,110	2.08	7.98	0.0140	0.0123
11	1900	685	1126.14	1,636	0.56	4.45	0.0217	0.0222
12	2100	735	1125.79	64	0.06	1.63	0.0469	0.0652
13	2300	785	1125.45	0	0.00	0.20	0.1691	0.1694
14	2500	835	1125.11	0	0.00	0.00	0.0017	0.0017
15	2750	897.5	1124.68	0	0.00	0.00	0.0017	0.0017
16	3000	960	1124.25	0	0.00	0.00	0.0017	0.0017
17	3200	960	1123.91	0	0.00	0.00	0.0017	0.0017
18	3450	960	1123.48	0	0.00	0.00	0.0017	0.0017
19	3700	960	1123.05	0	0.00	0.00	0.0017	0.0017
20	3950	960	1122.62	0	0.00	0.00	0.0017	0.0017
21	4200	960	1122.19	0	0.00	0.00	0.0017	0.0017

Computational Method

Rapid Gate Opening Condition

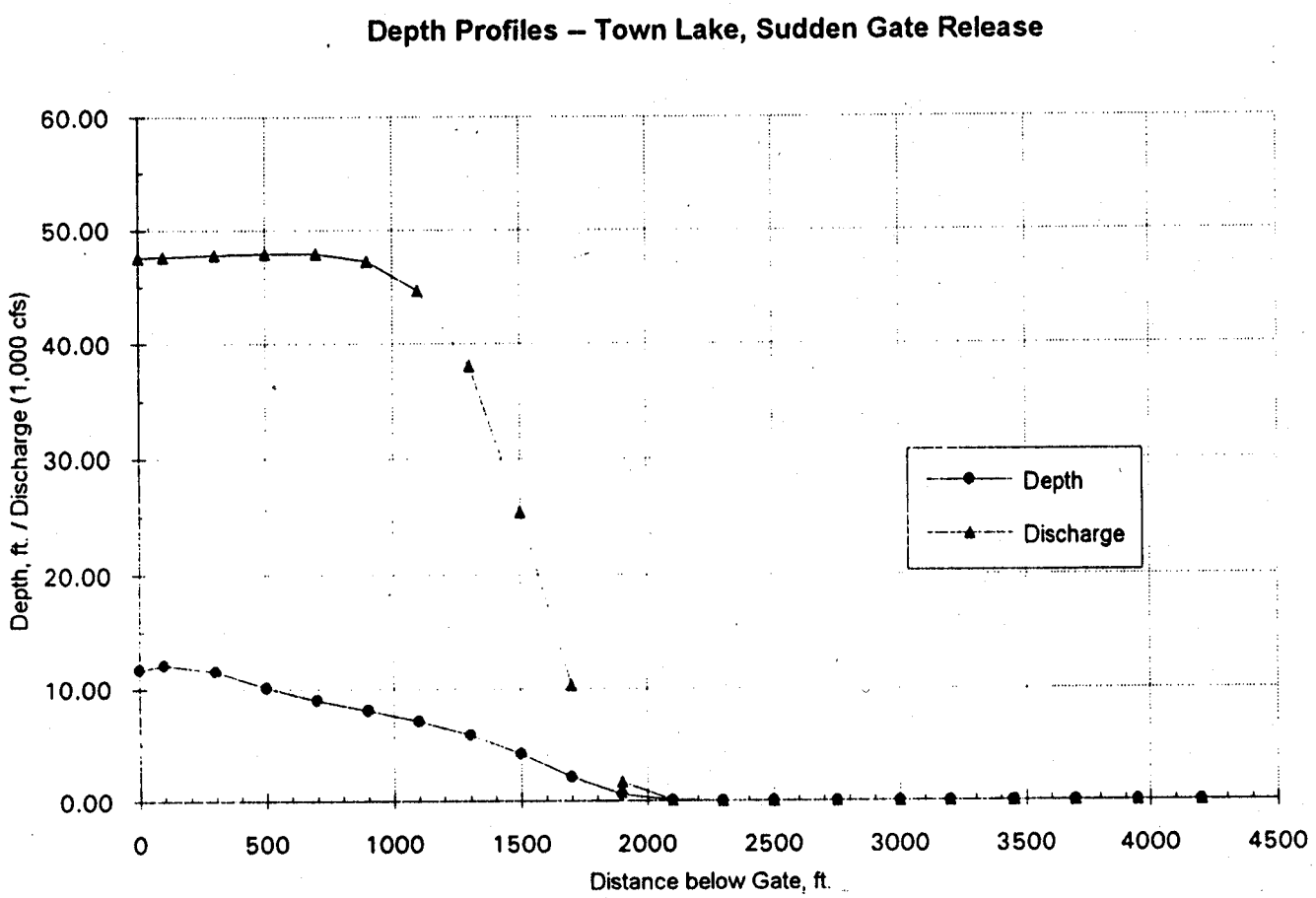
Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last revised: 8/19/94

			13
Release Volume:	0.22	acre-ft.	2,692.99
New Volume:	3,053.90	acre-ft.	3,165.59
Reservoir Stage:	1,149.53	ft.	1,148.00
Next Time Step =	501		1,150.00
Cumulative time =	100.2	sec	1,149.53

Sx		Diffusion Calc.				Raw Values		Plotted Values	
(ft./ft.)	Kx	q	dh	Vel	Fr	Discharge	Depth	Q(n+1)	y(n+1)
0.0079	2.88E+04	227	-6.20E-04	19.40	1.00	47,597	11.68	47.597	11.68
0.0079	3.05E+04	214	-6.40E-04	17.73	0.90	47,668	12.09	47.668	12.09
0.0080	2.79E+04	184	-5.90E-04	15.97	0.83	47,821	11.52	47.821	11.52
0.0083	2.20E+04	155	-4.00E-04	15.33	0.85	47,944	10.09	47.944	10.09
0.0086	1.78E+04	133	1.30E-04	14.81	0.87	47,901	8.98	47.901	8.98
0.0089	1.46E+04	115	1.68E-03	14.29	0.89	47,226	8.06	47.226	8.06
0.0094	1.16E+04	97	5.55E-03	13.65	0.90	44,707	7.12	44.707	7.12
0.0101	8.15E+03	75	1.32E-02	12.64	0.92	38,069	5.90	38.069	5.90
0.0117	4.25E+03	45	2.28E-02	10.88	0.94	25,405	4.17	25.405	4.17
0.0156	1.17E+03	17	2.48E-02	8.02	0.97	10,285	2.10	10.285	2.10
0.0276	1.00E+02	3	1.28E-02	4.49	1.05	1,691	0.57	1.691	0.57
0.0792	1.29E+00	0	2.22E-03	1.66	1.22	68	0.06	0.068	0.06
0.0726	0.00E+00	0	8.00E-05	0.00	0.00	0	0.00	0.000	0.00
0.0575	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00


Depth Profiles – Town Lake, Sudden Gate Release
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Depth, ft. / Discharge (1,000 cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Distance below Gate, ft.
Depth
Discharge

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last run: 8/19/94 3:00 PM

Data:				**Reservoir:**		
Location:	Salt River -- Town Lake, Tempe, Arizona				49,536	cfs (init.)
					3,165.59	ac-ft (init)
Init. Pool Elev.. =	1150 msl	dt =	0.2 sec	Volume =	2,946.97	ac-ft.
Gate Base Elev.. =	1132 msl	dx =	varies	Stage =	1149.0748	ft.
Channel Slope =	0.1717%	units:	US Customary	Time Step =	1000	
Manning Coef. =	0.035			t =	200.0	sec

Section Number	Cum.Length (ft.)	Width (ft.)	Invert Elev.. (msl)	Discharge (cfs)	Depth (ft.)	Velocity (fps)	Sc (ft./ft.)	Sf (ft./ft.)
1	0	210	1132.00	45,766	11.38	19.15	0.0079	0.0079
2	100	235	1129.23	45,834	11.77	17.50	0.0079	0.0057
3	300	285	1128.88	45,987	11.22	15.76	0.0080	0.0046
4	500	335	1128.54	46,146	9.83	15.14	0.0083	0.0052
5	700	385	1128.20	46,310	8.79	14.64	0.0087	0.0057
6	900	435	1127.85	46,480	7.99	14.20	0.0089	0.0062
7	1100	485	1127.51	46,652	7.35	13.80	0.0092	0.0067
8	1300	535	1127.17	46,825	6.83	13.45	0.0094	0.0070
9	1500	585	1126.82	46,981	6.39	13.13	0.0096	0.0074
10	1700	635	1126.48	47,064	6.01	12.83	0.0098	0.0077
11	1900	685	1126.14	46,916	5.67	12.54	0.0100	0.0080
12	2100	735	1125.79	46,121	5.32	12.22	0.0102	0.0083
13	2300	785	1125.45	43,730	4.88	11.79	0.0105	0.0087
14	2500	835	1125.11	37,969	4.22	11.11	0.0111	0.0095
15	2750	897.5	1124.68	23,702	2.93	9.33	0.0125	0.0107
16	3000	960	1124.25	8,147	1.35	6.49	0.0162	0.0146
17	3200	960	1123.91	1,433	0.38	3.96	0.0247	0.0319
18	3450	960	1123.48	49	0.04	1.42	0.0541	0.0946
19	3700	960	1123.05	0	0.00	0.15	0.2052	0.2056
20	3950	960	1122.62	0	0.00	0.00	0.0017	0.0017
21	4200	960	1122.19	0	0.00	0.00	0.0017	0.0017

Computational Method

Rapid Gate Opening Condition

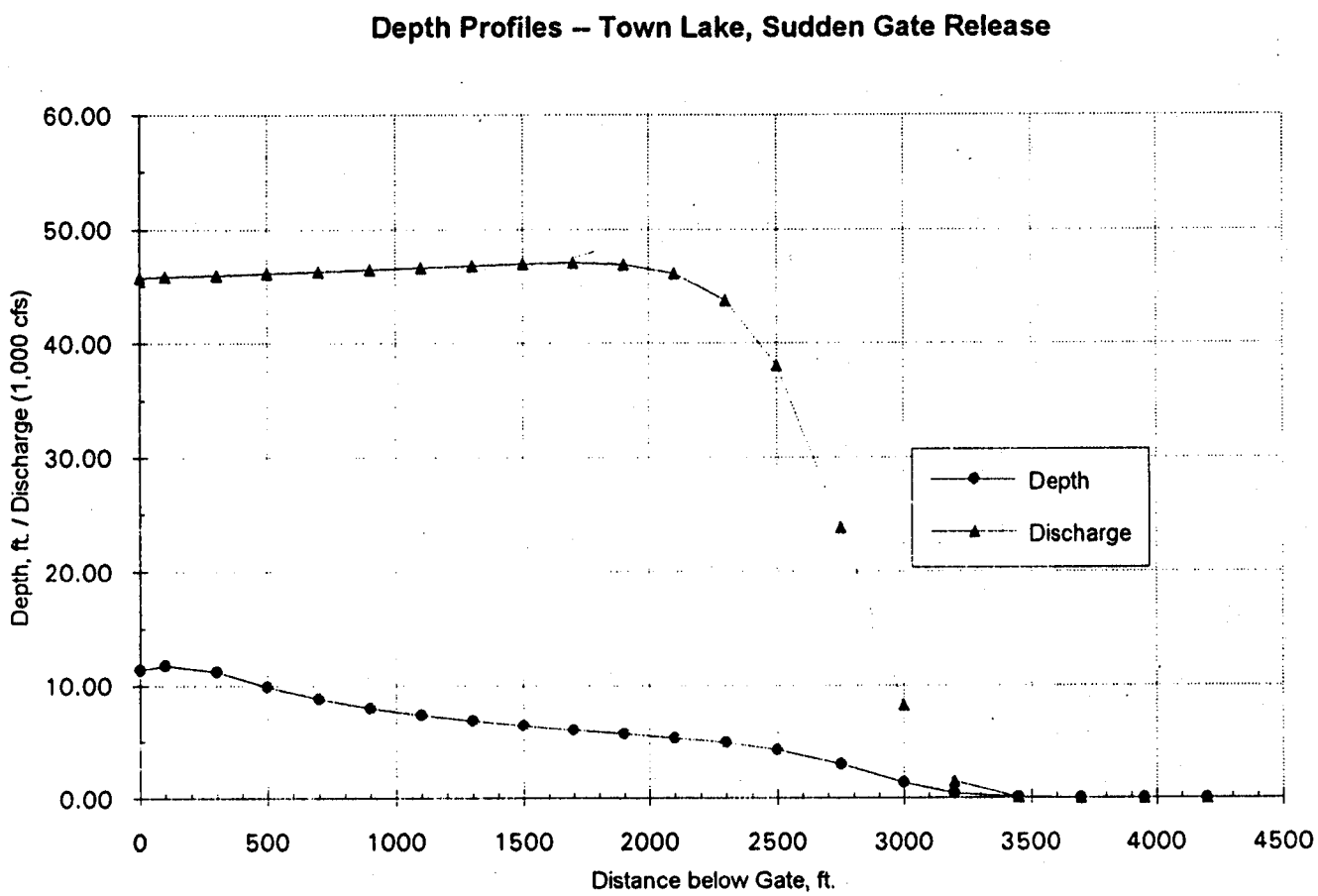
Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last revised: 8/19/94

			13
Release Volume:	0.21	acre-ft.	2,692.99
New Volume:	2,946.76	acre-ft.	3,165.59
Reservoir Stage:	1,149.07	ft.	1,148.00
Next Time Step =	1001		1,150.00
Cumulative time =	200.2	sec	1,149.07

Sx		Diffusion Calc.				Raw Values		Plotted Values	
(ft./ft.)	Kx	q	dh	Vel	Fr	Discharge	Depth	Q(n+1)	y(n+1)
0.0079	2.75E+04	218	-5.90E-04	19.14	1.00	45,762	11.38	45.762	11.38
0.0079	2.91E+04	206	-6.10E-04	17.49	0.90	45,831	11.77	45.831	11.77
0.0081	2.66E+04	177	-5.80E-04	15.76	0.83	45,983	11.22	45.983	11.22
0.0083	2.10E+04	149	-5.10E-04	15.14	0.85	46,142	9.83	46.142	9.83
0.0086	1.71E+04	129	-4.50E-04	14.64	0.87	46,306	8.79	46.306	8.79
0.0089	1.43E+04	113	-4.10E-04	14.20	0.89	46,476	7.99	46.476	7.99
0.0092	1.23E+04	101	-3.70E-04	13.80	0.90	46,649	7.35	46.649	7.35
0.0094	1.08E+04	92	-3.40E-04	13.45	0.91	46,822	6.83	46.822	6.83
0.0096	9.53E+03	84	-2.80E-04	13.13	0.91	46,978	6.39	46.978	6.39
0.0098	8.52E+03	77	-1.40E-04	12.83	0.92	47,063	6.01	47.063	6.01
0.0100	7.65E+03	71	2.30E-04	12.54	0.93	46,918	5.67	46.918	5.67
0.0103	6.79E+03	65	1.12E-03	12.22	0.93	46,135	5.32	46.135	5.32
0.0106	5.80E+03	58	3.15E-03	11.79	0.94	43,771	4.88	43.771	4.88
0.0114	4.40E+03	47	7.11E-03	11.12	0.95	38,061	4.22	38.061	4.22
0.0132	2.24E+03	28	1.32E-02	9.34	0.96	23,857	2.95	23.857	2.95
0.0178	5.35E+02	9	1.34E-02	6.52	0.98	8,265	1.37	8.265	1.37
0.0317	4.84E+01	2	6.99E-03	3.99	1.13	1,472	0.38	1.472	0.38
0.0947	5.70E-01	0	1.15E-03	1.46	1.33	52	0.04	0.052	0.04
0.0870	0.00E+00	0	4.00E-05	0.00	0.00	0	0.00	0.000	0.00
0.0695	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00
0.0017	0.00E+00	0	0.00E+00	0.00	0.00	0	0.00	0.000	0.00


Depth Profiles -- Town Lake, Sudden Gate Release
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Depth, ft. / Discharge (1,000 cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Distance below Gate, ft.
Depth
Discharge

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last run: 8/19/94 3:10 PM

Data:

Location: Salt River -- Town Lake, Tempe, Arizona

Init. Pool Elev.. =	1150 msl	dt =	0.2 sec	Volume =	2,783.98 ac-ft.
Gate Base Elev.. =	1132 msl	dx =	varies	Stage =	1148.3851 ft.
Channel Slope =	0.1717%	units:	US Customary	Time Step =	1800
Manning Coef. =	0.035			t =	360.0 sec

Reservoir: 49,536 cfs (init.)
3,165.59 ac-ft (init)

Section Number	Cum.Length (ft.)	Width (ft.)	Invert Elev.. (msl)	Discharge (cfs)	Depth (ft.)	Velocity (fps)	Sc (ft./ft.)	Sf (ft./ft.)
1	0	210	1132.00	43,021	10.92	18.75	0.0081	0.0081
2	100	235	1129.23	43,085	11.30	17.14	0.0080	0.0058
3	300	285	1128.88	43,229	10.77	15.44	0.0081	0.0046
4	500	335	1128.54	43,379	9.44	14.83	0.0085	0.0052
5	700	385	1128.20	43,535	8.43	14.34	0.0088	0.0058
6	900	435	1127.85	43,696	7.66	13.91	0.0091	0.0063
7	1100	485	1127.51	43,861	7.05	13.52	0.0093	0.0067
8	1300	535	1127.17	44,032	6.55	13.17	0.0095	0.0071
9	1500	585	1126.82	44,208	6.14	12.86	0.0098	0.0075
10	1700	635	1126.48	44,388	5.78	12.58	0.0100	0.0078
11	1900	685	1126.14	44,574	5.48	12.32	0.0101	0.0081
12	2100	735	1125.79	44,762	5.22	12.08	0.0103	0.0084
13	2300	785	1125.45	44,956	4.98	11.87	0.0105	0.0086
14	2500	835	1125.11	45,154	4.78	11.66	0.0106	0.0088
15	2750	897.5	1124.68	45,397	4.61	11.36	0.0107	0.0087
16	3000	960	1124.25	45,624	4.41	11.15	0.0109	0.0089
17	3200	960	1123.91	45,760	4.14	11.51	0.0111	0.0111
18	3450	960	1123.48	45,751	4.13	11.54	0.0111	0.0112
19	3700	960	1123.05	45,265	4.10	11.51	0.0112	0.0112
20	3950	960	1122.62	43,652	4.00	11.37	0.0113	0.0113
21	4200	960	1122.19	39,893	3.78	10.99	0.0115	0.0114

Computational Method

Rapid Gate Opening Condition

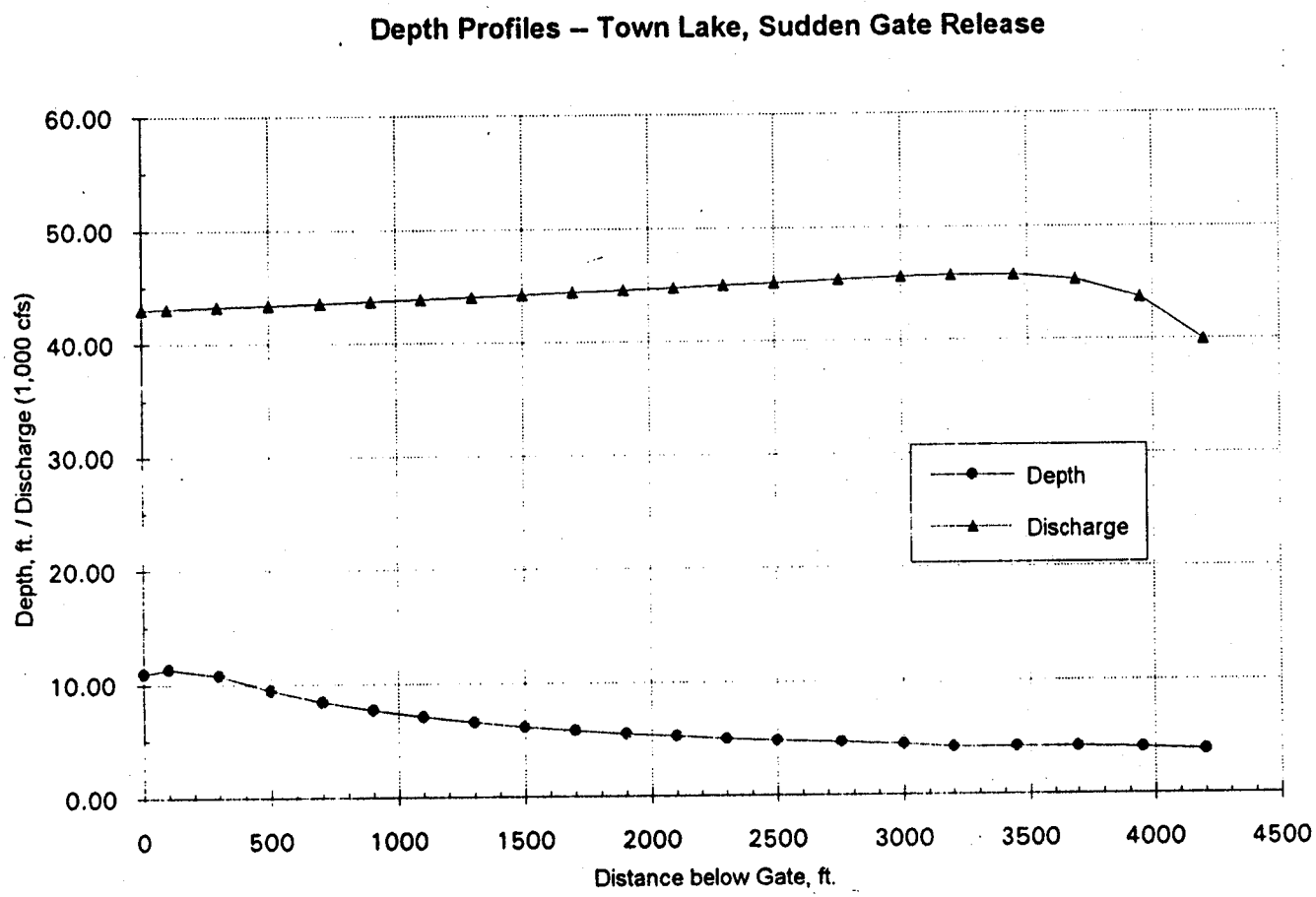
Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last revised: 8/19/94

			13
Release Volume:	0.20	acre-ft.	2,692.99
New Volume:	2,783.78	acre-ft.	3,165.59
Reservoir Stage:	1,148.38	ft.	1,148.00
Next Time Step =	1801		1,150.00
Cumulative time =	360.2	sec	1,148.38

Sx		Diffusion Calc.				Raw Values		Plotted Values	
(ft./ft.)	Kx	q	dh	Vel	Fr	Discharge	Depth	Q(n+1)	y(n+1)
0.0081	2.55E+04	205	-5.60E-04	18.75	1.00	43,018	10.92	43.018	10.92
0.0080	2.70E+04	194	-5.80E-04	17.14	0.90	43,082	11.30	43.082	11.30
0.0082	2.47E+04	166	-5.50E-04	15.44	0.83	43,226	10.77	43.226	10.77
0.0084	1.95E+04	140	-4.80E-04	14.83	0.85	43,376	9.44	43.376	9.44
0.0088	1.59E+04	121	-4.30E-04	14.34	0.87	43,531	8.43	43.531	8.43
0.0091	1.33E+04	107	-3.90E-04	13.91	0.89	43,693	7.66	43.693	7.66
0.0093	1.14E+04	95	-3.60E-04	13.52	0.90	43,858	7.05	43.858	7.05
0.0095	9.98E+03	86	-3.30E-04	13.17	0.91	44,029	6.55	44.029	6.55
0.0098	8.85E+03	79	-3.10E-04	12.86	0.91	44,205	6.14	44.205	6.14
0.0099	7.94E+03	73	-2.90E-04	12.58	0.92	44,385	5.78	44.385	5.78
0.0101	7.19E+03	68	-2.80E-04	12.32	0.93	44,570	5.48	44.570	5.48
0.0103	6.57E+03	63	-2.60E-04	12.08	0.93	44,759	5.22	44.759	5.22
0.0105	6.04E+03	59	-2.50E-04	11.87	0.94	44,952	4.98	44.952	4.98
0.0106	5.59E+03	56	-2.40E-04	11.66	0.94	45,150	4.78	45.150	4.78
0.0107	5.24E+03	52	-2.30E-04	11.36	0.93	45,394	4.61	45.394	4.61
0.0109	4.81E+03	49	-2.00E-04	11.15	0.94	45,621	4.41	45.621	4.41
0.0111	4.31E+03	48	-1.40E-04	11.51	1.00	45,757	4.14	45.757	4.14
0.0111	4.28E+03	48	1.00E-05	11.54	1.00	45,751	4.13	45.751	4.13
0.0112	4.22E+03	47	4.00E-04	11.51	1.00	45,272	4.10	45.272	4.10
0.0113	4.03E+03	45	1.34E-03	11.37	1.00	43,673	4.00	43.673	4.00
0.0114	3.66E+03	42	3.13E-03	11.00	1.00	39,944	3.78	39.944	3.78


Depth Profiles -- Town Lake, Sudden Gate Release
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Depth, ft. / Discharge (1,000 cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Distance below Gate, ft.
Depth
Discharge

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

Template by: George K. Cotton, PE

Last run: 8/19/94 3:19 PM

Data:

Location: Salt River -- Town Lake, Tempe, Arizona

Init. Pool Elev.. =	1150 msl	dt =	0.2 sec	Volume =	2,649.35 ac-ft.
Gate Base Elev.. =	1132 msl	dx =	varies	Stage =	1147.8095 ft.
Channel Slope =	0.1717%	units:	US Customary	Time Step =	2500
Manning Coef. =	0.035			t =	500.0 sec

Reservoir: 49,536 cfs (init.)
3,165.59 ac-ft (init)

Section Number	Cum.Length (ft.)	Width (ft.)	Invert Elev.. (msl)	Discharge (cfs)	Depth (ft.)	Velocity (fps)	Sc (ft./ft.)	Sf (ft./ft.)
1	0	210	1132.00	40,774	10.54	18.42	0.0081	0.0081
2	100	235	1129.23	40,837	10.90	16.83	0.0081	0.0058
3	300	285	1128.88	40,976	10.39	15.17	0.0082	0.0047
4	500	335	1128.54	41,121	9.11	14.57	0.0086	0.0053
5	700	385	1128.20	41,271	8.14	14.09	0.0089	0.0059
6	900	435	1127.85	41,424	7.40	13.66	0.0092	0.0064
7	1100	485	1127.51	41,583	6.81	13.28	0.0094	0.0068
8	1300	535	1127.17	41,749	6.33	12.94	0.0097	0.0072
9	1500	585	1126.82	41,920	5.92	12.64	0.0099	0.0076
10	1700	635	1126.48	42,093	5.58	12.36	0.0101	0.0079
11	1900	685	1126.14	42,268	5.29	12.10	0.0103	0.0082
12	2100	735	1125.79	42,449	5.04	11.87	0.0104	0.0085
13	2300	785	1125.45	42,635	4.81	11.66	0.0106	0.0087
14	2500	835	1125.11	42,825	4.61	11.46	0.0107	0.0089
15	2750	897.5	1124.68	43,068	4.46	11.16	0.0109	0.0088
16	3000	960	1124.25	43,317	4.26	10.96	0.0110	0.0090
17	3200	960	1123.91	43,506	4.00	11.32	0.0113	0.0112
18	3450	960	1123.48	43,745	4.01	11.37	0.0112	0.0113
19	3700	960	1123.05	43,979	4.02	11.39	0.0112	0.0112
20	3950	960	1122.62	44,213	4.04	11.41	0.0112	0.0112
21	4200	960	1122.19	44,447	4.05	11.43	0.0112	0.0112

Computational Method

Rapid Gate Opening Condition

Description: Solution of one-dimensional unsteady open channel flow downstream of an instantaneous opening of an in-channel gate . The numerical solution used is an explicit solution of the diffusion wave equation.

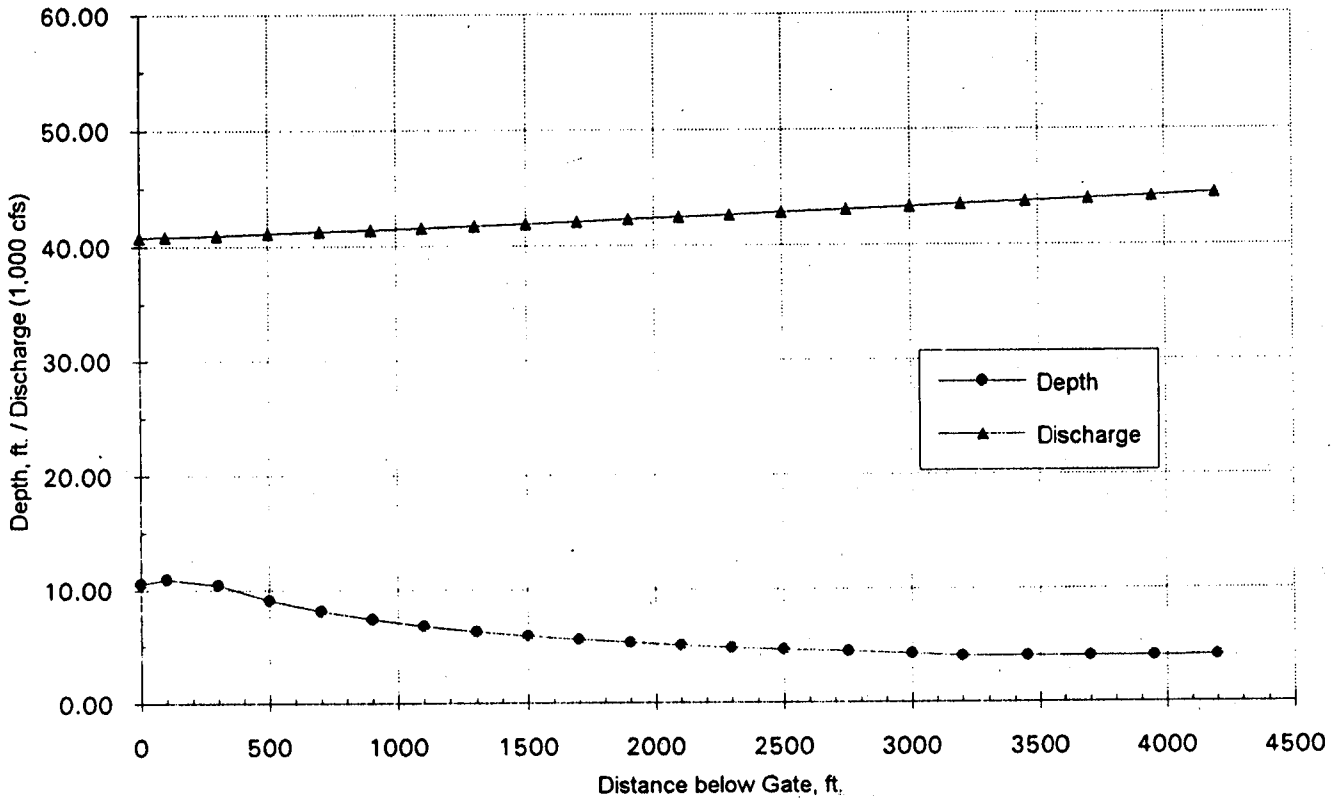
Template by: George K. Cotton, PE

Last revised: 8/19/94

			12
Release Volume:	0.19	acre-ft.	2,234.79
New Volume:	2,649.16	acre-ft.	2,692.99
Reservoir Stage:	1,147.81	ft.	1,146.00
Next Time Step =	2501		1,148.00
Cumulative time =	500.2	sec	1,147.81

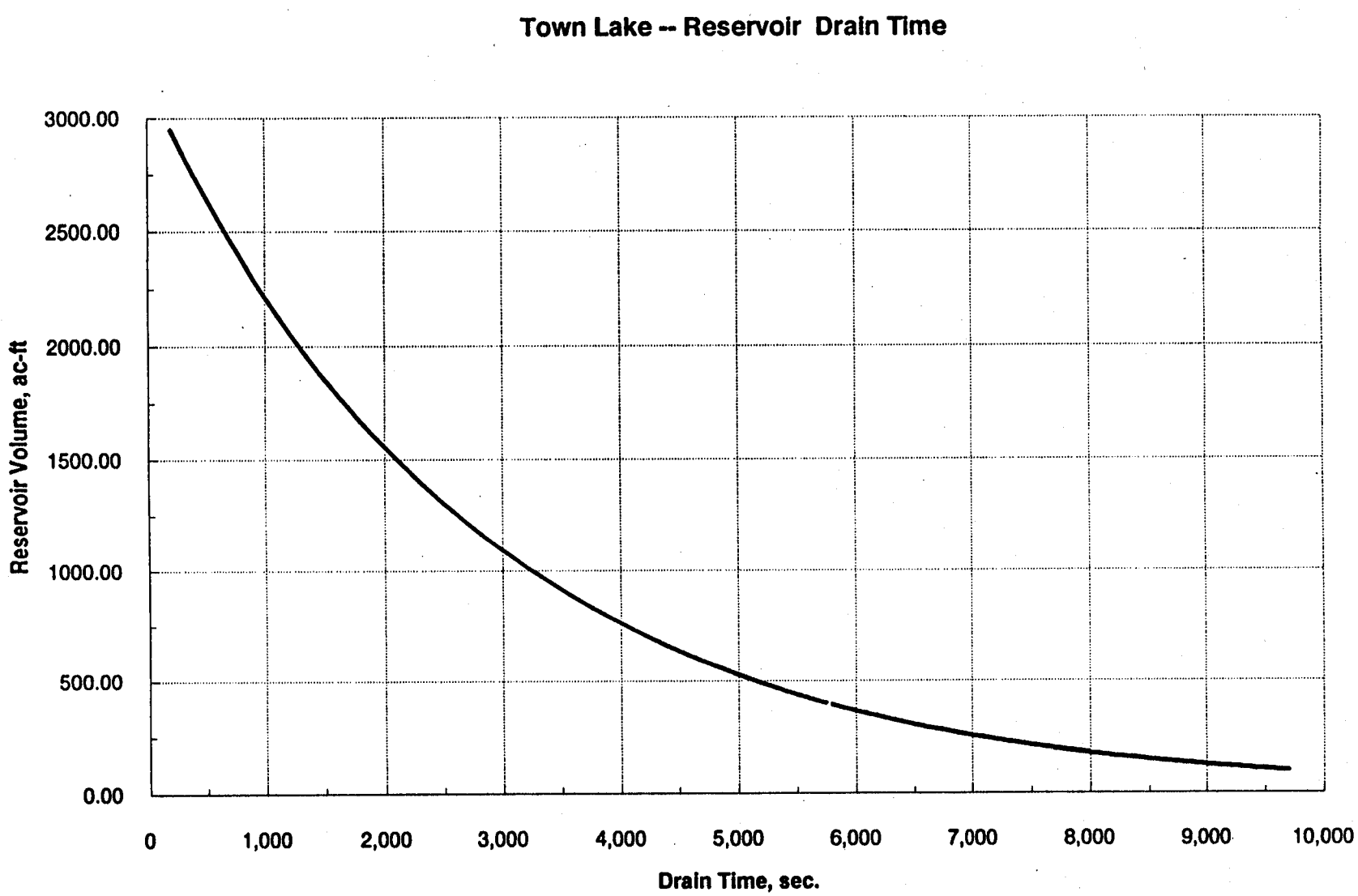
Sx		Diffusion Calc.				Raw Values		Plotted Values	
(ft./ft.)	Kx	q	dh	Vel	Fr	Discharge	Depth	Q(n+1)	y(n+1)
0.0081	2.38E+04	194	-5.40E-04	18.42	1.00	40,771	10.54	40.771	10.54
0.0081	2.53E+04	184	-5.60E-04	16.83	0.90	40,834	10.90	40.834	10.90
0.0083	2.31E+04	158	-5.30E-04	15.17	0.83	40,973	10.39	40.973	10.39
0.0085	1.83E+04	133	-4.70E-04	14.57	0.85	41,118	9.11	41.118	9.11
0.0089	1.49E+04	115	-4.10E-04	14.09	0.87	41,268	8.14	41.268	8.14
0.0092	1.25E+04	101	-3.80E-04	13.66	0.89	41,421	7.40	41.421	7.40
0.0094	1.07E+04	90	-3.40E-04	13.28	0.90	41,580	6.81	41.580	6.81
0.0097	9.35E+03	82	-3.20E-04	12.94	0.91	41,746	6.32	41.746	6.32
0.0099	8.29E+03	75	-3.00E-04	12.64	0.91	41,916	5.92	41.916	5.92
0.0101	7.44E+03	69	-2.80E-04	12.36	0.92	42,090	5.58	42.090	5.58
0.0102	6.74E+03	64	-2.60E-04	12.10	0.93	42,265	5.29	42.265	5.29
0.0104	6.16E+03	60	-2.50E-04	11.87	0.93	42,446	5.04	42.446	5.04
0.0106	5.66E+03	56	-2.40E-04	11.66	0.94	42,632	4.81	42.632	4.81
0.0107	5.24E+03	53	-2.30E-04	11.46	0.94	42,821	4.61	42.821	4.61
0.0109	4.92E+03	50	-2.20E-04	11.16	0.93	43,065	4.46	43.065	4.46
0.0110	4.52E+03	47	-2.10E-04	10.96	0.94	43,314	4.26	43.314	4.26
0.0112	4.06E+03	45	-2.00E-04	11.32	1.00	43,502	4.00	43.502	4.00
0.0112	4.05E+03	46	-2.00E-04	11.37	1.00	43,741	4.01	43.741	4.01
0.0112	4.08E+03	46	-2.00E-04	11.39	1.00	43,975	4.02	43.975	4.02
0.0112	4.10E+03	46	-2.00E-04	11.41	1.00	44,210	4.04	44.210	4.04
0.0112	4.13E+03	46	-2.00E-04	11.43	1.00	44,444	4.05	44.444	4.05

Depth Profiles -- Town Lake, Sudden Gate Release



Appendix C

Town Lake
Reservoir Drain-Time
Mode: One Gate Failure
Case: One and Two


Town Lake -- Reservoir Drain Time
Reservoir Volume, ac-ft
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Drain Time, sec.

Index	time sec	Q cfs	Volume ac-ft	Pool Elev. ft.	Percent Full
13	0	49,536	3165.59	1,150.00	100.00%
13	20	49,141	3142.94	1,149.90	99.28%
13	50	48,551	3109.03	1,149.76	98.21%
13	100	47,601	3054.12	1,149.53	96.48%
13	200	45,766	2946.97	1,149.07	93.09%
13	300	43,990	2841.91	1,148.63	89.77%
13	400	42,305	2740.92	1,148.20	86.58%
12	500	40,774	2649.35	1,147.81	83.69%
12	600	39,204	2555.74	1,147.40	80.74%
12	700	37,714	2465.74	1,147.01	77.89%
12	800	36,298	2379.17	1,146.63	75.16%
12	900	34,953	2295.84	1,146.27	72.52%
11	1,000	33,666	2215.60	1,145.91	69.99%
11	1,100	32,416	2138.31	1,145.57	67.55%
11	1,200	31,228	2063.89	1,145.23	65.20%
11	1,300	30,098	1992.20	1,144.91	62.93%
11	1,400	29,022	1923.11	1,144.60	60.75%
11	1,500	27,996	1856.48	1,144.30	58.65%
11	1,600	27,019	1792.21	1,144.02	56.62%
10	1,700	26,055	1730.19	1,143.73	54.66%
10	1,800	25,135	1670.37	1,143.45	52.77%
10	1,900	24,258	1612.67	1,143.18	50.94%
10	2,000	23,421	1556.98	1,142.92	49.18%
10	2,100	22,623	1503.21	1,142.67	47.49%
10	2,200	21,860	1451.28	1,142.43	45.85%
10	2,300	21,132	1401.10	1,142.20	44.26%
9	2,400	20,431	1352.58	1,141.97	42.73%
9	2,500	19,729	1305.68	1,141.74	41.25%
9	2,600	19,059	1260.39	1,141.52	39.82%
9	2,700	18,419	1216.64	1,141.31	38.43%
9	2,800	17,807	1174.35	1,141.10	37.10%
9	2,900	17,222	1133.47	1,140.90	35.81%
9	3,000	16,663	1093.94	1,140.71	34.56%
9	3,100	16,128	1055.68	1,140.52	33.35%
9	3,200	15,615	1018.66	1,140.34	32.18%
9	3,300	15,124	982.81	1,140.16	31.05%
8	3,400	14,652	948.09	1,139.99	29.95%
8	3,500	14,158	914.46	1,139.81	28.89%
8	3,600	13,687	881.95	1,139.64	27.86%
8	3,700	13,237	850.53	1,139.47	26.87%
8	3,800	12,806	820.14	1,139.30	25.91%
8	3,900	12,394	790.74	1,139.15	24.98%
7	4,000	11,997	762.29	1,138.99	24.08%
7	4,100	11,568	734.75	1,138.83	23.21%
7	4,200	11,160	708.19	1,138.66	22.37%

Index	time sec	Q cfs	Volume ac-ft	Pool Elev. ft.	Percent Full
7	4,300	10,771	682.57	1,138.51	21.56%
7	4,400	10,399	657.85	1,138.36	20.78%
7	4,500	10,045	633.97	1,138.21	20.03%
7	4,600	9,706	610.91	1,138.07	19.30%
6	4,700	9,362	588.63	1,137.93	18.59%
6	4,800	9,010	567.14	1,137.78	17.92%
6	4,900	8,676	546.46	1,137.63	17.26%
6	5,000	8,358	526.54	1,137.50	16.63%
6	5,100	8,055	507.35	1,137.36	16.03%
6	5,200	7,767	488.86	1,137.23	15.44%
6	5,300	7,493	471.03	1,137.11	14.88%
5	5,400	7,228	453.83	1,136.99	14.34%
5	5,500	6,944	437.24	1,136.86	13.81%
5	5,600	6,674	421.30	1,136.73	13.31%
5	5,700	6,419	405.97	1,136.61	12.82%
5	5,800	6,176	391.24	1,136.49	12.36%
5	5,900	5,945	377.06	1,136.38	11.91%
5	6,000	5,726	363.41	1,136.27	11.48%
5	6,100	5,518	350.27	1,136.17	11.06%
5	6,200	5,319	337.60	1,136.07	10.66%
4	6,300	5,122	325.39	1,135.97	10.28%
4	6,400	4,916	313.63	1,135.86	9.91%
4	6,500	4,721	302.35	1,135.76	9.55%
4	6,600	4,536	291.51	1,135.66	9.21%
4	6,700	4,360	281.10	1,135.56	8.88%
4	6,800	4,194	271.09	1,135.47	8.56%
4	6,900	4,036	261.46	1,135.38	8.26%
4	7,000	3,886	252.19	1,135.30	7.97%
4	7,100	3,743	243.27	1,135.22	7.68%
4	7,200	3,608	234.68	1,135.14	7.41%
4	7,300	3,478	226.40	1,135.06	7.15%
3	7,400	3,353	218.41	1,134.99	6.90%
3	7,500	3,213	210.71	1,134.91	6.66%
3	7,600	3,082	203.34	1,134.83	6.42%
3	7,700	2,957	196.26	1,134.75	6.20%
3	7,800	2,840	189.47	1,134.68	5.99%
3	7,900	2,728	182.95	1,134.61	5.78%
3	8,000	2,622	176.69	1,134.54	5.58%
3	8,100	2,522	170.67	1,134.47	5.39%
3	8,200	2,427	164.88	1,134.41	5.21%
3	8,300	2,336	159.31	1,134.35	5.03%
3	8,400	2,250	153.95	1,134.29	4.86%
3	8,500	2,168	148.78	1,134.24	4.70%
3	8,600	2,090	143.80	1,134.18	4.54%
3	8,700	2,016	139.00	1,134.13	4.39%

Index	time sec	Q cfs	Volume ac-ft	Pool Elev. ft.	Percent Full
3	8,800	1,945	134.38	1,134.08	4.24%
3	8,900	1,878	129.91	1,134.03	4.10%
2	9,000	1,809	125.60	1,133.98	3.97%
2	9,100	1,732	121.45	1,133.92	3.84%
2	9,200	1,660	117.47	1,133.87	3.71%
2	9,300	1,592	113.66	1,133.82	3.59%
2	9,400	1,528	110.00	1,133.77	3.47%
2	9,500	1,467	106.50	1,133.72	3.36%
2	9,600	1,409	103.13	1,133.68	3.26%
2	9,700	1,354	99.90	1,133.63	3.16%
2	9,800	1,302	96.79	1,133.59	3.06%
2	9,900	1,253	93.80	1,133.55	2.96%
2	10,000	1,206	90.92	1,133.51	2.87%
2	10,100	1,162	88.15	1,133.47	2.78%
2	10,200	1,119	85.49	1,133.44	2.70%
2	10,300	1,079	82.92	1,133.40	2.62%
2	10,400	1,041	80.44	1,133.37	2.54%
2	10,500	1,004	78.05	1,133.34	2.47%
2	10,600	969	75.75	1,133.31	2.39%
2	10,700	936	73.52	1,133.28	2.32%
2	10,800	904	71.37	1,133.25	2.25%
2	10,900	874	69.30	1,133.22	2.19%
2	11,000	845	67.29	1,133.19	2.13%
2	11,100	817	65.35	1,133.17	2.06%
2	11,200	791	63.48	1,133.14	2.01%
2	11,300	765	61.66	1,133.12	1.95%
2	11,400	741	59.91	1,133.09	1.89%
2	11,500	718	58.21	1,133.07	1.84%
2	11,600	695	56.56	1,133.05	1.79%
2	11,700	674	54.96	1,133.03	1.74%
2	11,800	653	53.42	1,133.00	1.69%
1	11,900	628	51.92	1,132.98	1.64%
1	12,000	602	50.47	1,132.95	1.59%
1	12,100	577	49.09	1,132.93	1.55%
1	12,200	554	47.77	1,132.90	1.51%
1	12,300	532	46.49	1,132.88	1.47%
1	12,400	511	45.27	1,132.85	1.43%
1	12,500	492	44.10	1,132.83	1.39%
1	12,600	473	42.97	1,132.81	1.36%
1	12,700	455	41.88	1,132.79	1.32%
1	12,800	438	40.84	1,132.77	1.29%
1	12,900	422	39.83	1,132.75	1.26%
1	13,000	407	38.87	1,132.73	1.23%
1	13,100	392	37.93	1,132.71	1.20%
1	13,200	378	37.03	1,132.70	1.17%

Index	time sec	Q cfs	Volume ac-ft	Pool Elev. ft.	Percent Full
1	13,300	365	36.16	1,132.68	1.14%
1	13,400	352	35.33	1,132.67	1.12%
1	13,500	340	34.52	1,132.65	1.09%
1	13,600	329	33.73	1,132.64	1.07%
1	13,700	318	32.98	1,132.62	1.04%
1	13,800	307	32.25	1,132.61	1.02%
1	13,900	297	31.54	1,132.59	1.00%
1	14,000	288	30.86	1,132.58	0.97%
1	14,100	279	30.20	1,132.57	0.95%
1	14,200	270	29.56	1,132.56	0.93%
1	14,300	261	28.94	1,132.55	0.91%
1	14,400	253	28.34	1,132.53	0.90%