APPENDIX G

Hydraulic Analysis for Prospect Island Alternatives

PROSPECT ISLAND FISH AND WILDLIFE HABITAT RESTORATION PROJECT MODIFICATION REPORT

SOLANO COUNTY, CA

HYDRAULIC DESIGN REPORT

AUGUST 1997

CIVIL DESIGN BRANCH
SACRAMENTO DISTRICT CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

PROSPECT ISLAND FISH AND WILDLIFE HABITAT RESTORATION PROJECT
HYDRAULIC DESIGN REPORT

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PROSPECT ISLAND FISH AND WILDLIFE HABITAT RESTORATION PROJECT MODIFICATION REPORT

HYDRAULIC DESIGN REPORT

1. INTRODUCTION

1.1 Study Area and Background - Prospect Island is located approximately 20 miles south of Sacramento. Prospect Island is bordered by the Sacramento River Deep Water Ship Channel (DWSC) to the west, Miner Slough to the east, the confluence of the DWSC and Miner Sough to the south, and a levee to the north. Prospect Island is approximately four miles long and one to two miles wide (see Figure 1).

1.2 Authorization - This project is authorized under Section 135 of the Water Resources Development Act of 1986.

1.3 Purpose and Scope - The purpose of this study is to restore fish and wildlife habitat on Prospect Island and to eliminate maintenance on the DWSC levee on Prospect Island. Hydraulic Design was tasked with hydrodynamic modeling and analysis of the project area of Prospect Island as well as portions of the DWSC and Miner Slough for two different alternatives. A terrain model (DTM) representative of the topography was created. The two-dimensional hydrodynamic model RMA2 was run to simulate dynamic conditions over a one day period using a typical tidal cycle, and to simulate a high flow event using February 1986 data over a 3 day period. Velocity currents, flow, and water surface elevations were determined quantitatively at the breaches, through the channels, and within the island. Wind and ship wave effects, erosion effects on the Miner Slough levee, and the potential for both internal and exterior scour/sedimentation were analyzed qualitatively.

1.4 References -

1) Work Order Request No. 97-1-D, Prospect Island Project Modification Report (PMR).

2) U.S. Army Corps of Engineers, December 1994. Draft Reconnaissance Report, "Prospect Island Fish and Wildlife Habitat Restoration Study."

2. ALTERNATIVES DESCRIPTION

Two alternatives were hydrodynamically modeled and analyzed. These alternatives are labeled Alternative 4 and Alternative 5 to be consistent with the numbering in the Project Modification Report (PMR). Alternative 4 contains a 300 ft breach at the southern end of the DWSC and a 300 ft breach at the northern end of Miner Slough. Alternative 5 contains a 300 ft breach at the southern end of the DWSC and a 300 ft breach at the southern end of Miner Slough. The projects features within the island (which are common to both alternatives) and the breach locations for each alternative are shown on Figure 2.

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3. COMPUTER MODELING AND ANALYSIS

3.1 Hydraulic Model - RMA2 is a two dimensional depth averaged finite element hydrodynamic numerical model used for computing water surface elevations, flow across designated mesh line strings, and horizontal velocity components in rivers, harbors, and estuaries for subcritical, free surface flow in two-dimensional fields. Dynamic modeling was simulated for this study.

3.2 Model Execution - In order to execute RMA2, two input files must be generated. These files are a geometry file and a boundary condition file. The geometry file is the 2D finite element mesh describing the bottom of the surface to be modeled, and is comprised of triangular and quadrilateral elements (see Figure 3). The boundary condition file contains flow data, head data, Manning's n-values (which correspond to the material types found in the geometry file), and turbulent exchange coefficients. The pre and postprocessing program FastTABS or SMS (SMS is the more current software which is replacing FastTABS) were used in creating the geometry and boundary condition files. The geometry file, which is in ASCII format, must be converted to a binary format prior to executing RMA2 using a program called GFGEN. RMA2 is run using the binary geometry file and the ASCII boundary condition file. The hydraulic results are written to a binary solution file and ASCII output file. After loading the binary solution file in the pre and post-processing program FastTABS, or SMS, results such as velocity vectors, water surface elevation contours, and depth contours can be viewed.

3.3 Topography - The topography used to create the RMA-2 mesh is from a topographic survey (1-foot contour interval), and DWSC and Miner Slough channel cross sections completed in 1995. The survey is based on the North American Datum of 1927, California Coordinate system zone 2. A base Intergraph terrain model (DTM) was created from this survey data.

3.4 Mesh Construction - Working in a microstation design file, an array of points spaced at a 200 foot interval (in the x and y, or east-west and north-south, directions) were placed over the area to be modeled. The array points are used to represent the topographic conditions of the 2D mesh where little other detail such as channels or project features is required. In areas requiring greater detail the array points were deleted. In the DWSC and Miner Slough, points were inserted into the design file along channel cross sections at an alignment perpendicular to flow at locations which define the section such as the channel toe, invert, etc. Project features such as islands and the channel within Prospect Island were defined by inserting points into the design file at the design elevation and location using the habitat design plan as a background. The array points and points defining the channels were "draped" onto the DTM created from the survey data (see paragraph 3.3) to assign an elevation to each point using Inroads (Intergraph civil design software). These "draped" points along with the project feature points (which were input at the designed elevation) were saved as and ASCII file and input into the RMA2 pre and postprocessing program FastTABS/SMS. The points represent the nodes of the 2D finite element mesh. By commanding FastTABS/SMS to connect the imported nodes and by connecting the nodes manually using a systematic approach, triangular and quadrilateral elements were constructed to form the mesh which describes the surface being modeled. The nodes (xyz format), elements, and material types are stored in the geometry file. Figure 3 shows

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the finite element mesh.

3.5 Boundary Conditions - Normal hydrologic conditions within Prospect Island are driven by tidal action. For this simulation, an average condition 24 hour tidal cycle at one hour intervals was used at the downstream boundary (located near the DWSC and Miner Slough confluence, see Figure 3). This boundary condition tidal cycle is based on tidal stage measurements for a typical day at the Ryer Island tidal gage. Refer to the reconnaissance Hydrology Report for tidal cycle development information. The tidal cycle (along with other information) is plotted on Figure 4. During a high flow tidal effects are minimal. To model a high flow, or flood event, a boundary condition file was developed from the results of a UNET model representing the February 1986 flood event. The UNET model was developed for the American River Study. The upstream dynamic flow boundary, located at the upstream end of Miner Slough, is based on the computed flow hydrograph at the Miner Slough/Sutter Slough junction of the UNET model. The dynamic head boundary, located at the downstream end of the model, is based on the computed stage hydrograph of the UNET model at Cache Slough. Modeling was performed for approximately a three day period at a three hour time step using this high flow condition. Appendix A contains the ASCII boundary condition file representing the 24-hour tidal cycle run for Alternative 5.

3.6 Turbulent Exchange Coefficients - Turbulent exchange coefficients (EV) for all material types were originally assigned a value of 300 to obtain a stable solution. The tidal cycle simulation for Alternative 5 was subsequently run with lower turbulent exchange values since it is desirable to obtain a stable solution with the lowest turbulent exchange values possible. Material properties with a turbulent exchange of 200 was the lowest which produced a stable solution. Turbulent exchanges are sensitive to changes in velocities. Throughout this dynamic tidal simulation, velocity magnitude and directions as well as depths are continuously changing. Areas which are shallow and/or oscillate between wet and dry states, interior island areas, and breaches are the most sensitive area of the model and therefore, required a somewhat high turbulent exchange coefficient for a stable solution. The lowering of the turbulent exchange coefficients from 300 to 200 did not significantly change the results. All other simulations used turbulent exchange coefficients of 300.

3.7 Roughness Coefficients - Table 1 shows the n-values used in the model.

4. MODEL RUNS/RESULTS

4.1 Hydrodynamic Models - The hydrodynamic model representing Alternative 5 (breaches at the southern end of the DWSC the southern end of Miner Slough) was constructed and run first. After this two-dimensional model was completed, one dimensional elements were added to extend the model along the DWSC approximately three miles in the northerly upstream direction and along Miner Slough approximately one mile in the easternly upstream direction. The purpose of the one dimensional elements was to test the difference in results within Prospect Island and the island breaches. This test was done because the model containing only two-dimensional elements (see Figure 3) does not have any upstream boundaries, and since it does not extend to the head of tide on either the DWSC or Miner Slough, there was a concern that the

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"dead end" areas (or upstream end of the model) may have an effect on the overall hydraulic results. The differences in water surface elevations and velocities were negligible, so one dimensional elements were not used in further modeling. The mesh without the one dimensional elements was modified by removing the Miner Slough breach at the southern end and placing a breach at the northern end of Miner Slough to represent Alternative 5. The three meshes described above were used to perform the modeling described in this study.

TABLE 1
Prospect Island Modeling Manning's n-values

Description	Manning's n-value
Deep Water Ship Channel	0.032
Miner Slough	0.032
Breaches	0.03
Channels within Island	0.03
Islands	0.04
Mesh Topography	0.03

4.2 Exchange Volume Computation - The volume of water within the island at a given water surface elevation was determined using InRoads (Intergraph software). Volumes were determined at one foot intervals (reference Figure 5). The high high, low low, low high, and high low water surface elevations within Prospect Island (resulting from the RMA2 model runs) and a corresponding volume of water was calculated based on linearly interpolating between the InRoads volume values. From the volumetric data, exchange rates were estimated quantitatively. Recirculation and replacement patterns were viewed using FastTABS/SMS. Though not modeled hydrodynamically, wind will be a major factor influencing recirculation.

4.3 Alternative 4

4.3.1 Tidal Cycle Simulation - Alternative 4 has an estimated volume exchange time equaling approximately 1.6 days. In other words, the volume of water entering Prospect Island will leave within 1.6 days. Based on the hydraulic model, this analysis does not imply that complete recirculation will occur within the 1.6 days. Some water will leave in less time than 1.6 days and some water will take longer than 1.6 days to exit the island. Figure 5 displays Prospect Island volumes and tabulates volumes for maximum and minimum water surface elevations for this tidal cycle simulation.

Velocity vectors representing flow direction and velocity magnitude (velocity vector lengths are proportioned according to their magnitude) at various times steps throughout this simulation are provided in Appendix B. The velocity vector plots are helpful in determining qualitatively the circulation patterns occurring at different time steps. There is a distinct area located near the middle of the island where flow from each of the breaches meet. This creates an area of low velocities (velocities get no greater than 0.05 fps) and water movement throughout the tidal cycle. An area near the cross levee at the south end of the island also shows very little water movement. However, this alternative provides better flow and circulation than alternative 5 (see paragraph 4.4.1) in the northern area of the island. Velocities throughout most of the island are less than 0.2 fps. It is only in the vicinities of the breach locations where velocities are greater.

The maximum velocity at the DWSC breach ranges from 4.7 to 6.9 fps, with the 6.9 fps located at a section in the middle of the breach. The maximum velocity at the Miner Slough breach ranges from 3.2 to 10.7 fps, with 10.7 fps at a section in the center of the breach. The 10.7 fps appears to be a high value. This is probably due to a rapid change in elevation within the model between the breach and Miner Slough.

Figure 4 shows the calculated water surface elevations in the island over a typical tidal cycle. The typical tidal cycle is shown to demonstrate the variations between the water surface elevations at the downstream end boundary and the water surface elevations in Prospect Island. The maximum tidal water surface elevation within Prospect Island is 4.6-feet and the minimum tidal water surface elevation is 1.6-feet.

Figure 6 shows flows through the DWSC breach. The maximum flow into the island is 3010 cfs and the maximum flow exiting the island is 4710 cfs. Figure 7 shows flows through the Miner Slough breach throughout the tidal cycle simulation. The maximum flow into the island at the Miner Slough breach is 1610 cfs and the maximum flow exiting the island is 2400 cfs.

4.4 Alternative 5

4.4.1 Tidal Cycle Simulation - Alternative 5 has an estimated volume exchange time equaling 1.3 days. Although complete recirculation will not occur in 1.3 days, the volume of water entering the island will on average leave, or be replaced, within 1.3 days (reference Figure 5 for display of volume computation information). The lowest velocities and least amount of circulation occurs in the northern area of Prospect Island. This is mainly due to the distance (about 2 miles) from the breach locations to this area of the island. The modeling results indicate that the upper area of Prospect Island will never be exchanged under the tidal cycle modeled. As velocity vectors were followed through the course of the tidal cycle, it shows that water in the northern area of the island will only get approximately 1/3 to ½ of the distance towards the breaches before the tide reverses. Therefore, this upper area would never be replaced. However, modeling does not include any mixing due to wind action or any mixing that may occur as the tide transitions between flood and ebb tide. Additionally, the northern area of the island and a few other areas which have the higher ground elevations, will become dry under some tidal cycles (which were not used in the modeling).

In the northern area of the island, maximum velocities are always below 0.1 fps. Maximum velocities do not become greater than 0.1 fps until water is below the upper end of the main channel (or the northern breach location in Alternative 4). Maximum velocities throughout the island are below 0.5 fps except at the vicinity of the breaches. The maximum velocity at the DWSC breach is 6 fps. This velocity is seen over the middle section of the breach. Maximum velocities are less than 5.5 fps at the other sections of the breach. At the Miner Slough breach, the maximum velocity is 9.0 at an area near the center of the breach, with velocities ranging from 7.2 to 9.0 fps at other areas along the breach. Velocities outside of the island dissipate to less than 1 fps over a short distance. Velocity vectors representing flow direction and velocity magnitude (velocity vector lengths are proportioned according to their magnitude) are provided in Appendix B.

Water surface elevations over a typical tidal cycle in the island are shown in Figure 4. Water surface elevations range from an elevation of 4.6 to 0.9 within Prospect Island for the hydrologic tidal cycle that was modeled. The stage in the island for Alternative 5 has a wider range of depth (reference Figure 4) resulting in a shorter volume exchange time when compered to the tidal cycle model of Alternative 4.

Flows through the DWSC breach are shown in Figure 6. The maximum flow into the island is 5970 cfs and the maximum flow exiting the island is 4320 cfs. Flows through the Miner Slough breach are shown in Figure 7. The maximum flow into the island is 4564 cfs and the maximum flow exiting the island is 3990 cfs.

4.4.2 High Flow Simulation - February 1986 high flow event data for an approximate three day period was modeled using the Alternative 5 mesh (see paragraph 3.5 for boundary condition information). Figure 8 shows the Project inflow at the upstream end of Miner Slough, flows entering the Miner Slough breach, and flows exiting the DWSC breach. The difference between the flow at the upstream end of the Project and the flow entering the Miner Slough breach is equal to the amount of flow traveling downstream through Miner Slough. As seen on Figure 8, a maximum of about 12,000 cfs (about half of the peak flow) will flow into Prospect Island from the Miner Slough Breach. Nearly the same flow will exit the DWSC breach and continue downstream towards the confluence of the DWSC and Miner Slough. The only difference between existing and project conditions, is that a flow of about 12,000 cfs will flow through Prospect Island and out to the DWSC rather than flowing down Miner Slough. This will not change the water surface elevations significantly or alter the current level of flood protection in and around the project area. There will be no induced flooding as a result of the project since all flows will converge at the DWSC/Miner Slough confluence and will be similar to the existing condition flows.

Figure 9 shows a comparison between the stages at the upstream end of Miner Slough and the water surface elevations in the island for the February 1986 high flow data.

Velocities through the breaches are greatest when the inflow hydrograph at Miner Slough is still rising. This is because the downstream stages are still low and there is still a tidal influence. As the downstream stages increase, maximum velocities through the breaches decrease. The maximum velocity through the Miner Slough breach is 5.9 fps. The maximum velocity through the DWSC breach is 6.1 fps over the middle section of the breach, but maximum velocities range from 3.5 to 6.1 fps across the breach at this time step.

5. WIND AND SHIP WAVE ANALYSIS

5.1 Wind Wave - The wind-wave runup analysis was conducted to determine the magnitude of wind-induced wave action on the existing exterior levees, and the interior designed islands of Prospect Island. The analysis on the exterior levees assumes a flooded condition and the interior island analysis assumes a high tide condition. These assumptions provide the maximum wind induced wave action. The analysis was performed according to ETL 1110-2-305, "Determining Sheltered Water Wave Characteristics".

Wind data was collected from the climatological data station (National Weather Service) at Stockton Metro Airport for the period of 1963 to 1988. Based on the data the primary wind direction is from the south-east; however, since the fetch lengths vary (depending on the wind direction) all of the recorded wind directions were evaluated. A land to water adjustment factor of 1.1 was applied to obtain the fastest mile, or highest wind velocity.

Under flood conditions, an average depth of 13.5' was used (based on the maximum water surface elevation obtained from the 2D modeling of 12.5' and an average elevation within Prospect Island of -1.0'). The depth at the levee toe varies (between 10.5' and 16.5') depending on the levee being evaluated. Levee slopes of 2, 3, and 5 (H) to 1(V) were evaluated. A slope of 5(H):1(V) exists on the DWSC levee (which is subjected to south-east and east winds), while a slope of 3 or 2(H) to 1(V) slope is assumed appropriate for all other exterior island levees. Although the primary wind direction is from the south-east, the greatest wind-wave runup is from a north wind. This largely due to the steeper levee slope and depth of water at the toe on the south levee. Table 2 displays the results of the for the flood condition.

For the interior (project designed) islands, an average water depth within the island and at the embankment toe was assumed to be 5.5'. This is based on the maximum water surface elevation within Prospect Island of about 4.5', from the 2D modeling results of Alternative 5 using the average tidal cycle (see Figure 4), and an average island elevation of -1.0'. The greatest wind-wave runup is 1.52' from a south-west wind. The design embankment slope is 5(H) to 1(V). Table 3 displays the wind-wave runup results for all recorded wind directions.

Prospect Island flooded during January of 1997 from a breach on the Miner Slough levee. The cross levee at the southern end was also breached. Overtopping of the cross levee occurred, and based on a site visit, it also appeared that the southern end of the DWSC levee had overtopped. Erosion from wind action at high water levels within the island has occurred along the northern interior levee of Prospect Island. The cross levee has eroded due to water flowing through the breach as well as wave action. Under normal tidal action the northern levee should not experience erosion because this part of the island is at a higher elevation and is often dry. However, without some type or bank protection, levee erosion is likely along the north levee and cross levee during flood events (or when there are high stages in Prospect Island).

Erosion is expected on the Prospect Island interior islands immediately following construction.

Once vegetation on the islands has been established, erosion should be minimal.

TABLE 2
WIND-WAVE RUNUP - FLOOD CONDITIONS

Direction	Design Wind	Fetch Length	Levee Slope	Depth @ Toe	Wave Height	Wind Setup & Wave Runup
N	31.5	2.2	3:1 2:1	16.5	1.8	2.9' 4.0'
NW	35.0	1.2	3:1 2:1	10.5	1.7	2.8' 3.7'
W	29.5	1.1	3:1 2:1	10.5	1.3	1.9' 2.8'
SW	26.5	1.7	3:1 2:1	10.5	1.4	2.3' 3.1'
E	33.5	1.1	5:1 3:1	11.5	1.5	1.8' 2.6'
SE	45.0	1.2	5:1 3:1	11.5	2.1	2.5' 3.6'

TABLE 3
WIND-WAVE RUNUP ON INTERIOR ISLANDS

Direction	Design Wind	Fetch Length	Wave Height	Wind Setup & Wave Runup
N	32.0	1.4	1.3	1.5'
NW	34.5	0.9	1.2	1.4'
W	29.0	0.8	1.0	1.1'
SW	26.5	1.7	1.2	1.4'
E	33.0	0.7	1.1	1.2'
SE	44.0	0.6	1.4	1.5'

5.2 Ship Wave - Impacts from ship waves will be minimal to non-existent. There is really no concern at or near the breach on the DWSC because this levee will no longer be maintained once the project is constructed. However, if there is a reason to maintain the dimensions of the DWSC breach, the breach should be armored to prevent erosion from ship wave action. Waves propagating through the breach will not have a significant effect on the interior islands.

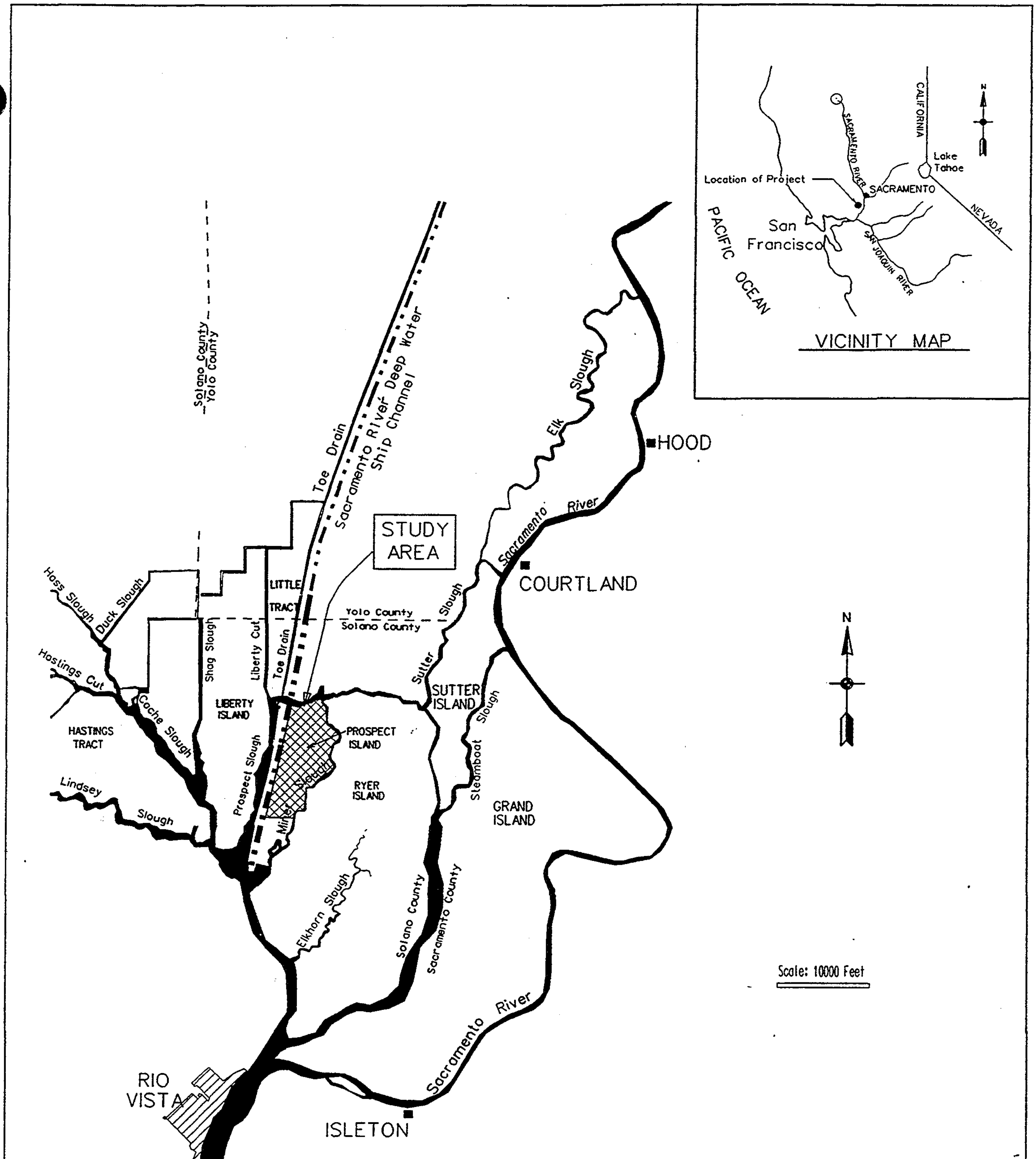
6. SCOUR/SEDIMENTATION ASSESSMENT

The results of the hydrodynamic modeling indicate very low velocities within Prospect Island for both the tidal simulation and flood simulation (Appendix B shows velocity vectors and contours for the tidal simulation). Higher velocities (greater than 1 fps) are only seen in the vicinity of the breaches. Due to the low velocities and the minimal distances in which they exist, the potential for scouring and sedimentation will be negligible. To prevent erosion of the breach at Miner Slough, protection will be necessary.

7. SUMMARY

Alternative 5, consisting of a 300 ft breach at the southern end of the DWSC and a 300 ft breach at the southern end of Miner Slough, is the chosen alternative. Water entering Prospect Island will stay approximately 1.3 days before exiting. Figures 4-9 show the quantitative modeling results (ie volumes, water surface elevations, and flows) graphically and in tabular form. This alternative has no impacts to the existing level of protection or flood inducement. Water flowing through the DWSC breach under a normal hydrologic tidal cycle or during a flood event will have an insignificant impact to ship traffic within the DWSC.

FIGURES



PROSPECT ISLAND
1135 RESTORATION

STUDY AREA

MAY 1997

FIGURE 1

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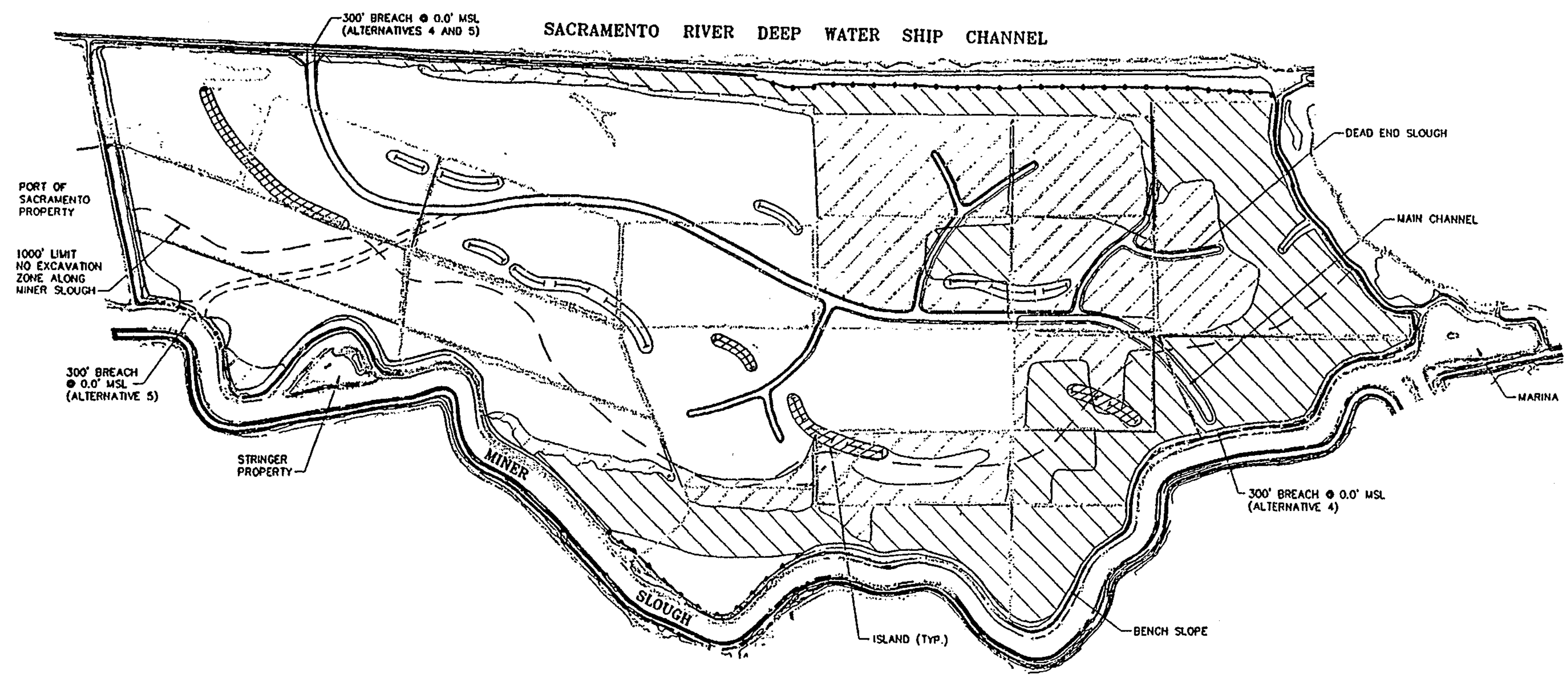
C-089004



GRAPHIC SCALE

0 600 1200 2400

1" = 600 Ft.

NOTE: INCLUDES BREACH LOCATIONS FOR ALTERNATIVES 4 AND 5.

US Army Corps of Engineers Sacramento District

DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

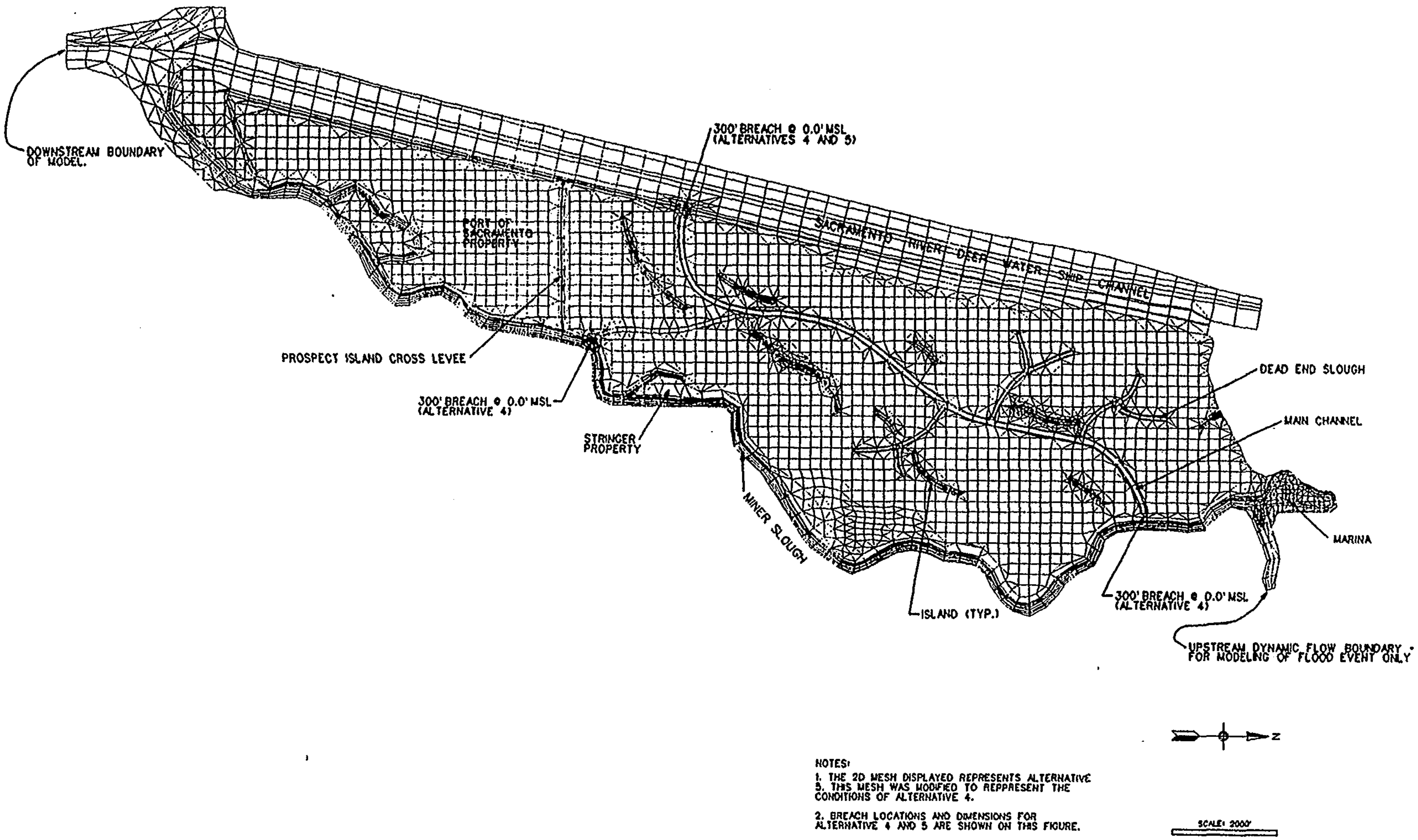
SOLANO COUNTY CALIFORNIA

PROSPECT ISLAND

HABITAT PLANS

FIGURE 2

C — 0 8 9 0 0 4



NOTES:

1. THE 2D MESH DISPLAYED REPRESENTS ALTERNATIVE 5. THIS MESH WAS MODIFIED TO REPRESENT THE CONDITIONS OF ALTERNATIVE 4.
2. BREACH LOCATIONS AND DIMENSIONS FOR ALTERNATIVE 4 AND 5 ARE SHOWN ON THIS FIGURE.

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PROSPECT ISLAND
1135 RESTORATION

2D-HYDRODYNAMIC
FINITE ELEMENT MESH

FIGURE
3

PROSPECT ISLAND

Downstream Tidal Cycle/Stage in Island

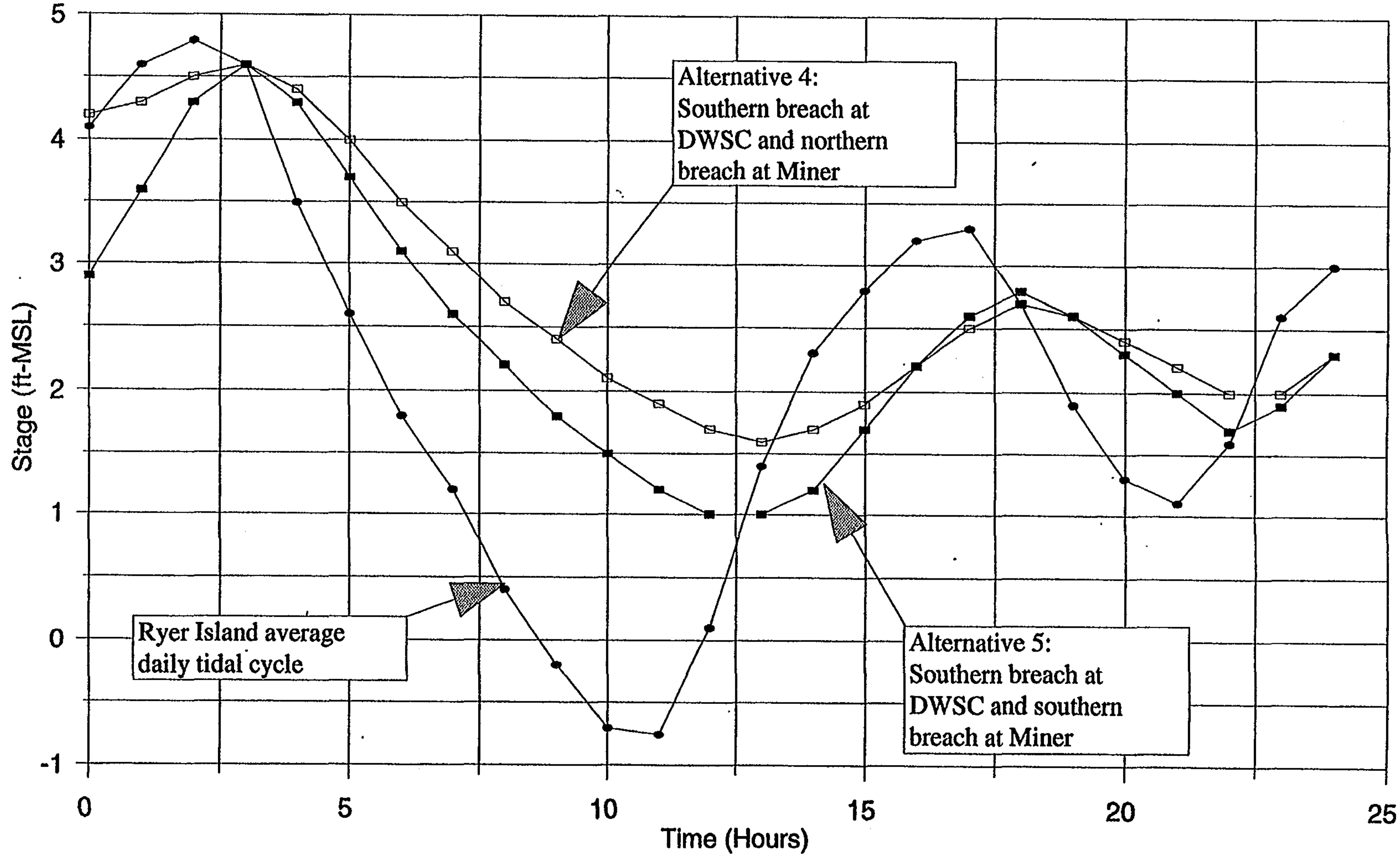
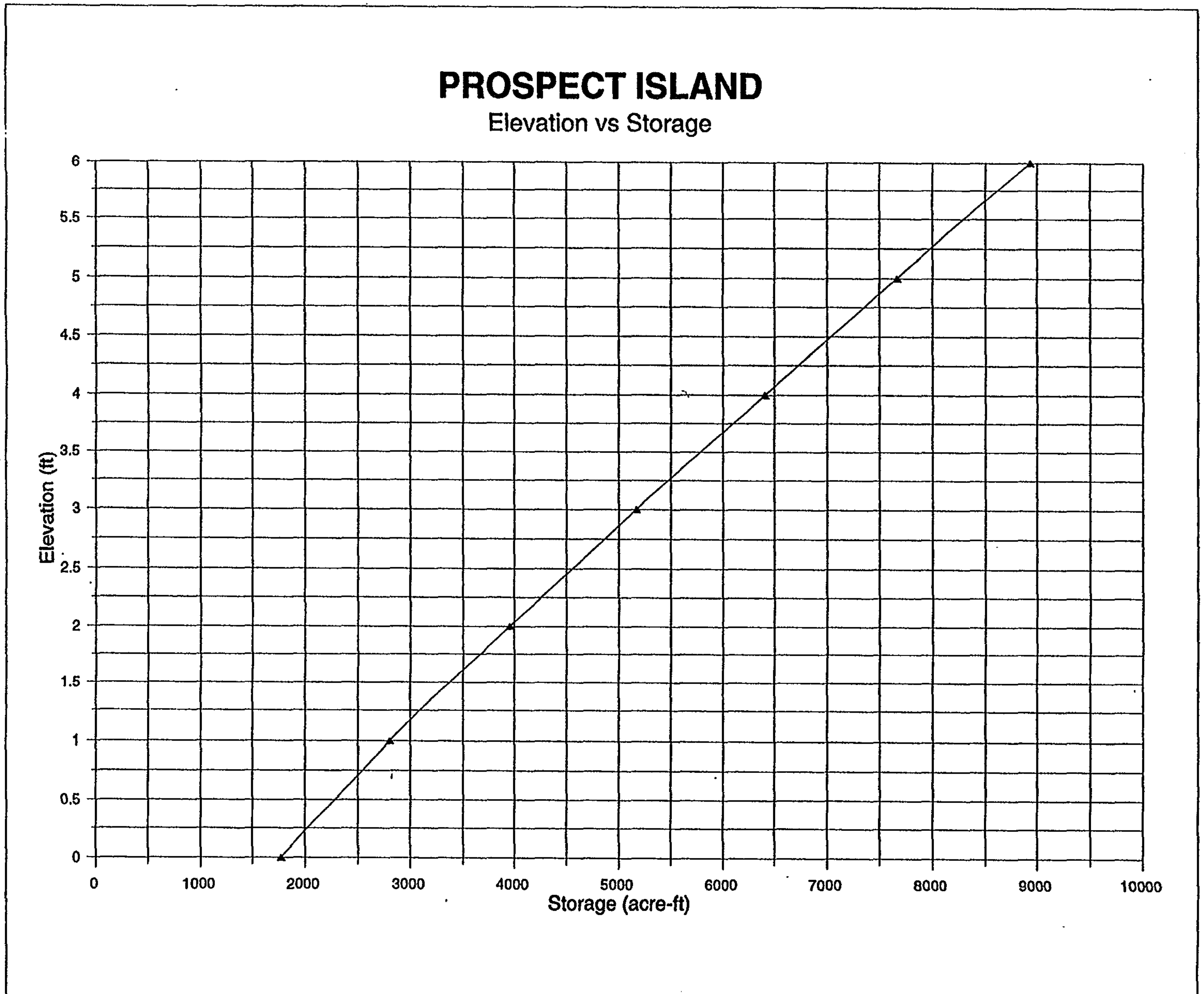


FIGURE 4

C-089007



PROSPECT ISLAND	
Elevation	Fill (ac-ft)
0	1768
1	2803
2	3955
3	5170
4	6411
5	7669
6	8935

Alternative 4	
WSEL	Vol (ac-ft)
4.6	7216.0
1.6	3494.3
2.7	4805.6
2.0	3955.0

Alternative 5	
WSEL	Vol (ac-ft)
4.6	7216.0
0.9	2741.0
2.8	4902.8
1.8	3701.6

FIGURE 5

C-089007

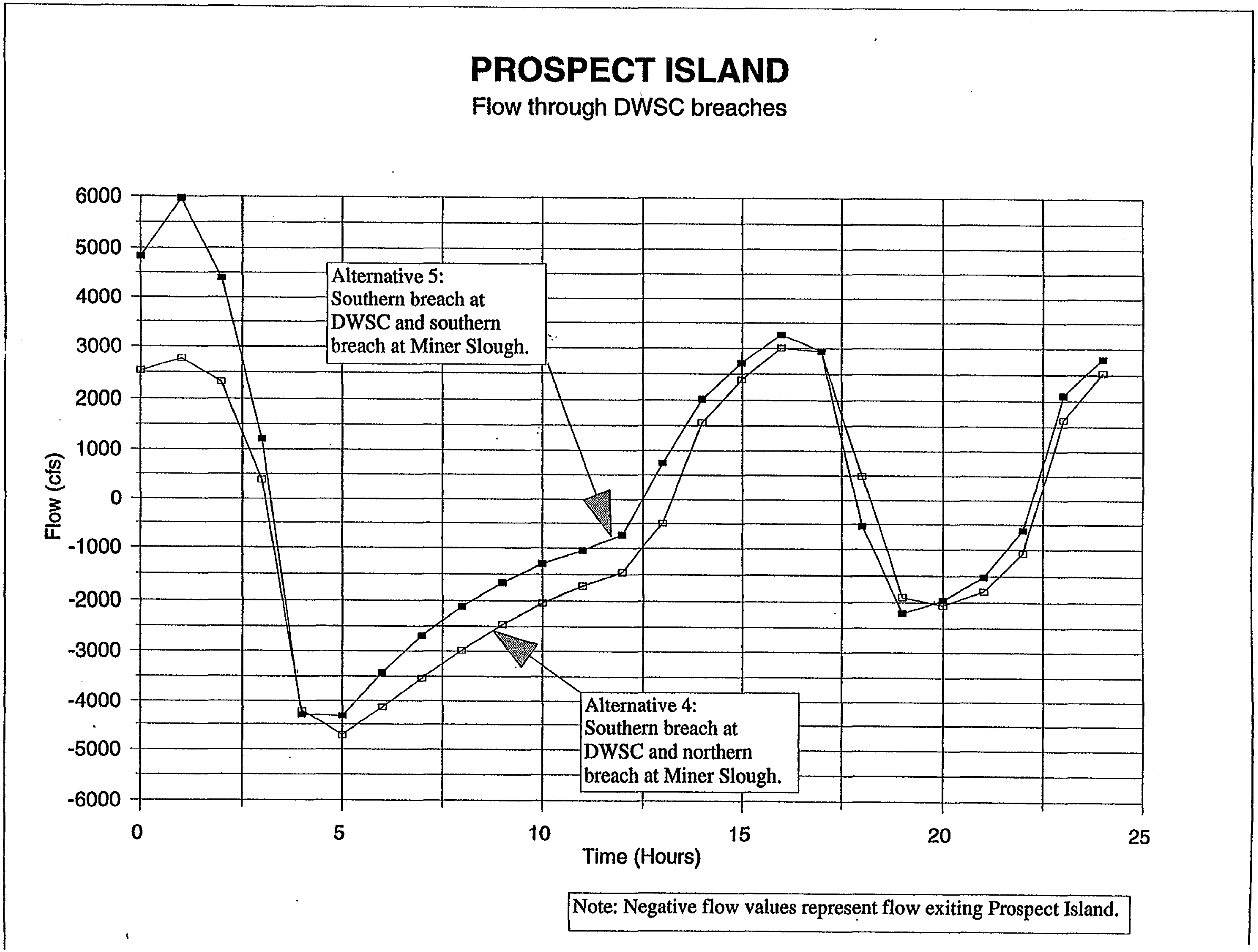

PROSPECT ISLAND
Flow through DWSC breaches
Flow (cfs)
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
0
5
10
15
20
25
Time (Hours)
Alternative 5:
Southern breach at DWSC and southern breach at Miner Slough.
Alternative 4:
Southern breach at DWSC and northern breach at Miner Slough.
Note: Negative flow values represent flow exiting Prospect Island.

FIGURE 6

PROSPECT ISLAND

Flow through Miner Slough breaches

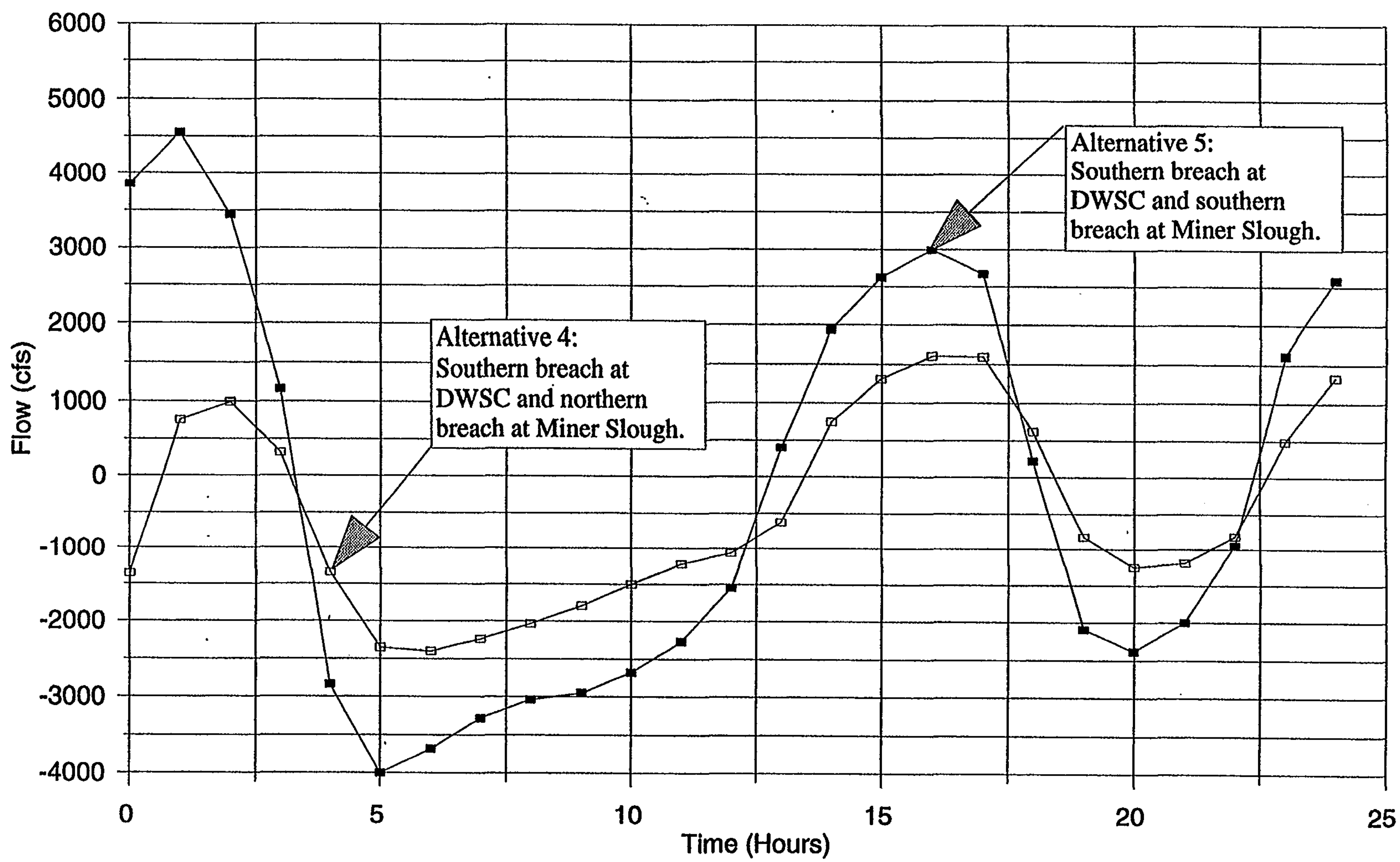


FIGURE 7

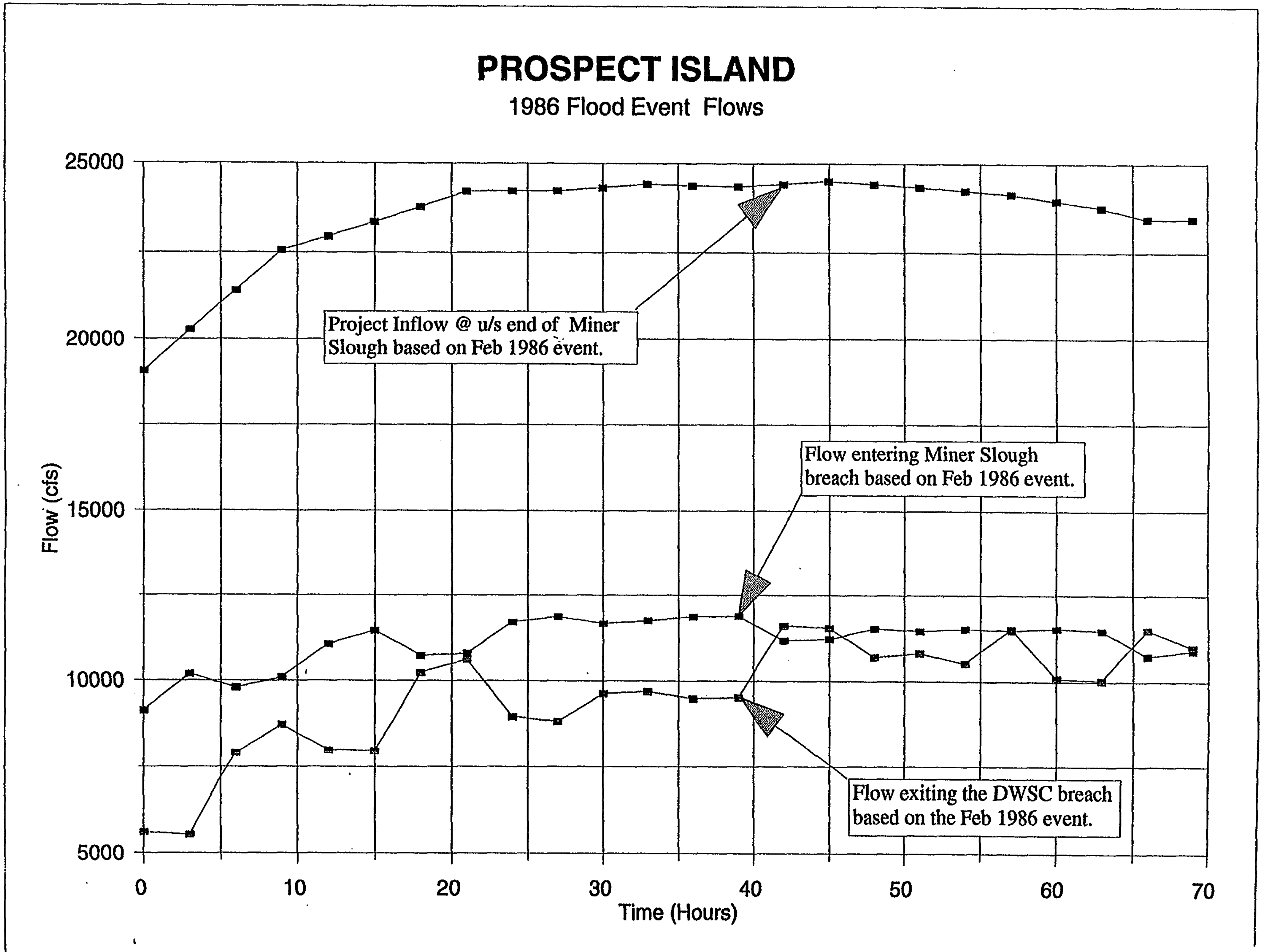

PROSPECT ISLAND
1986 Flood Event Flows
Flow (cfs)
25000
20000
15000
10000
5000
0
10
20
30
40
50
60
70
Time (Hours)
Project Inflow @ u/s end of Miner Slough based on Feb 1986 event.
Flow entering Miner Slough breach based on Feb 1986 event.
Flow exiting the DWSC breach based on the Feb 1986 event.

FIGURE 8

PROSPECT ISLAND

1986 Event Stages w/ D/S Head Boundary

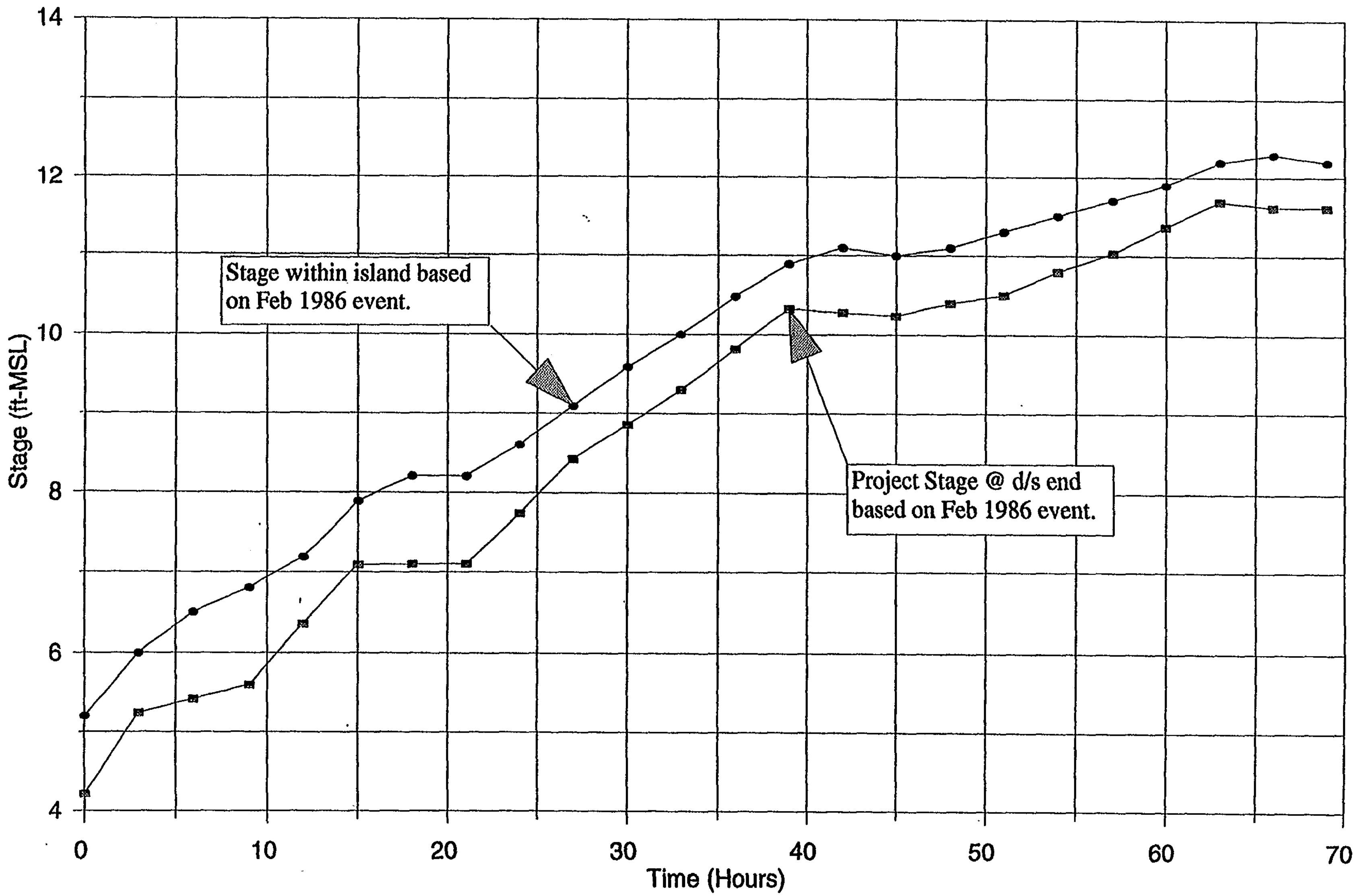


FIGURE 9

APPENDIX A

RMA2 BOUNDARY CONDITION FILE

```
T1 Prospect Island Alternative 5
T2 EV's at 200
T3 pros_a5.bc 08/27/97
$L 0 0 60 64 0 3 0
SI 0
GC 6 1 3 5 7 9 11
GC 5 4629 4440 4435 4191 4021
GC 5 3854 3829 3620 3464 3334
GC 6 3038 3042 3045 3048 3051 3054
GC 8 3449 3446 3443 3440 3437 3434
GC 3431 3428
DE 0.25 1.1 9
DM 1 5.5 4 0.05 0
DMT 4 4 3 0.02 0
DMT 5 5.5 3 0.02 0
DMT 6 4 3 0.03 0
DMT 7 2 1 0.02 0
EV 1    200.00   200.00   200.00   200.00    0.0300
EV 2    200.00   200.00   200.00   200.00    0.0320
EV 3    200.00   200.00   200.00   200.00    0.0300
EV 4    200.00   200.00   200.00   200.00    0.0400
EV 5    200.00   200.00   200.00   200.00    0.0400
EV 6    200.00   200.00   200.00   200.00    0.0300
EV 7    200.00   200.00   200.00   200.00    0.0300
FT 15
IC 105.5 0 0.25
TI 8 8 0.10000 0.10000
TR 1 0 0 0
TZ 1 45 46 0 0
BHL 1 105.5
END Simulation at time = 0.00
BHL 1 105
END Simulation at time = 1.00
BHL 1 103.5
END Simulation at time = 2.00
BHL 1 103
END Simulation at time = 3.00
BHL 1 103
END Simulation at time = 4.00
BHL 1 103
END Simulation at time = 5.00
BHL 1 103
END Simulation at time = 6.00
BHL 1 103
END Simulation at time = 7.00
BHL 1 104.1
END Simulation at time = 8.00
BHL 1 104.6
END Simulation at time = 9.00
BHL 1 104.8
END Simulation at time = 10.00
BHL 1 104.6
END Simulation at time = 11.00
BHL 1 103.5
END Simulation at time = 12.00
BHL 1 102.6
END Simulation at time = 13.00
```

BHL 1 101.8
END Simulation at time = 14.00
BHL 1 101.2
END Simulation at time = 15.00
BHL 1 100.4
END Simulation at time = 16.00
BHL 1 99.8
END Simulation at time = 17.00
BHL 1 99.3
END Simulation at time = 18.00
BHL 1 99.3
END Simulation at time = 19.00
BHL 1 100.1
END Simulation at time = 20.00
BHL 1 101.4
END Simulation at time = 21.00
BHL 1 102.3
END Simulation at time = 22.00
BHL 1 102.8
END Simulation at time = 23.00
BHL 1 103.2
END Simulation at time = 24.00
BHL 1 103.3
END Simulation at time = 25.00
BHL 1 102.7
END Simulation at time = 26.00
BHL 1 101.9
END Simulation at time = 27.00
BHL 1 101.3
END Simulation at time = 28.00
BHL 1 101.1
END Simulation at time = 29.00
BHL 1 101.6
END Simulation at time = 30.00
BHL 1 102.6
END Simulation at time = 31.00
BHL 1 103
END Simulation at time = 32.00
BHL 1 104.1
END Simulation at time = 33.00
BHL 1 104.6
END Simulation at time = 34.00
BHL 1 104.8
END Simulation at time = 35.00
BHL 1 104.6
END Simulation at time = 36.00
BHL 1 103.5
END Simulation at time = 37.00
BHL 1 102.6
END Simulation at time = 38.00
BHL 1 101.8
END Simulation at time = 39.00
BHL 1 101.2
END Simulation at time = 40.00
BHL 1 100.4
END Simulation at time = 41.00
BHL 1 99.8

```
END Simulation at time = 42.00
BHL 1 99.3
END Simulation at time = 43.00
BHL 1 99.3
END Simulation at time = 44.00
BHL 1 100.1
END Simulation at time = 45.00
STOP
HEAD
XY1 1 46 0 0 0 0.000000000000000e+000 ryer2
0.000 106.1000
1.000 105.0000
2.000 103.5000
3.000 103.0000
4.000 103.0000
5.000 103.0000
6.000 103.0000
7.000 103.0000
8.000 104.1000
9.000 104.6000
10.000 104.8000
11.000 104.6000
12.000 103.5000
13.000 102.6000
14.000 101.8000
15.000 101.2000
16.000 100.4000
17.000 99.8000
18.000 99.3000
19.000 99.3000
20.000 100.1000
21.000 101.4000
22.000 102.3000
23.000 102.8000
24.000 103.2000
25.000 103.3000
26.000 102.7000
27.000 101.9000
28.000 101.3000
29.000 101.1000
30.000 101.6000
31.000 102.6000
32.000 103.0000
33.000 104.1000
34.000 104.6000
35.000 104.8000
36.000 104.6000
37.000 103.5000
38.000 102.6000
39.000 101.8000
40.000 101.2000
41.000 100.4000
42.000 99.8000
43.000 99.3000
44.000 99.3000
45.000 100.1000
LEND
```

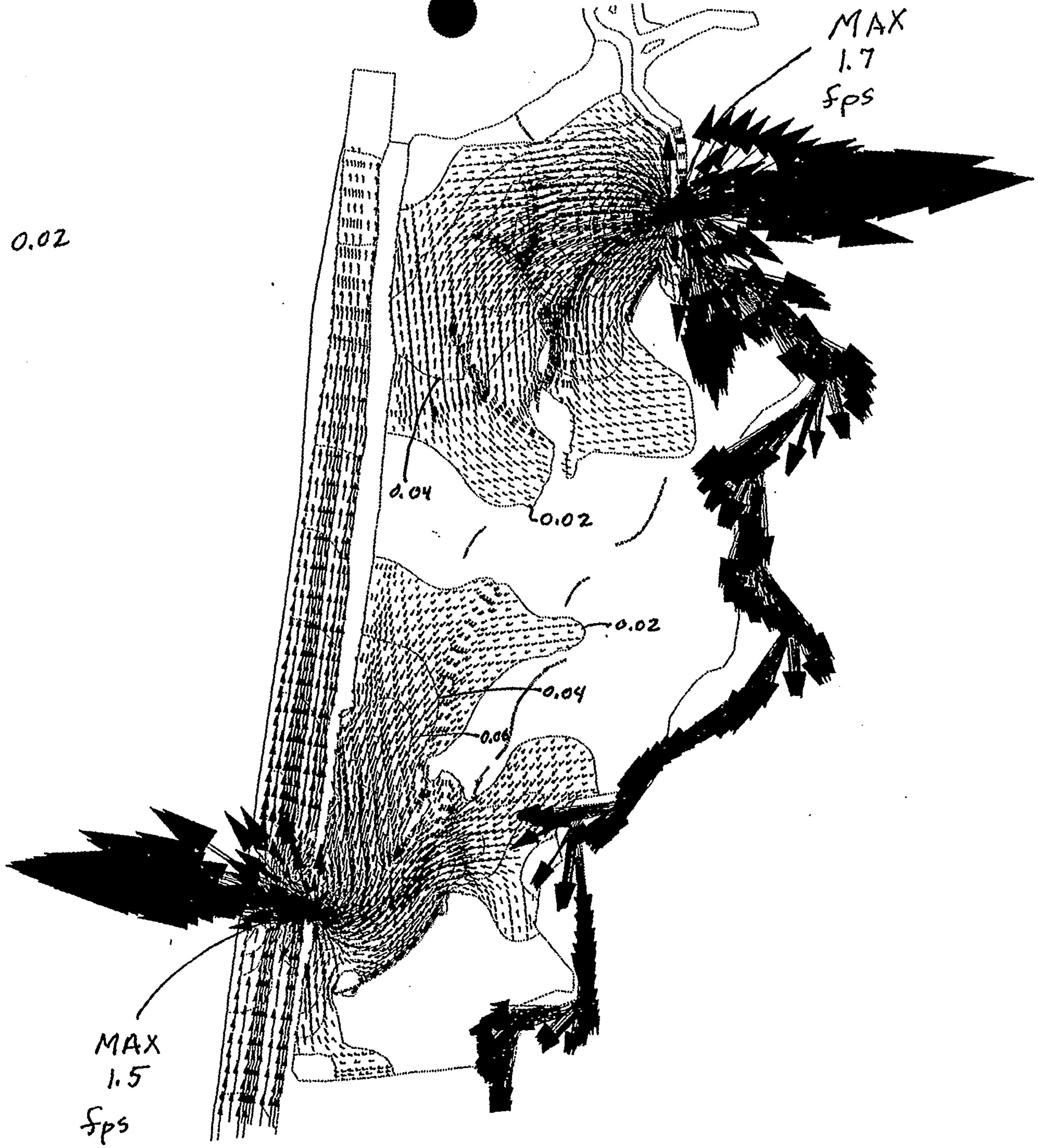
APPENDIX B

VELOCITY VECTORS AND CONTOURS

ALTERNATIVE 4

C-089017

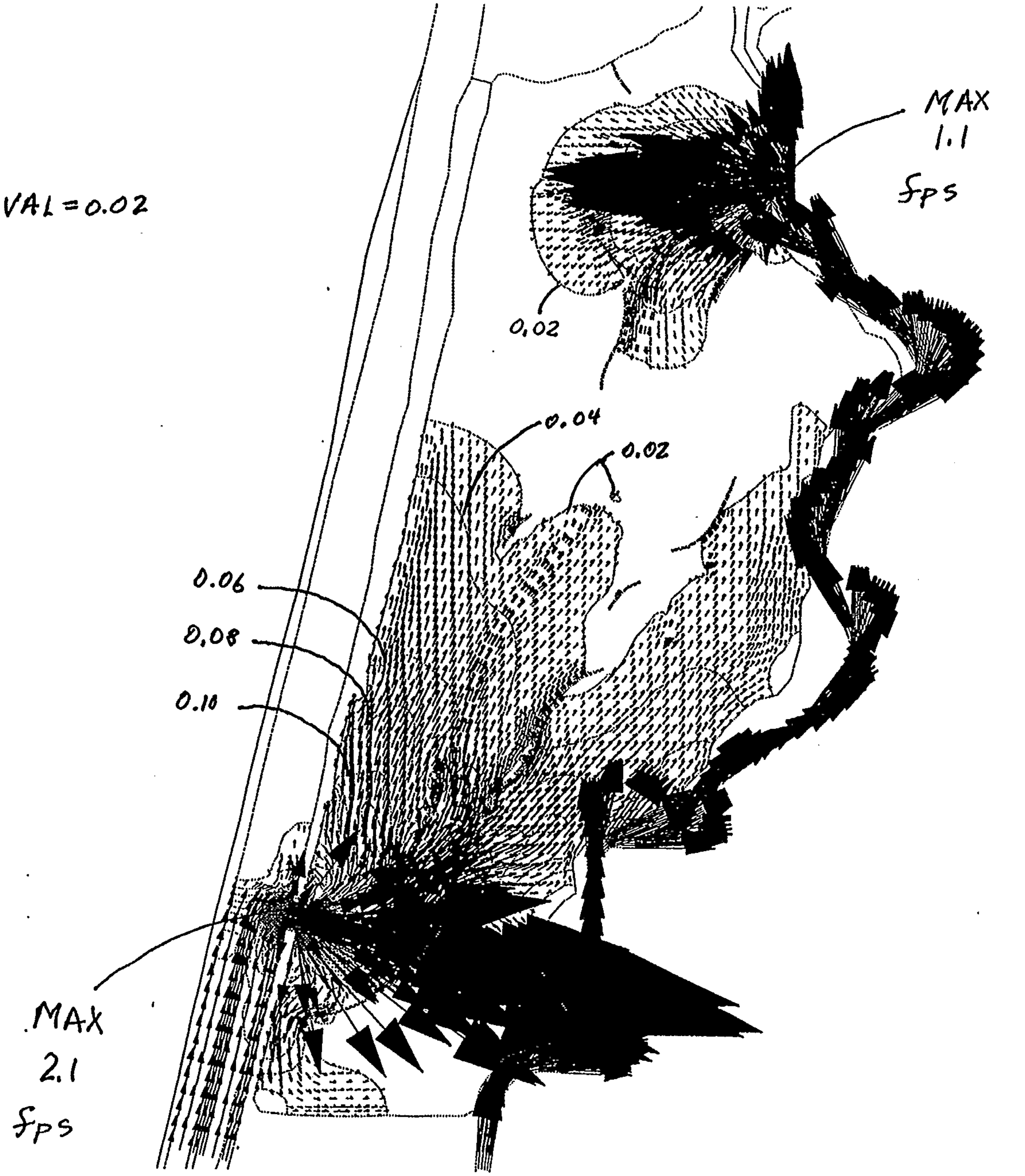
TIME 1 hrs
CONTOUR INTERVAL = 0.02



C-089018

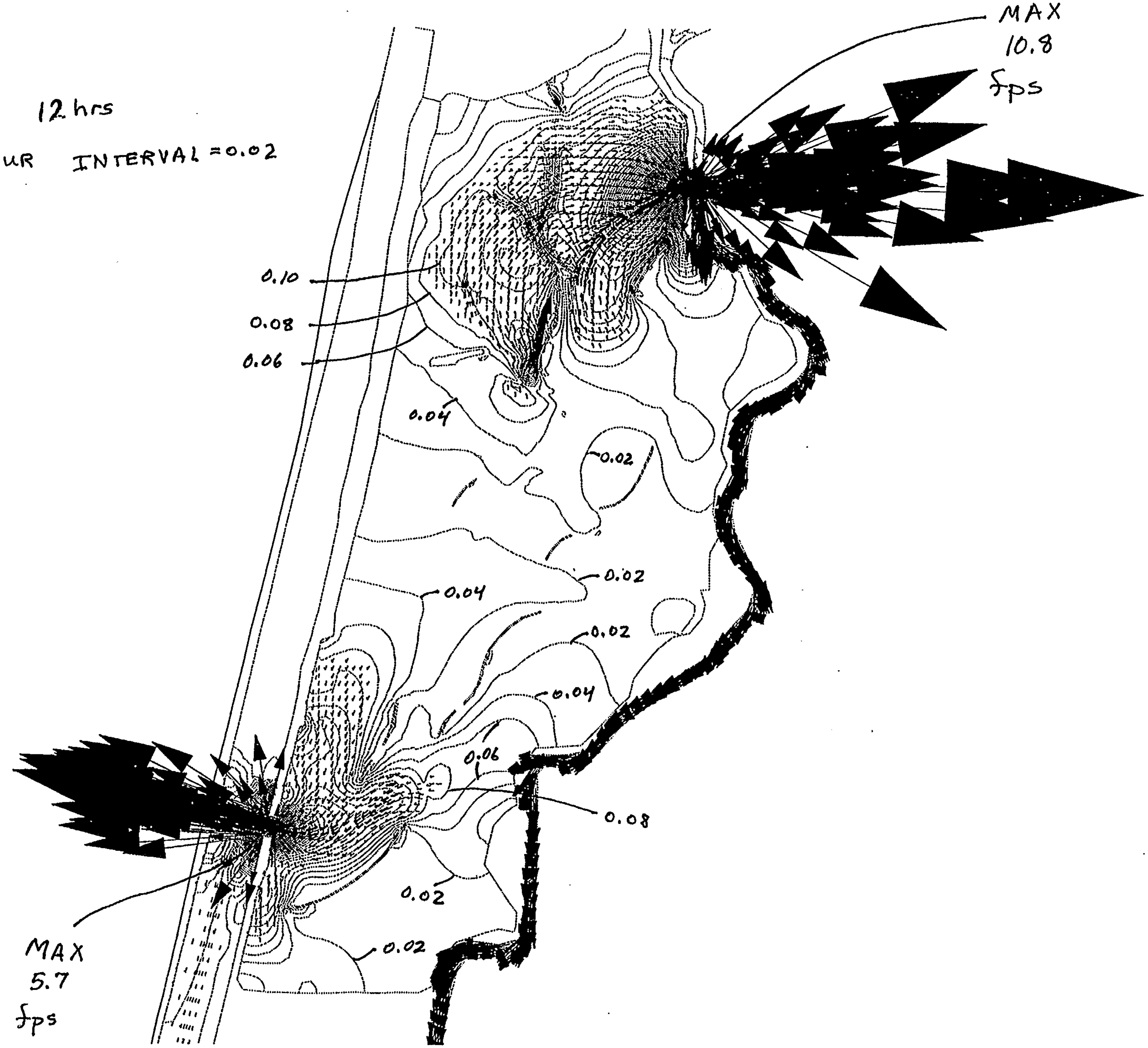
TIME 3 hrs

CONTOUR INTERVAL = 0.02



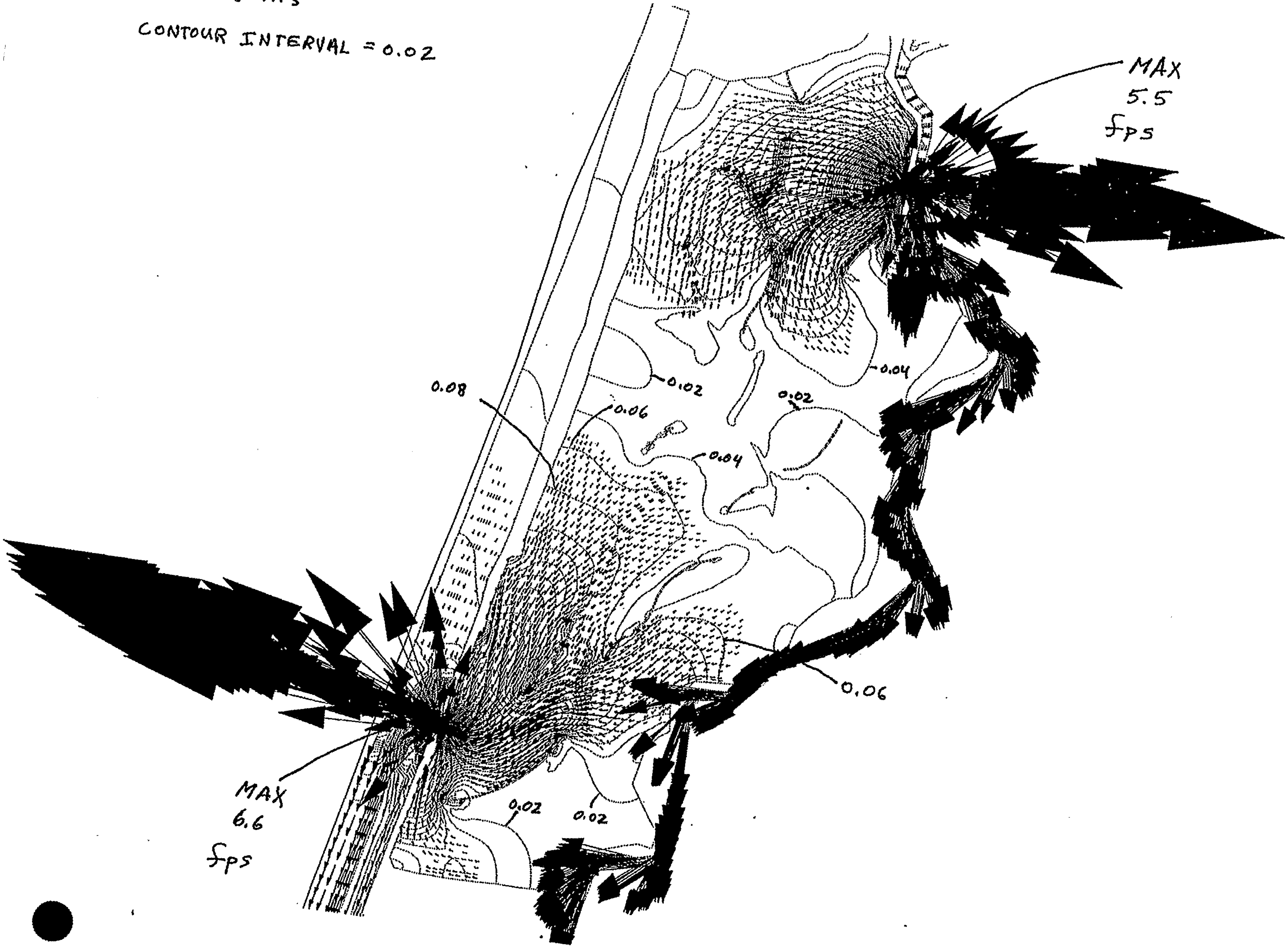
TIME 12 hrs

CONTOUR INTERVAL = 0.02



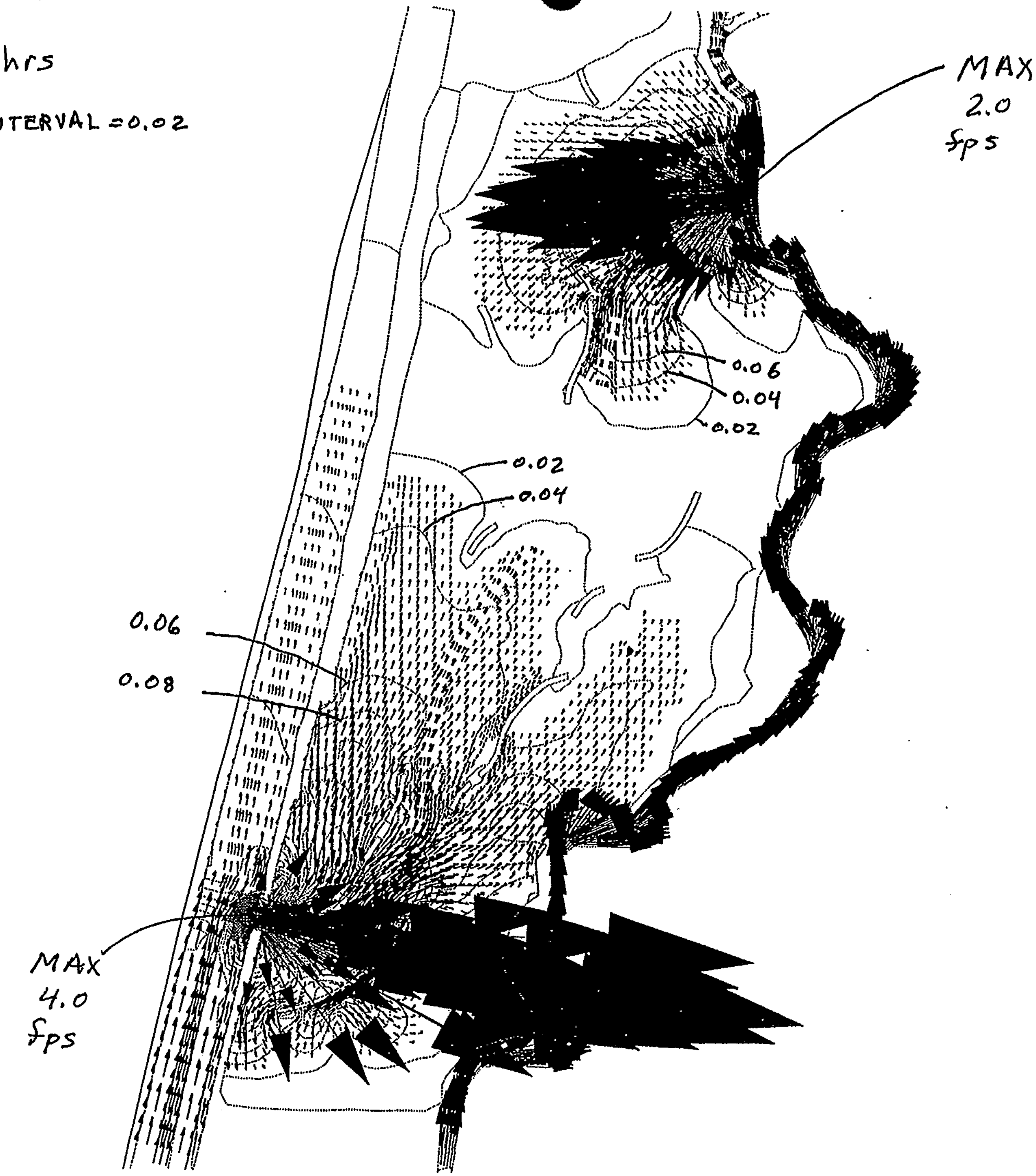
TIME 8 hrs

CONTOUR INTERVAL = 0.02



TIME 15 hrs

CONTOUR INTERVAL = 0.02



C-089022

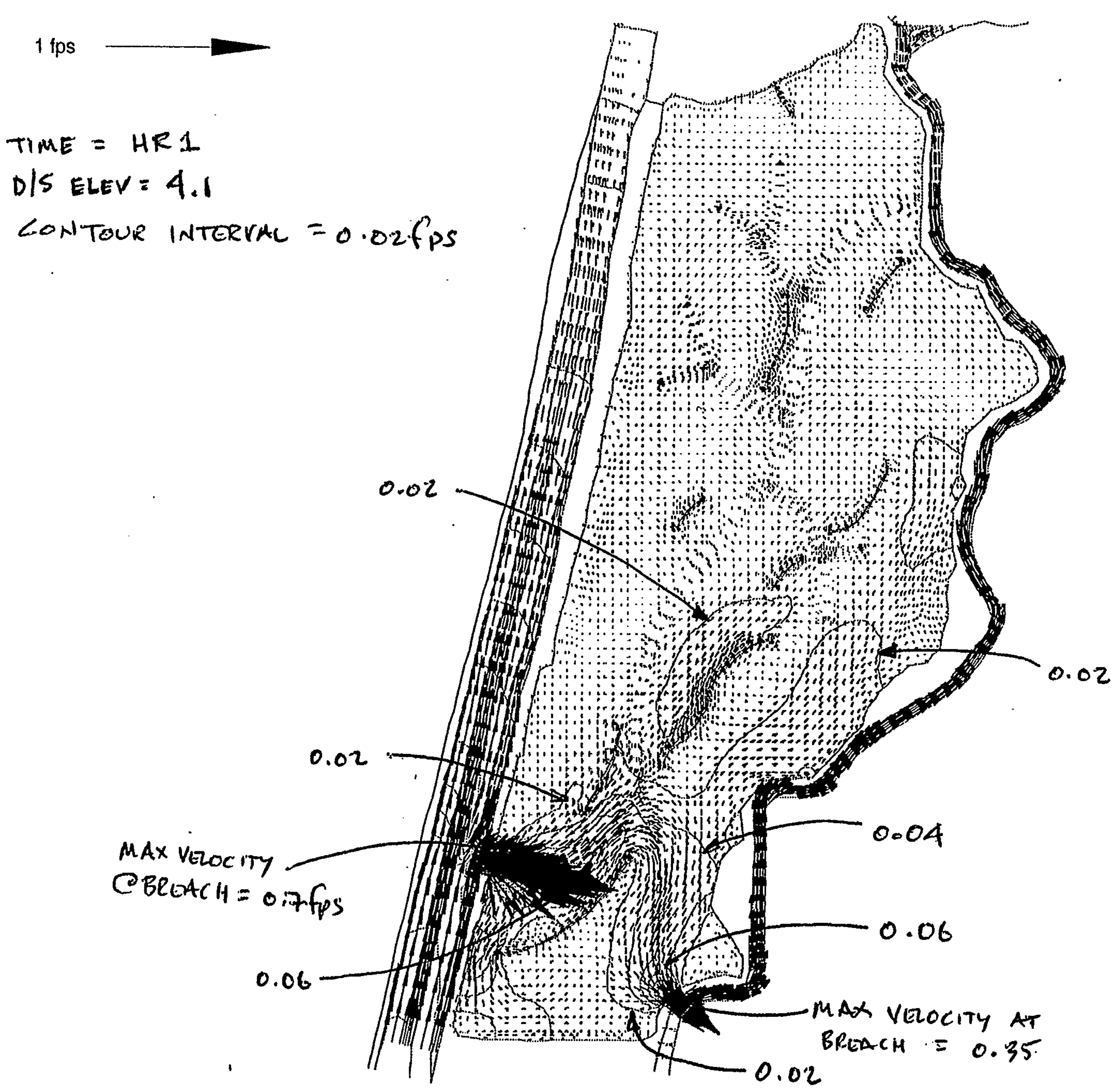
C-089022

ALTERNATIVE 5

C-089023

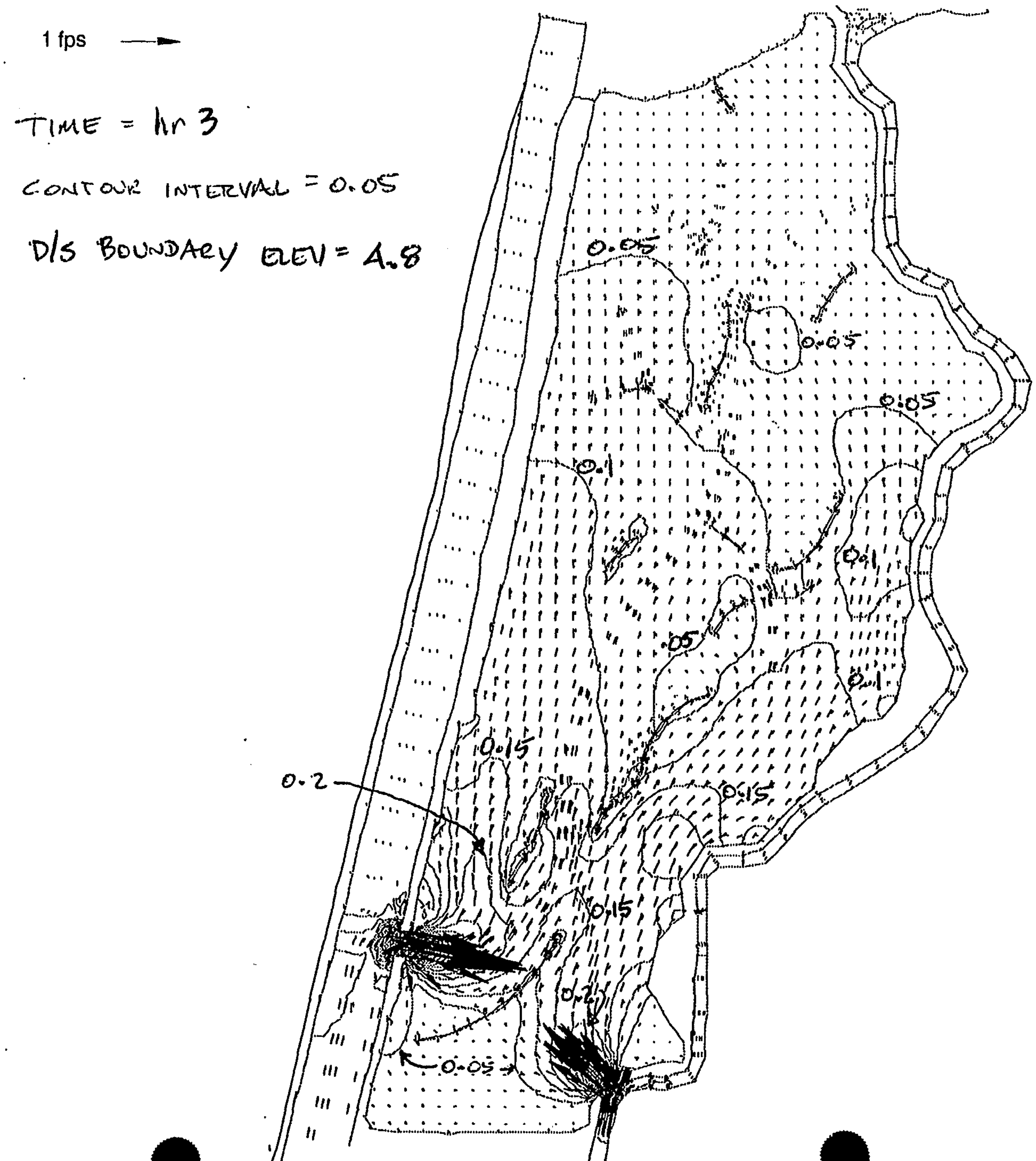
C-089024

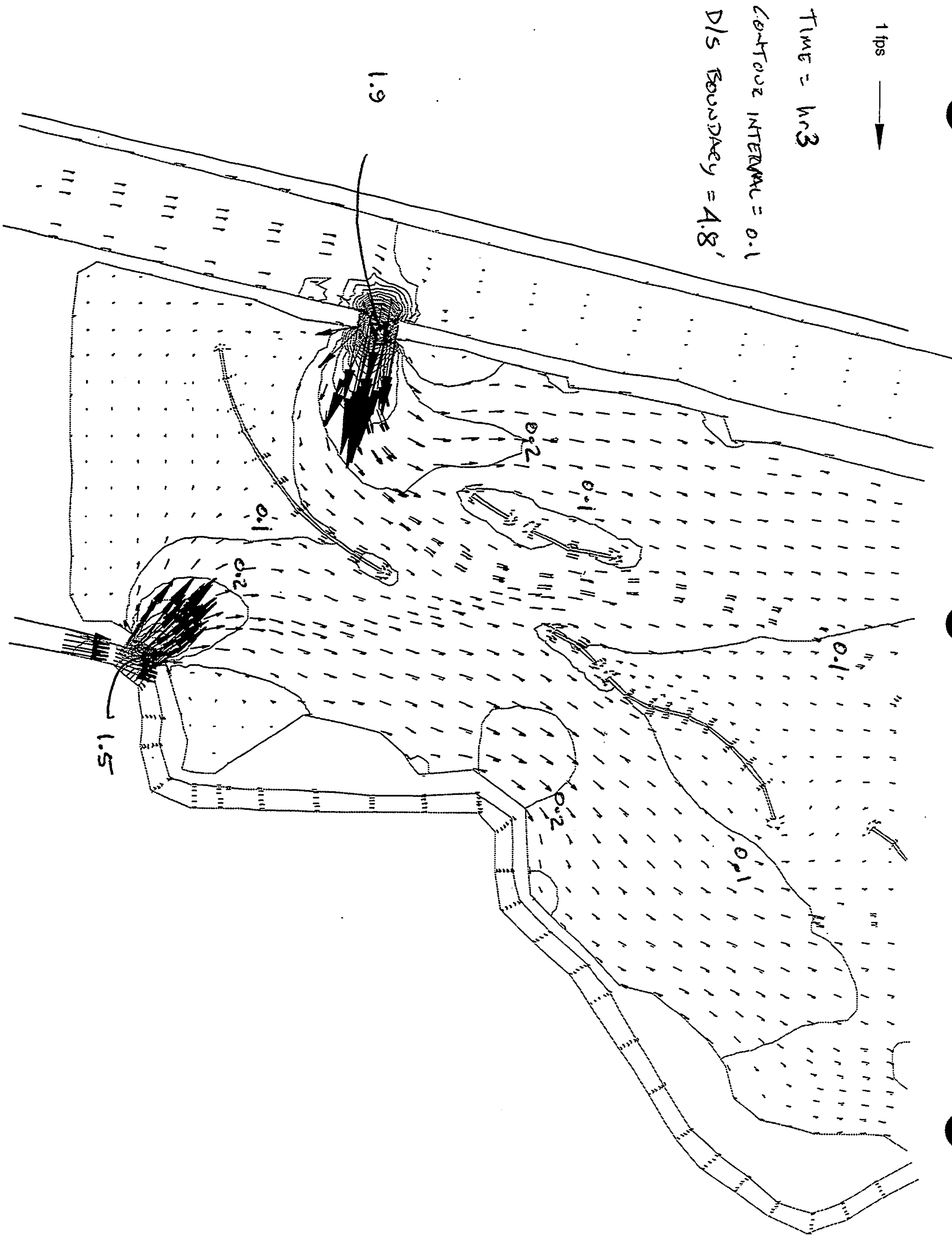
ALTERNATIVE 5



C—089024

ALTERNATIVE 5





C-089026

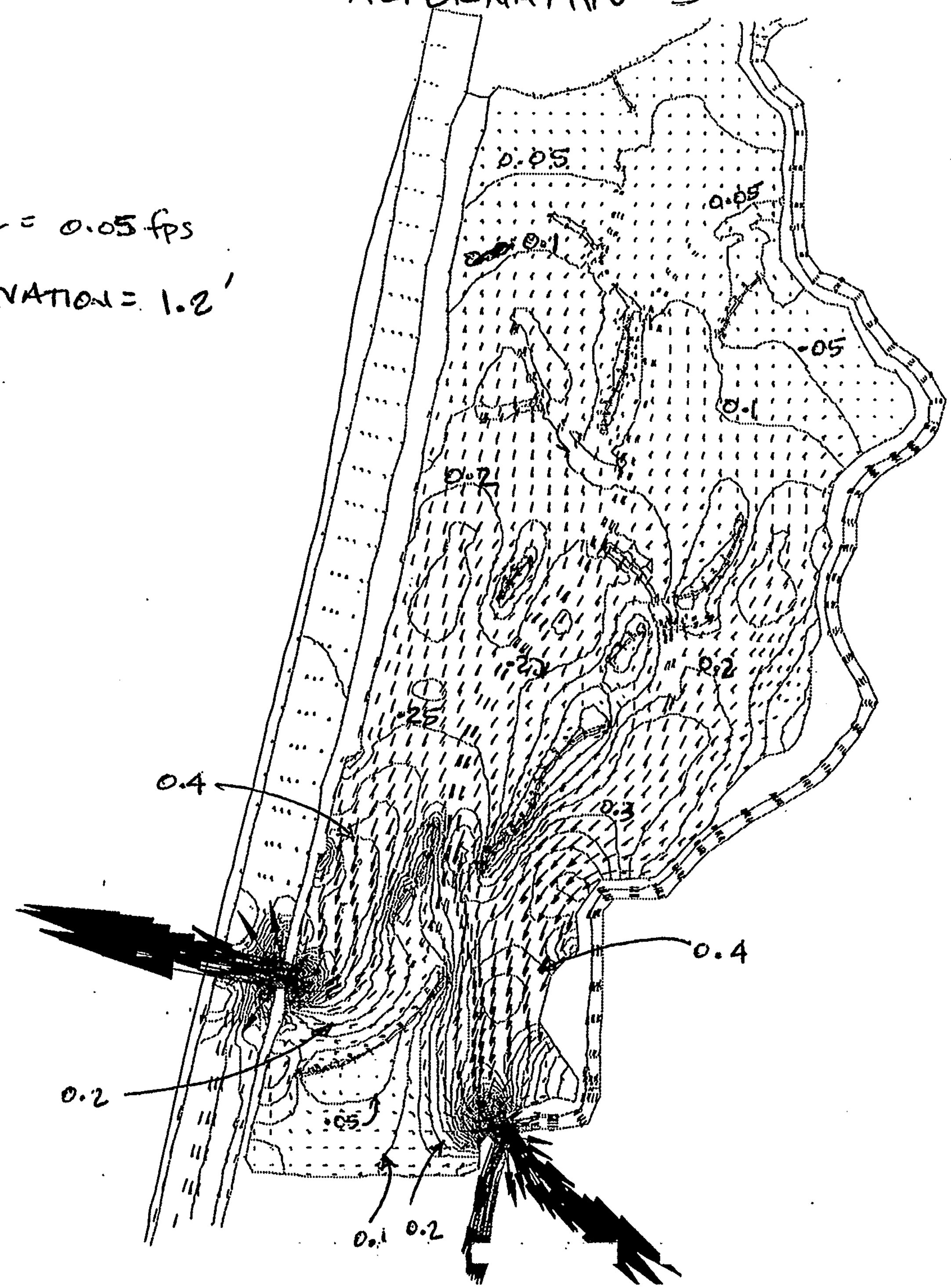
ALTERNATIVE 5

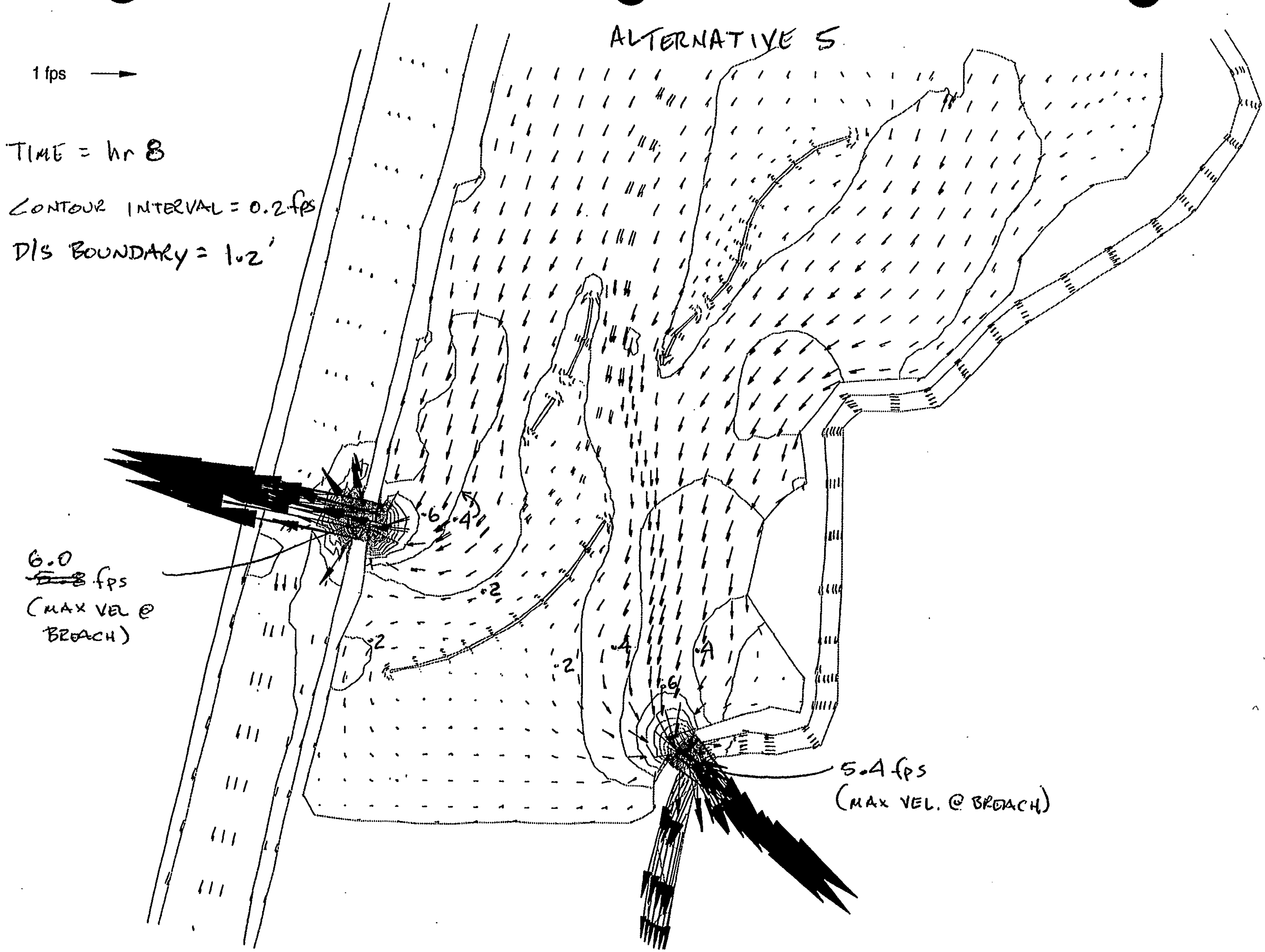
1 fps →

TIME = hr 8

CONTOUR INTERVAL = 0.05 fps

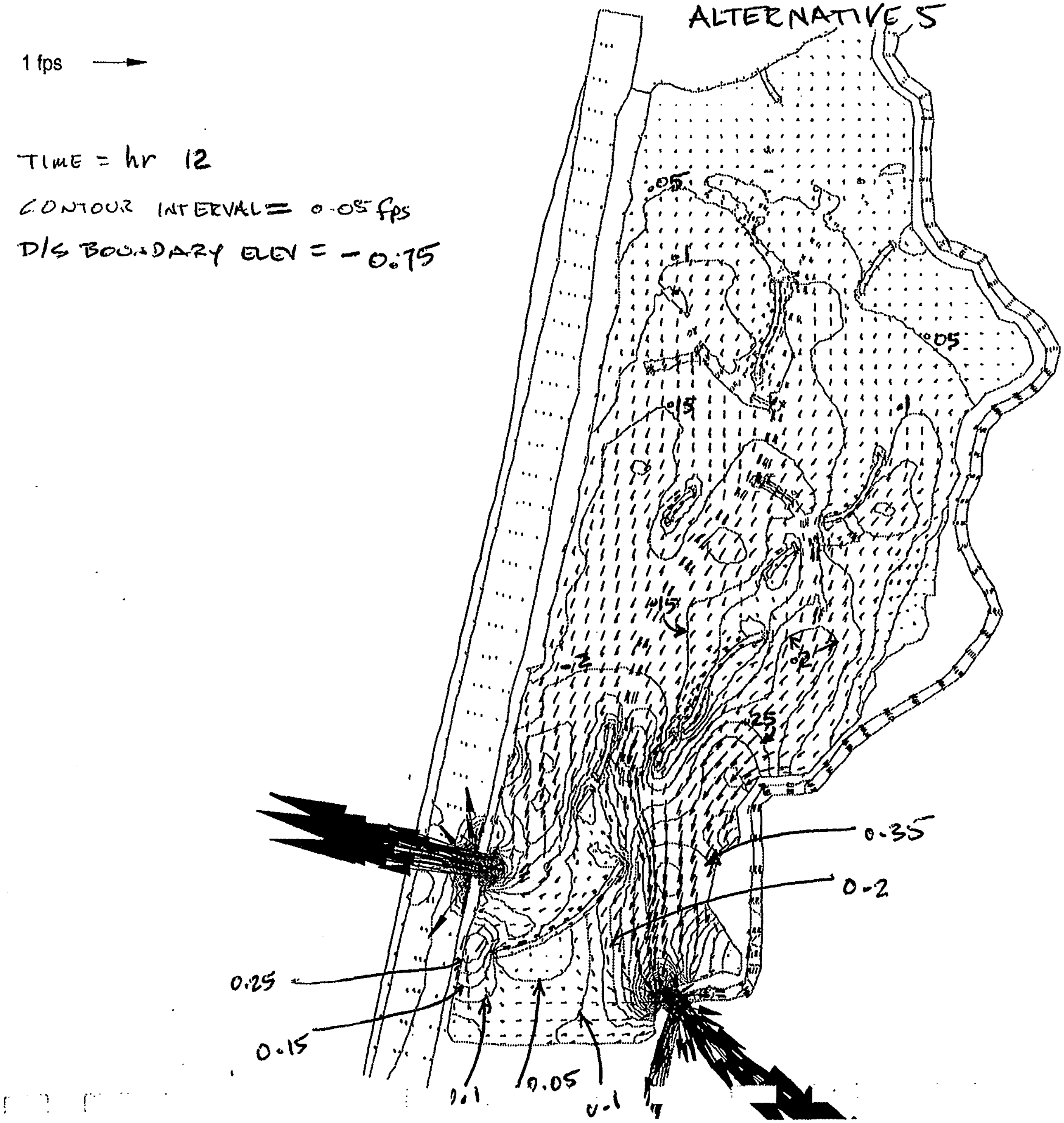
D/S BOUNDARY ELEVATION = 1.2'



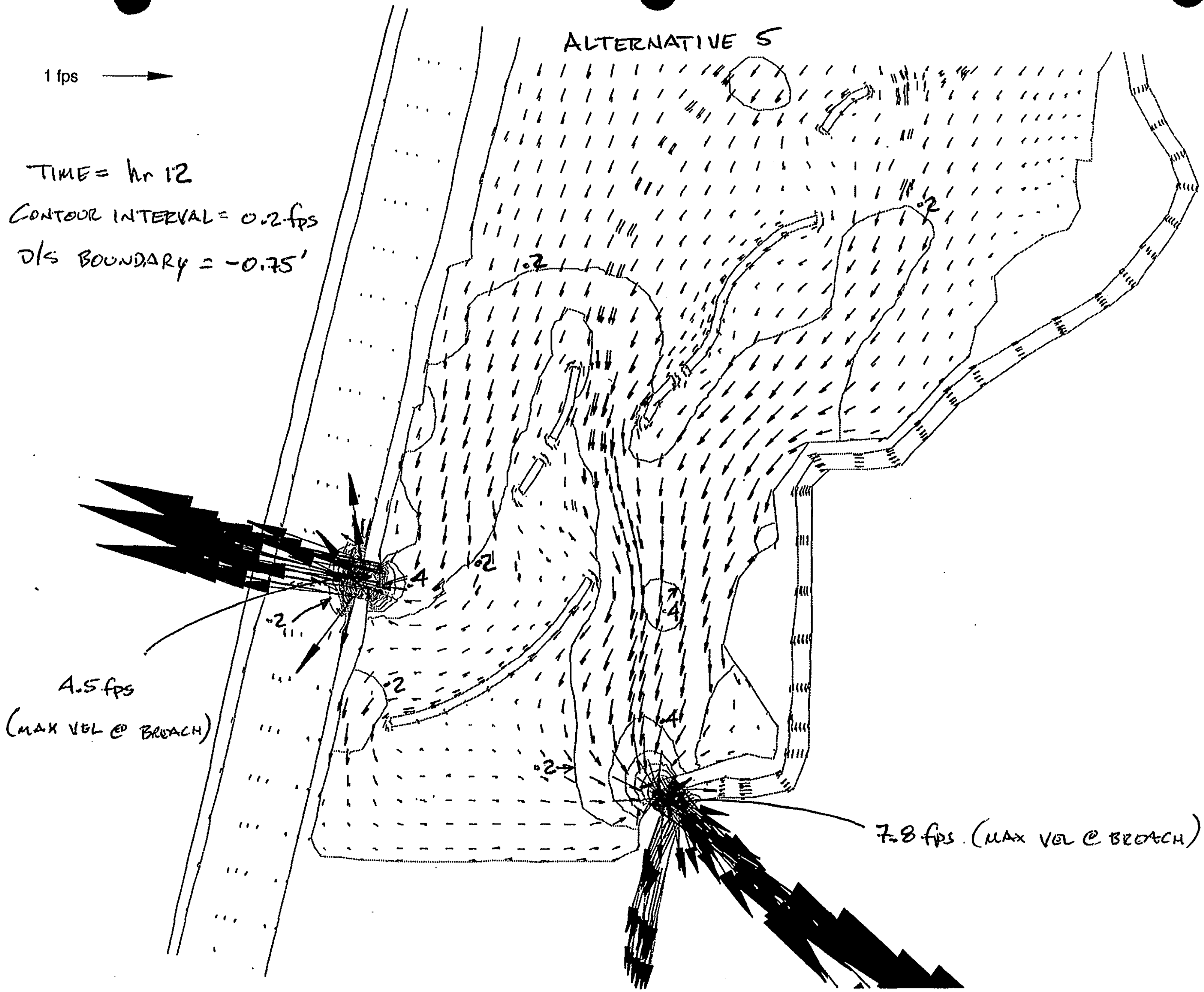

ALTERNATIVE 5
1 fps
TIME = hr 8
CONTOUR INTERVAL = 0.2 fps
D/S BOUNDARY = 1.2'
6.0 fps
(MAX VEL @ BREACH)
5.4 fps
(MAX VEL. @ BREACH)
.2
.4
.6

C-089028

ALTERNATIVE 5

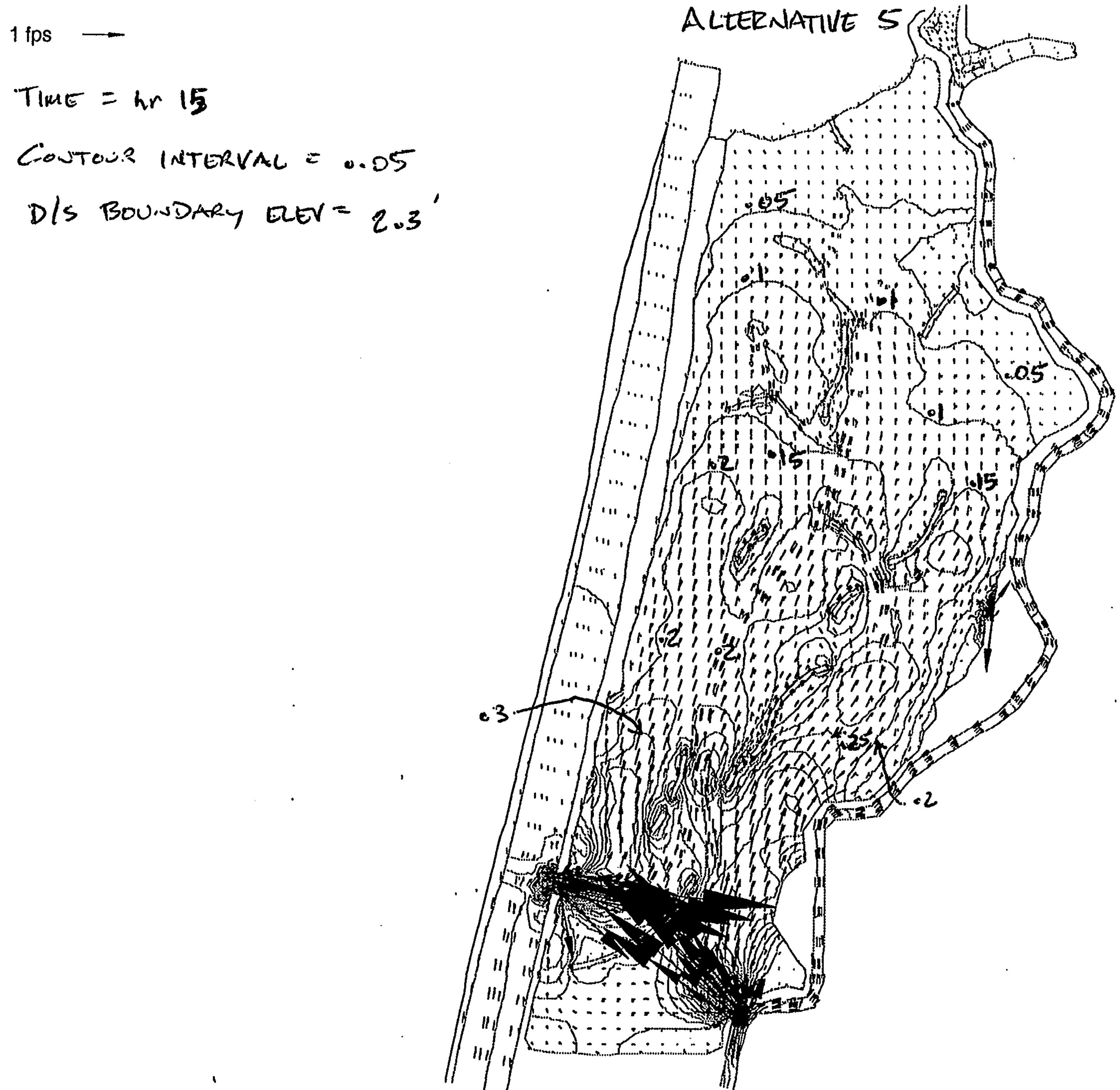


C-089029

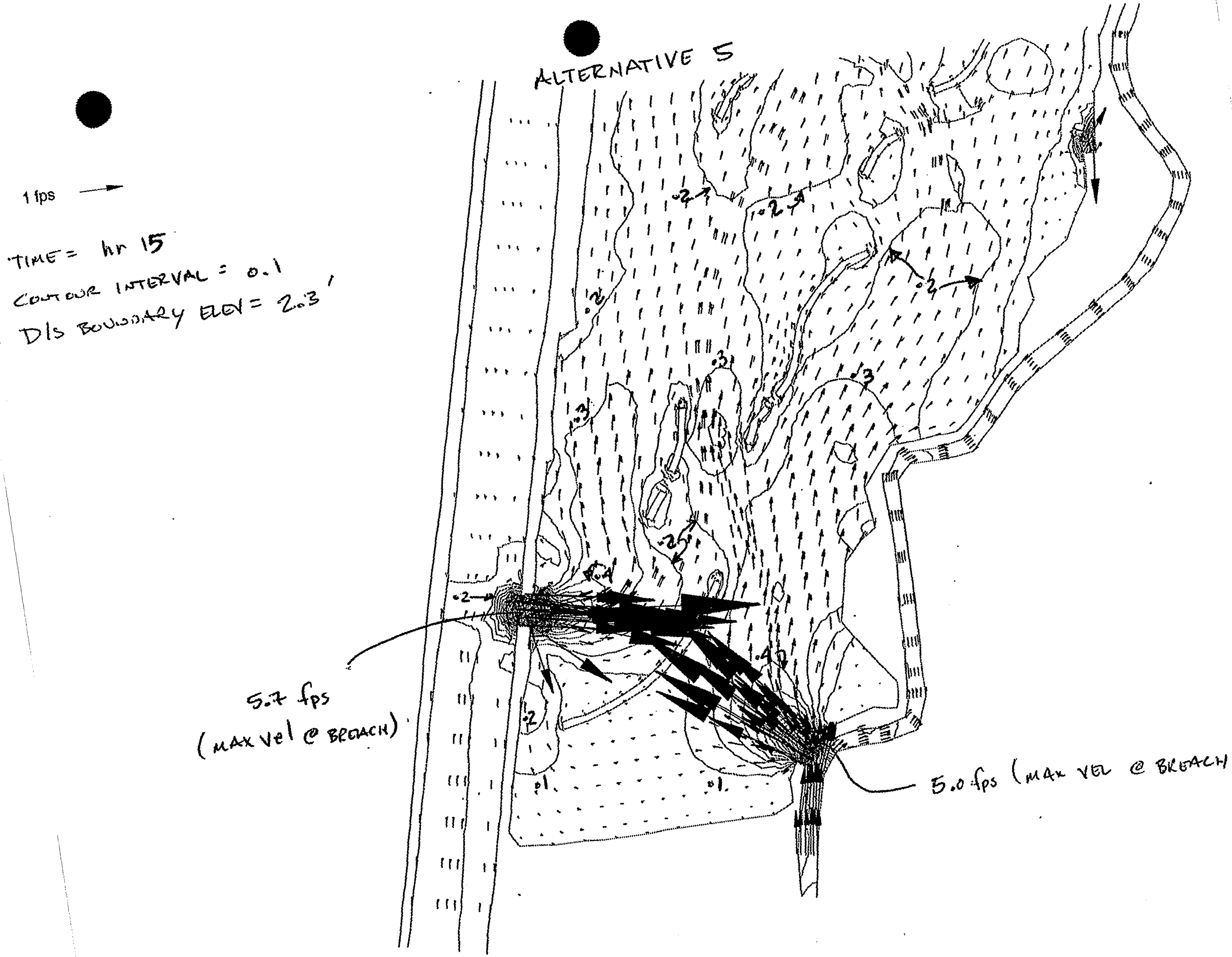

ALTERNATIVE 5
1 fps
TIME = hr 12
CONTOUR INTERVAL = 0.2 fps
D/S BOUNDARY = -0.75'
4.5 fps
(MAX VEL @ BREACH)
7.8 fps (MAX VEL @ BREACH)
.2
.4

C-089030

ALTERNATIVE 5



C-089031



C-089032

C-089032