MONITORING THE EFFECTS OF INTERIM FLOWS FROM GLEN CANYON DAM ON SANDBAR DYNAMICS AND CAMPSITE SIZE IN THE COLORADO RIVER CORRIDOR, GRAND CANYON NATIONAL PARK, ARIZONA

ANNUAL REPORT: 31 JANUARY, 1993

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Cooperative Agreement: CA8006-8-0002

Project Name: INTERIM FLOW SAND BAR SURVEY

Principal Investigator: Dr. Stanley S. Beus

Government Technical representative: Dr. Peter G. Rowlands

Short Title of Work: INTERIM FLOW SAND BAR SURVEY: Annual Report

Effective Date of Cooperative Agreement: 9-1-92

Cooperative Agreement Expiration Date: 1-31-95

Funded by: The U.S. Department of Interior
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Sponsored by: The U.S. Department of Interior
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Northern Arizona University, Campus Box 5614
Flagstaff, AZ 86011

National Park Service Cooperative Agreement: CA8006-8-0002

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INTERIM FLOW SAND BAR
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A. MAJOR ACCOMPLISHMENTS

1. Overview of Project

The Bureau of Reclamation is the lead agency charged with preparing an Environmental Impact Statement on the impacts of Glen Canyon Dam operations on resources downstream in Glen and Grand canyons. Implementation of Interim Flow criteria for Glen Canyon Dam during the EIS preparation period requires that sand bar and campsite conditions be monitored to assess whether degradation of those sediment resources has been stabilized by this action. The present research is a monitoring study designed to evaluate the effectiveness of interim flows in reducing sand bar degradation and camp site loss through dam operations. This project is being conducted through the National Park Service Cooperative Parks Studies Unit at Northern Arizona University in Flagstaff, Arizona, with Dr. Stanley S. Beus as principal investigator, Mr. Matthew Kaplinski and Joseph E. Hazel Jr. as research associates, Linda A. Tedrow as a graduate research technician, Lisa Kearsly as campsite size investigator, and Dr. Peter G. Rowlands as government contracting officer.

2. Objectives

A. Monitor subaerial and subaqueous sand bar topography on an annual basis on 30 representative sand bars in the Colorado River corridor downstream from the Glen Canyon Dam during the interim flow period.

B. Compare topographic change on sand bars from July, 1991 to September, 1991, October/November, 1991, October, 1992 and October, 1993.

C. Determine how interim flows are affecting beach size, morphology, and camping area.

D. Assist in compilation of the above data for the GCES/NPS Geographic Information System (GIS).

E. Compare topographic change on sand bars from October, 1992 to February, 1993 and asses the sand bar dynamics due to a large flooding event in the river corridor.

3. Accomplishments

The sand bar survey portion of this study has successfully completed one river survey expedition from October 15 to November 3. The data collected included topographic and bathymetric data from 30 sand bar study sites along the Colorado River corridor (Table 1). In this report, we present the results from 27 of the 30 sand bars surveyed.

Data collection for the campsite size portion of this study has consisted of one river trip during September, 1992. During the trip, 111 campsites; 77 of which were in critical reaches, and 34 of which were in non-critical reaches were measured. Gross changes in campsite size area were assessed and tallied to prepare a descriptive analysis of changes in campsite area since implementation of interim flows.

B. PROBLEMS ENCOUNTERED

One problem has occurred that involved an increase in processing time required for the bathymetric data collected on our Oct.15-Nov.3 survey trip. Because delivery of the HYDROGRAPHICS SURVEY PACKAGE did not occur in time to include the equipment on our river trip, we were forced to modify existing bathymetric survey protocol to meet our survey goals. As a result, processing time of the bathymetric analog profiles was increased by 250%; an increase that we had not

accounted for in our original budget. The problem was solved by submitting a budget modification, which has subsequently been approved, that requested the re-allocation of funds from equipment to personnel to cover additional processing/analysis time. An additional delay in processing time was incurred during the geology departments move to Friar Hall, during which the department's computing facilities were inoperative for approximately 2 weeks.

C. FISCAL STATUS

1. Cooperative Agreement Amount: $293,769.00
2. Expenditures and Commitments to Date: $82,630.93
3. Estimated Funds Required to Complete Work: $211,138.07
4. Estimated Date of Completion of Work: 1-1-95

   Final report, final management report,
   final oral report ..... 1 January, 1995

D. ACTION REQUESTED OF NPS

1. Continued support of this project during the analysis and report preparation phases is requested of the NPS.

E. FUTURE PLANS

1. We are presently on schedule with this project and will be following the timetable for completion of tasks and deliverables.

Table 1: Schedule for completion of tasks and deliverables for sand bar studies in the Grand Canyon.

DELIVERABLE(S)	DUE DATE
Pre-study Oral Presentation, secure equipment, conduct crew training for field data collection	1 August,1992
First quarterly report (QR)	1 October, 1992
First sampling trip	1-18 October, 1992
Annual progress report, annual management report	31 January 1993
Second sampling trip	15 February 1993
QR	1 April, 1993
QR	1 August, 1993
QR	1 October, 1993
Third sampling trip	1-18 October, 1993
Annual progress report, annual management report	31 January 1994
QR	1 April, 1994
QR	1 August, 1994
Draft final technical and management reports	1 October, 1994
Final report, final management report, final oral report	1 January, 1995

F. PRELIMINARY RESULTS

Sand Bar Surveys

We have collected topographic and bathymetric data from 30 sand bars during survey river trips in September, 1991, November, 1991, and October, 1992, in order to compare changes in sand bar morphology due to Glen Canyon Dam interim flow operations (Figure 1). This report presents preliminary results from the 1992 surveys and compares these results with the 1991 interim flow surveys and the surveys of Beus et al. (1992). Following the methods of Beus et al. (1992), we have calculated the sediment volume within what we term the "hydrologically active zone" (HAZ), that portion of the sand bar exposed to the range of dam operations (142-850 m^3/s).

Sediment Volume Within the HAZ

Surveys conducted shortly after the onset of interim flows show a system-wide negative response of sandbar HAZ to the new discharge pattern (Figure 2). After 14 months of low and high volume interim flows the response was as follows: of the 27 beaches evaluated, 59 % (16) have lost sediment volume within the HAZ, 26% (7) have gained volume, and 15% (7) have remained the same as compared to volumes calculated from the survey previous to the onset of interim flows (Figure 2). Among the different deposit types sampled, reattachment bars showed the most significant HAZ volume increases (-6, 2.6, 87, 93 mile), while separation deposits showed the most volume loss (e.g. 45, 50, 202 mile). HAZ volume was increased in every reattachment bar case by deposition below the maximum interim flow stage elevation along the upstream portion of the bar platform.

Deposition at these lower stage elevations can result in a situation where the HAZ plan area is increased, while HAZ volume decreases. A preliminary analysis of the relationship between volume vs. area change has shown that an analysis of area change alone accounts for only 70% of the change within the HAZ, perhaps, in part due to the aforementioned circumstances.

Sand Bar Profiles

Figures 3 to 6 present profiles from several of the study sand bars and demonstrate several relationships inferred from the HAZ volume analysis. Lower stage elevations of the interim flows have resulted in erosion of the upper portion of the bar by the development and subsequent shoreward migration of cutbanks along the shoreline (e.g. Figures 3, profile 5; Figure 4, profile 4). Obviously, sediment lost from higher elevations cannot be replaced by interim flows because of their lower stage elevations. Figures 5 and 6 demonstrate ~~that~~ deposition occurring within the range of interim flow stage elevations along reattachment bar platforms and can account for significant HAZ volume increases. Deposition within these recirculation zones also includes sediment in-filling of eddy return channels (Figure 4, profiles 1 & 2; Figure 5, profile 5 & 6).

Campsite Size Study

Of the 111 reevaluated campsites, 15 camps, all in critical reaches, consist entirely of campsite area which is well above 850 m^3/s. Since these camps are above the HAZ during interim flows and during non-flood years of fluctuating flows, they were not directly influenced by interim flows and will not be evaluated with the rest of the campsites.

Ninety six campsites, 63 in critical reaches, and 33 in non-critical reaches have campsite area below 850 m^3/s and will be evaluated here. Of these sites, 13 have increased in size, 44 have decreased in size, and 39 have remained the same size (Table 2).

TABLE 2. CAMPSITE SIZE CHANGES

	CAMPSITE AREA		
	INCREASE	DECREASE	SAME
ALL CAMPS Percent (number) n=96	13% (13)	46% (44)	41% (39)
CRITICAL REACHES Percent (number) n=63	11% (7)	54% (34)	35% (22)
NON-CRITICAL REACHES Percent (number) n=33	18% (6)	30% (10)	52% (17)

Decrease in Size

Nearly half (46%) of the camps have decreased in size. A higher percentage of these camps occur in critical reaches (54%) than non-critical reaches (30%); however, these and other differences in number between critical and non-critical reaches are not significant ($X^2_{2df} = 4.86$, $X>0.05$).

The campsites which decreased in size can be broken down into several categories, which are as follows:

Gone	3
Large decrease	4
Moderate decrease	22
Slight decrease	8
Still very large camps	7
Total	44

Campsites which are "gone" are those which have lost sufficient sediment so that they no longer fit the 1992 campsite definition; the definition states that there needs to be space sufficient for 10 or more people plus a standard kitchen and toilet in a non-emergency situation (Kearsley and Warren 1992). All three campsites categorized as "gone" were in critical reaches where campsites are scarce. Campsites categorized as "large decrease" have lost approximately one half of the campable area measured in 1991. All four campsites with this categorization are also in critical reaches.

Campsites categorized as "slight decrease" have lost small portions of campable area and have not decreased in carrying capacity. Often, the areas which have eroded were suboptimal and had little recreational value.

Campsites which are "still very large camps" are those which have capacity far exceeding the maximum allowable group size of 36 people; decreased area in these campsites does not affect the sites' carrying capacity, as they can still accommodate more than 36 people. These campsites are in both critical reaches and non-critical reaches.

In addition to the above 44 campsites which have decreased in size, 14 sites have also decreased in size from flash floods. In these sites, gullies or drainages had formed since 1991 in what had been campable areas. These sites were not included with the others that have decreased in size because their loss of sediment was not directly related to interim flows.

Increase in Size

Thirteen percent of the campsites increased in size (Table 2). There is a trend for a greater percentage of camps in non-critical reaches to increase in size than critical reaches; however, as with the decreased sized camps, this difference is not significant.

The campsites which increased in size can be broken down into the following categories:

Slight increase	4
Moderate increase	3
Low water increase	6
Total	13

Campsites categorized as "slight increase" have slight increases in the amount of campable area; these increases, however, are too small to increase the carrying capacity of these camps. Campsites categorized as "low water increase" have new campable area available only below 425 m^3/s. These areas would not be useable unless flows remained well below 425 m^3/s.

Discussion

Both the amount of sediment within the HAZ and the area available for camping have decreased since the beginning of interim flow operations from GCD. Our observation is that sediments are being eroded from the higher elevation portions of the sand bars and that deposition, not necessarily of the same sediment, is occurring along the lower portion of the sand bars below the maximum elevation of interim flows (Figure 8). This observation is not surprising when considering that interim flow operations have exposed a greater portion of the sand bar to erosion by cutbank development, side channel flash flood/heavy precipitation events, wind deflation, as well as human impacts. Continued interim flow operations can be expected to result in continued erosion of the upper portions of the sand bars resulting in a loss of both camping area and wildlife habitat.

Deposition is occurring along the lower portions of sand bars within the interim flow tidal range and subaqueously as well. Our preliminary analysis indicates that, while HAZ volumes are generally decreasing, sediment is accumulating within recirculation zones at, or below the level of the HAZ. The primary goal of the interim flows was to maintain sediment storage in the river system. We have observed sediment accumulation in recirculation zones which suggests that interim flow objectives are being met. However, the erosion of sediment resources at higher bar elevations cannot be replaced by interim flows. In addition, deposition within the recirculation zone is filling in return channels, thereby destroying native fish habitat. Based upon these observations, we believe that periodic bar-building floods released from the GCD will be required to deliver sediment at higher sand bar elevation and increase the erosive power of recirculation currents in an attempt to deflate infilled return channels.

Conclusions

1. Interim flow operations from Glen Canyon Dam have led to erosion of the higher elevation portions of sand bars.

2. Interim flow operations from Glen Canyon Dam have resulted in deposition along the lower portions of some sand bars, particularly reattachment bars, below the maximum interim flow stage elevation.

3. Occasional bar-building "flood flows" are necessary to replace sediments eroded from higher sand bar elevations and for habitat maintenance.

G. INVENTORY OF PROPERTY ACQUIRED DURING THE REPORT PERIOD

QUANT.	DESCRIPTION
2	notebook microcomputer P.C.'s
2	Math Co-processor chips
1	Color Monitor
2	extra notebook microcomputer batteries
1	microcomputer battery charger
1	port replicator
1	101 keyboard
100	3.5" 1.4Mb computer diskettes
1	Hewlett Packard 42S scientific calculator
2	notebook keyboard covers

H. ANNUAL MANAGEMENT REPORT

The following summary of expenditures indicates the partitioning of the funds allocated to this project. Detailed worksheets are also on file in addition to the formal accounting documents retained by the university. Because of unavoidable delays in processing time, a budget modification was submitted to re-allocate funds from equipment to personnel.

Sandbar/Campsite Size
Expenditures (actual and emcumbered) thru 12/31/92

	Encumbered	Actual	
Employees (salaries)	$18,420.40	$26,768.89	
Employee Related Expenses	5,832.05	3,732.36	
Category Totals	$24,252.45	$30,501.25	
Total Employee Expenses			$54,753.70
Computer Equipment		$ 6,538.80	
Office/Computer Supplies		$ 1,656.24	
Classroom/Lab/Field Supplies	$ 94.97		
Tools/Tech Parts		$ 120.78	
Film developing/copies		$ 50.52	
Conference/Registration Fees		$ 150.00	
Category Totals	$ 94.97	$ 8,516.34	
Total Operation Expenses			$ 8,611.31
Travel		$ 1,006.92	
Total Travel Expenses			$ 1,006.92
Indirect Costs	$10,322.85	$ 7,936.15	
Total Indirect Costs			$18,259.00

Total Spending Authority	$108,227.00
Total Expenses	$ 82,630.93
Uncommitted Amount	$ 25,596.07

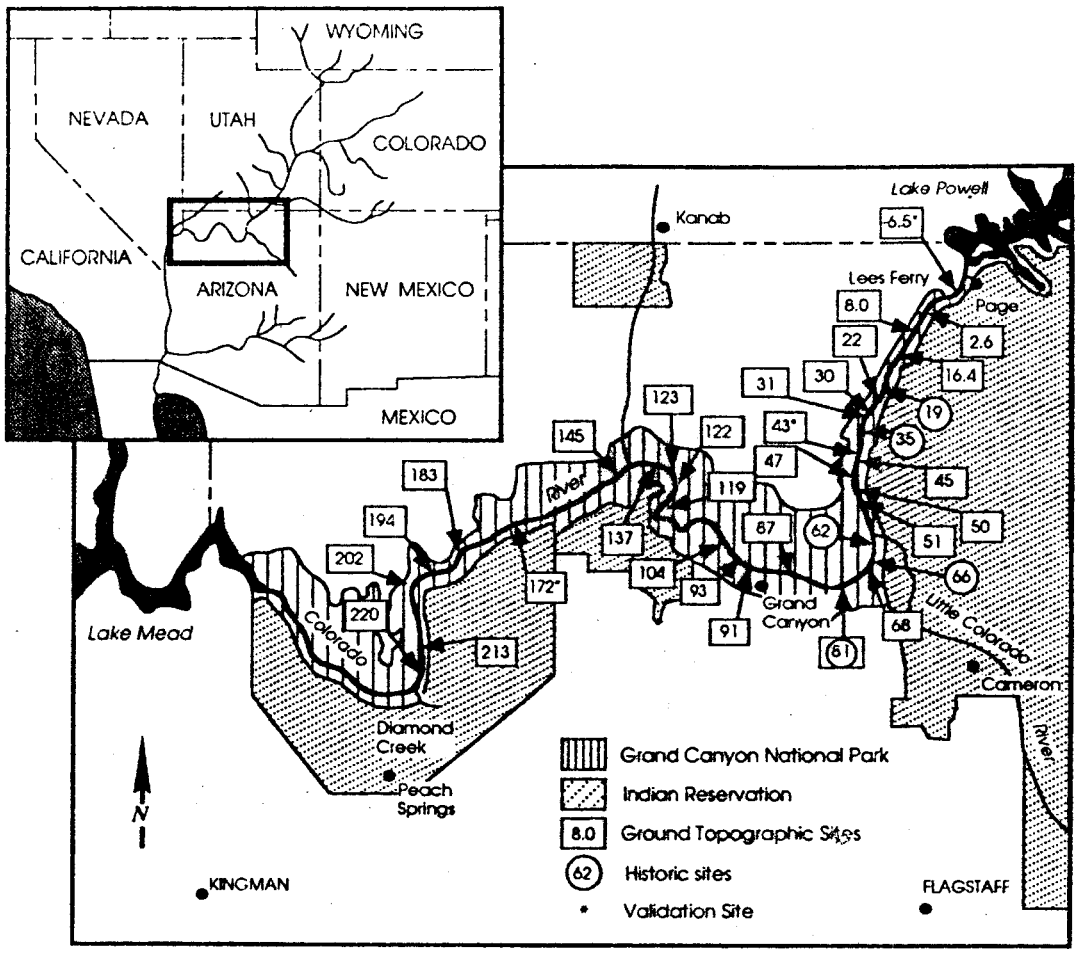


Figure 1. Location map showing study locations

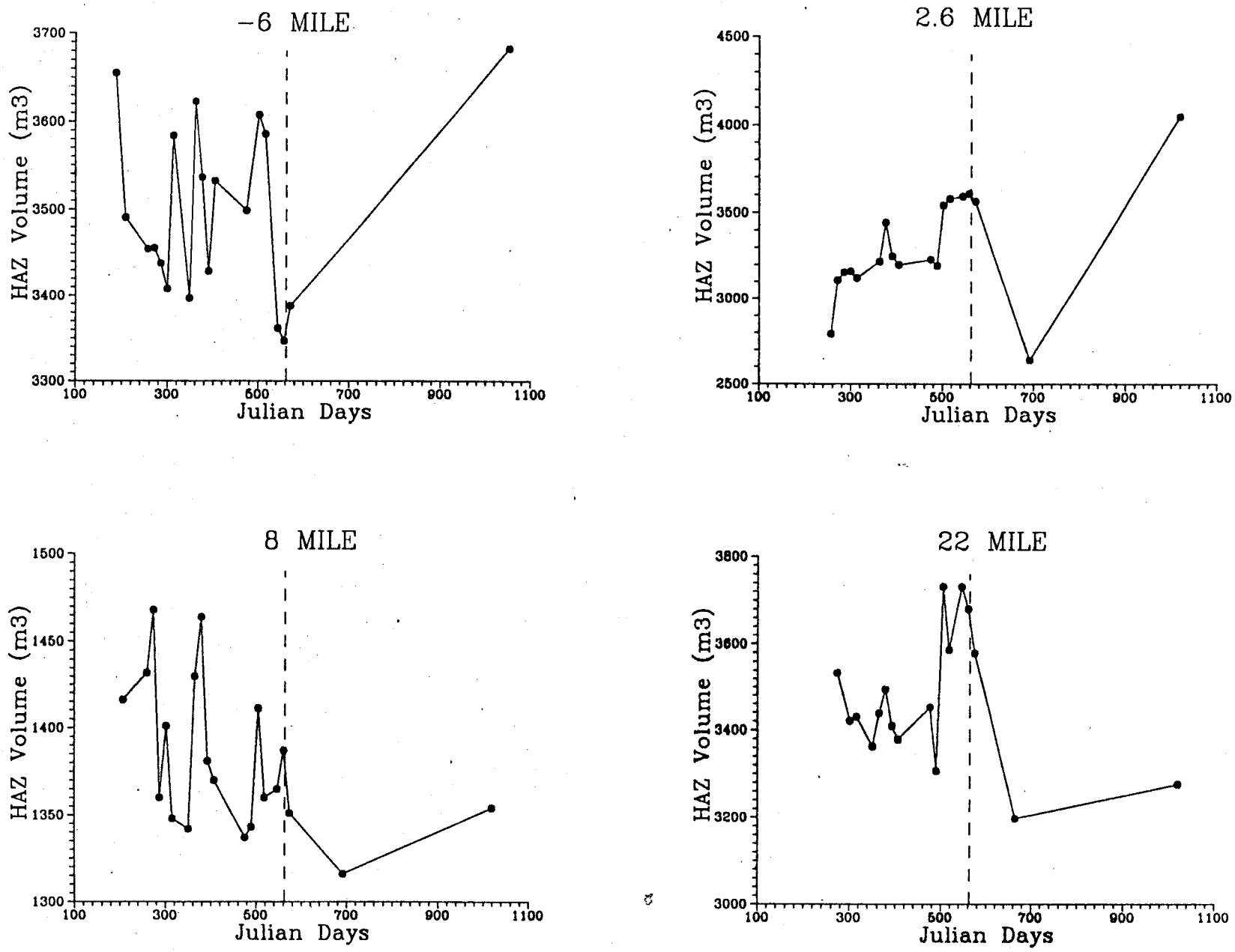
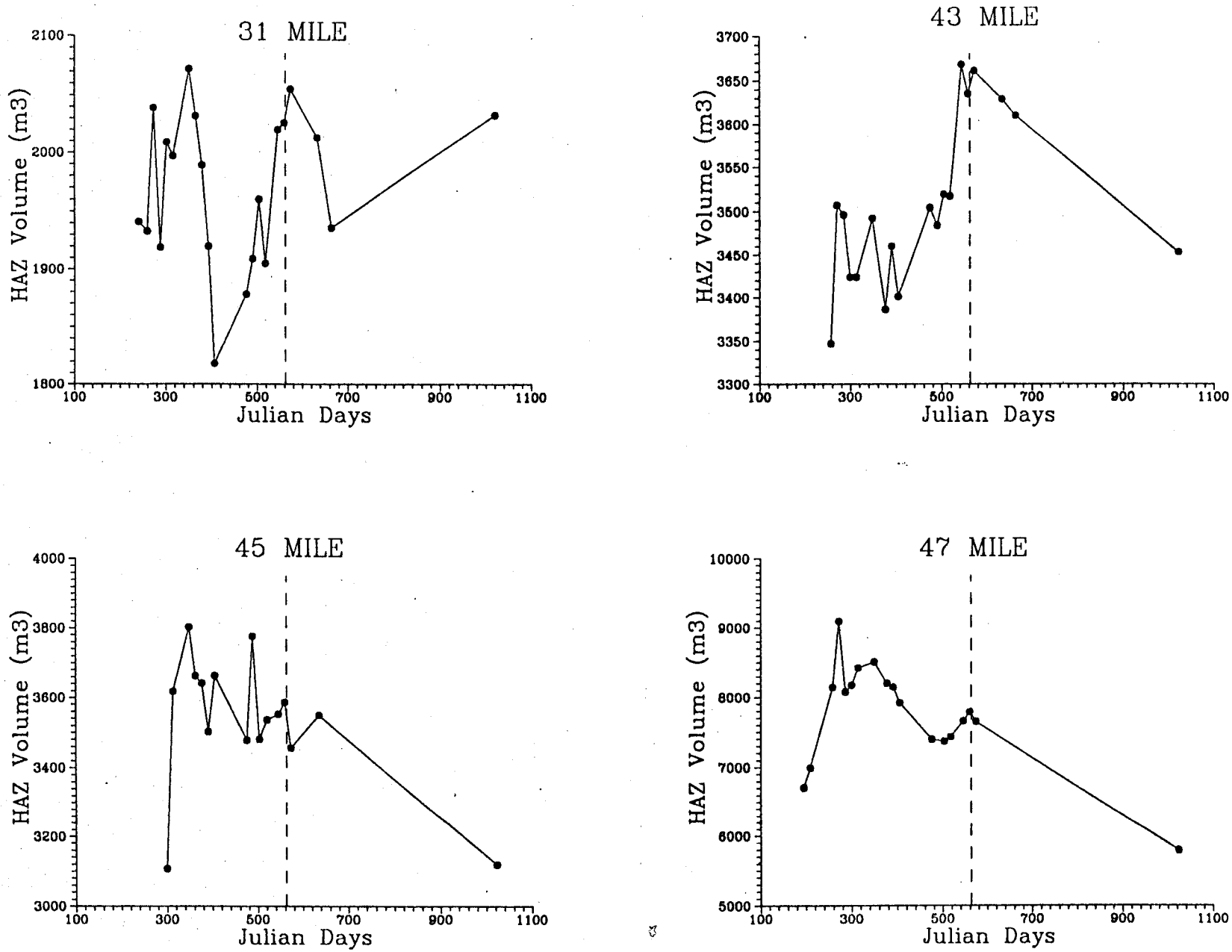


Figure 2. Volume vs. Time plots for 27 sand bars. Vertical dashed line represents the beginning of interim flow operations



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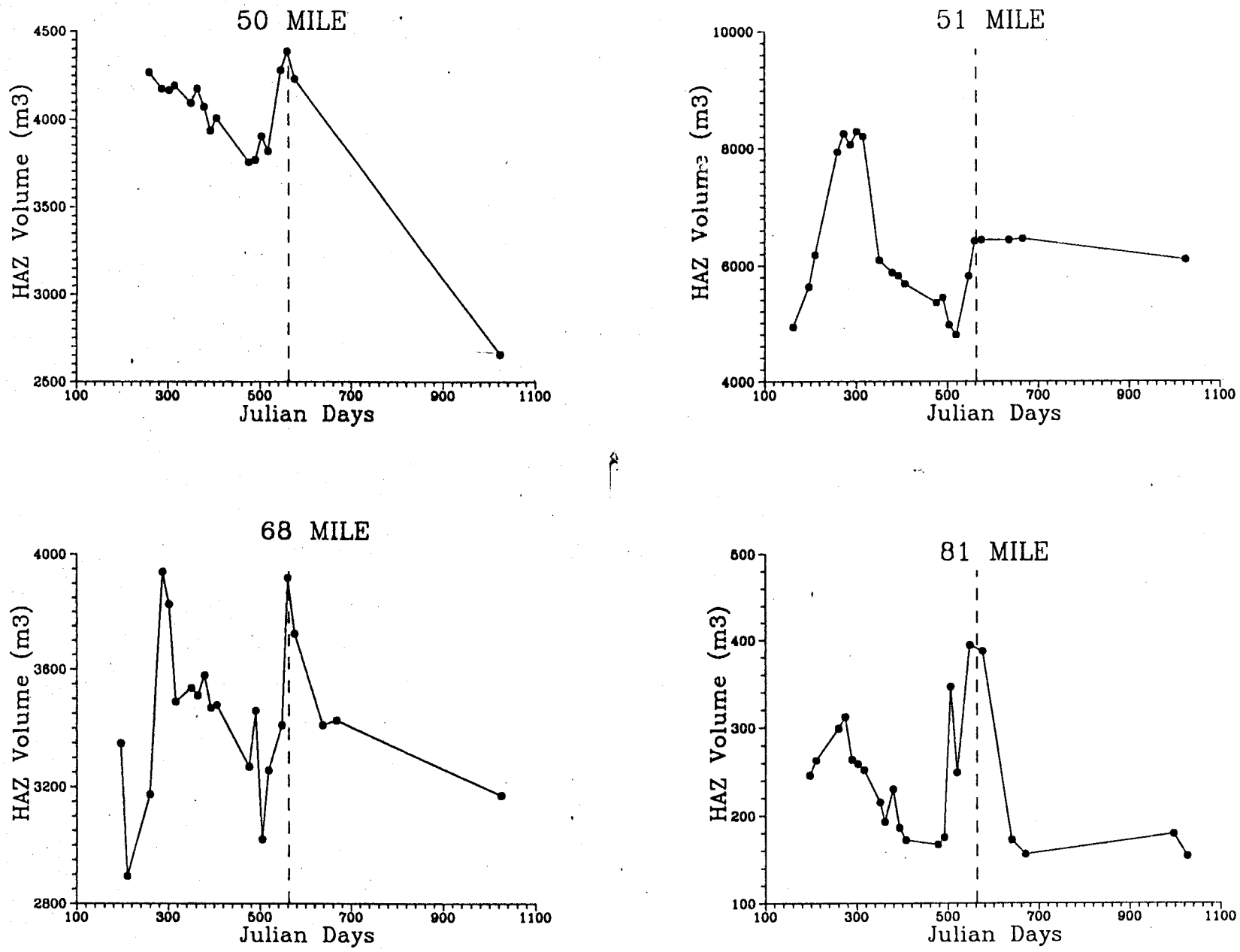

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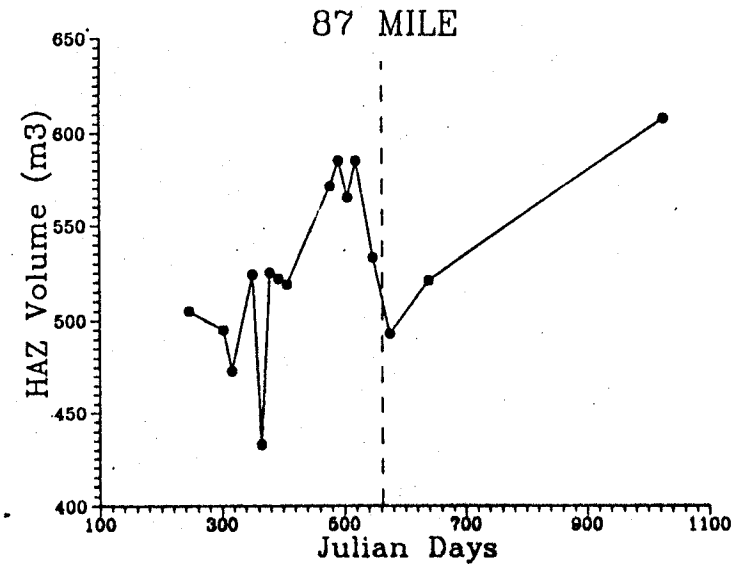

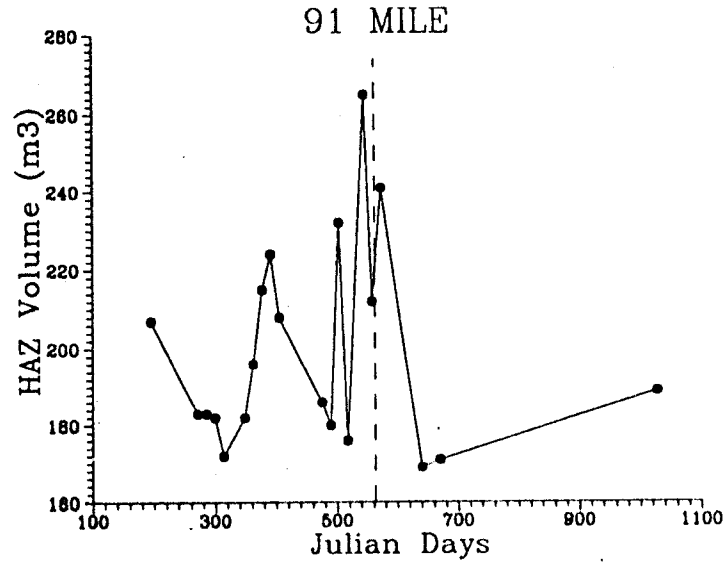

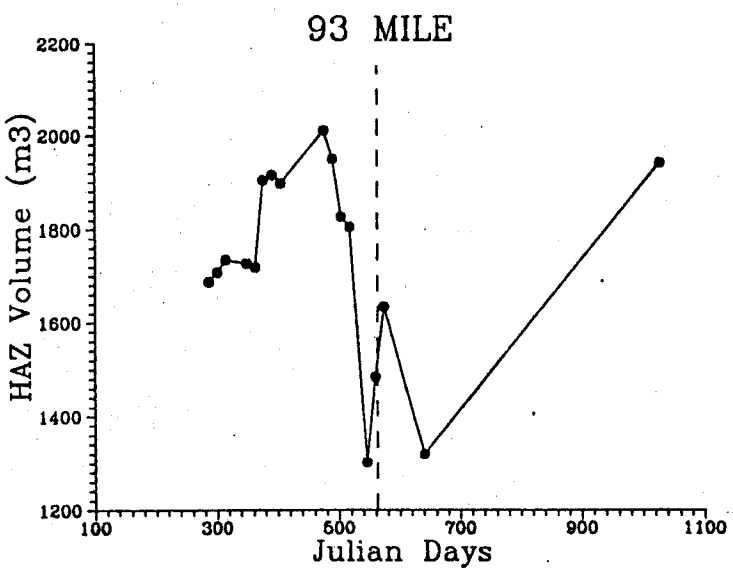

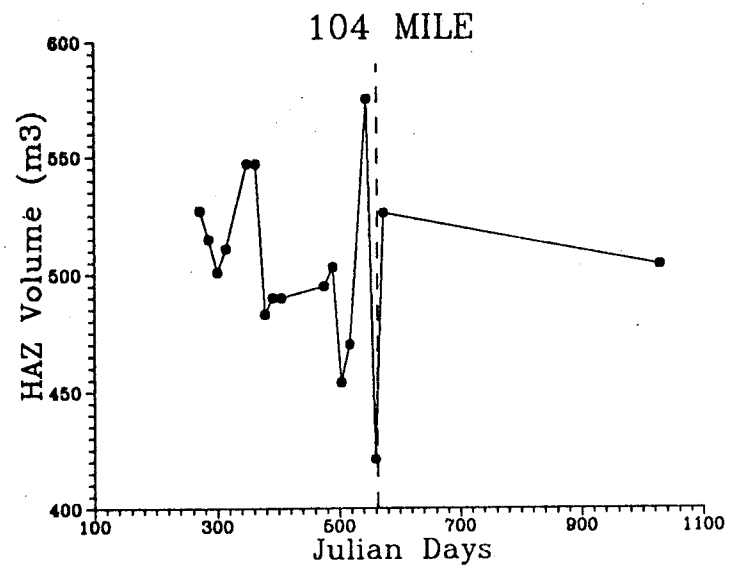

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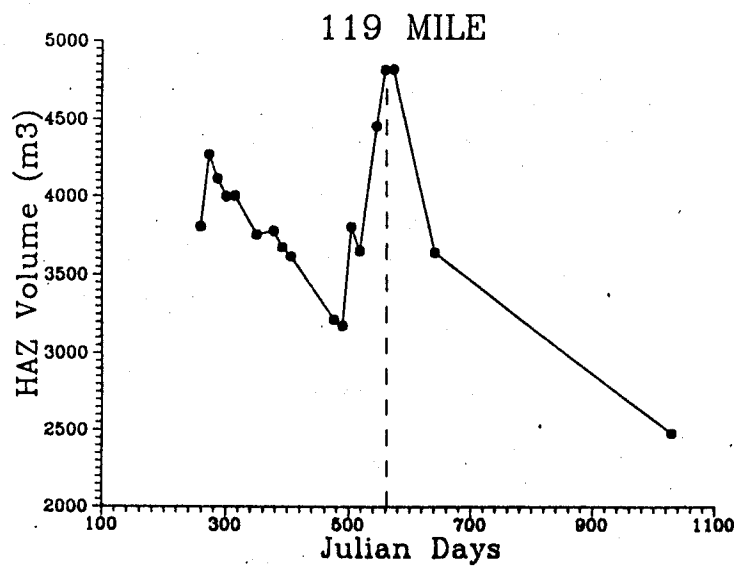

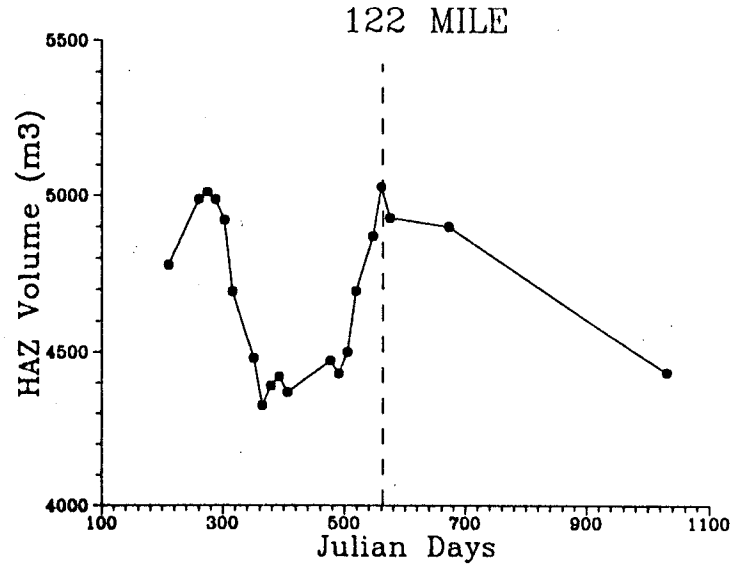

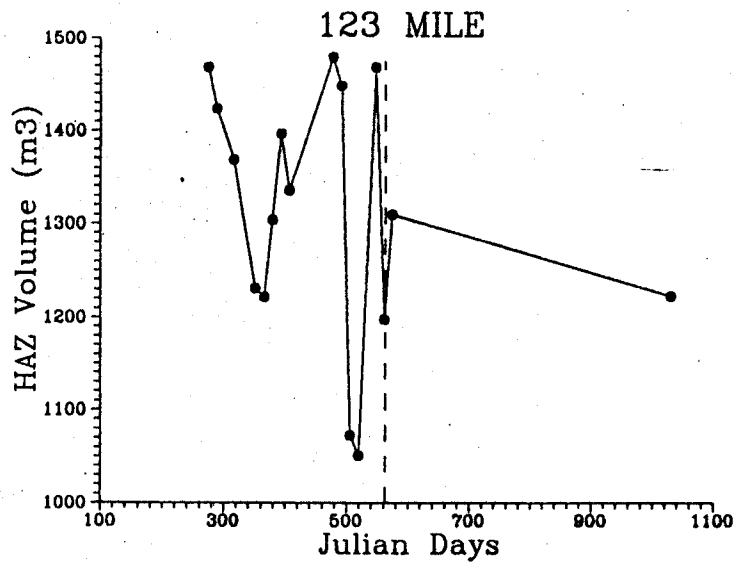

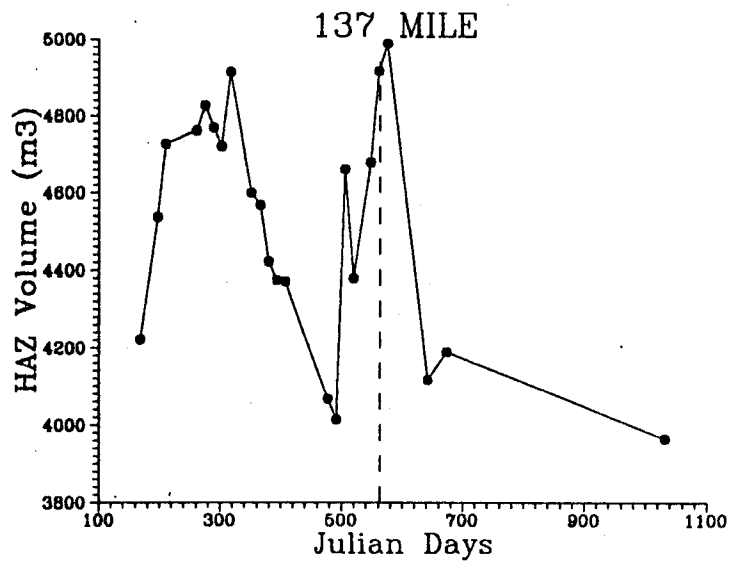

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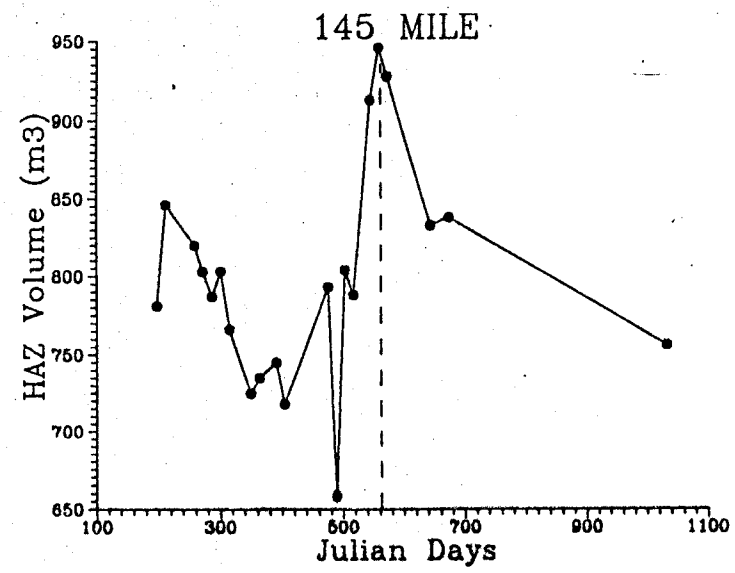

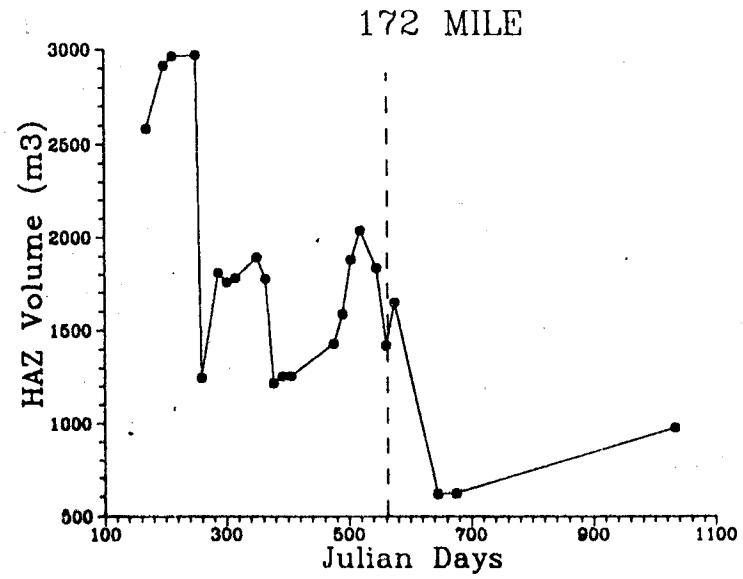

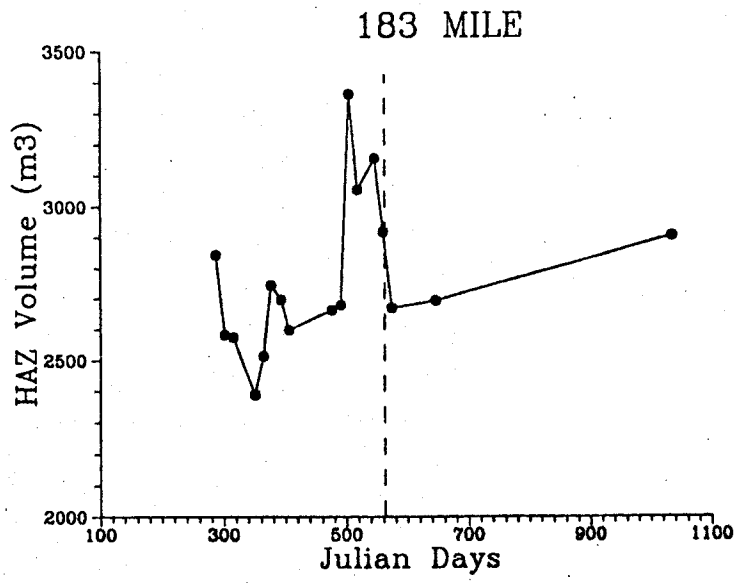

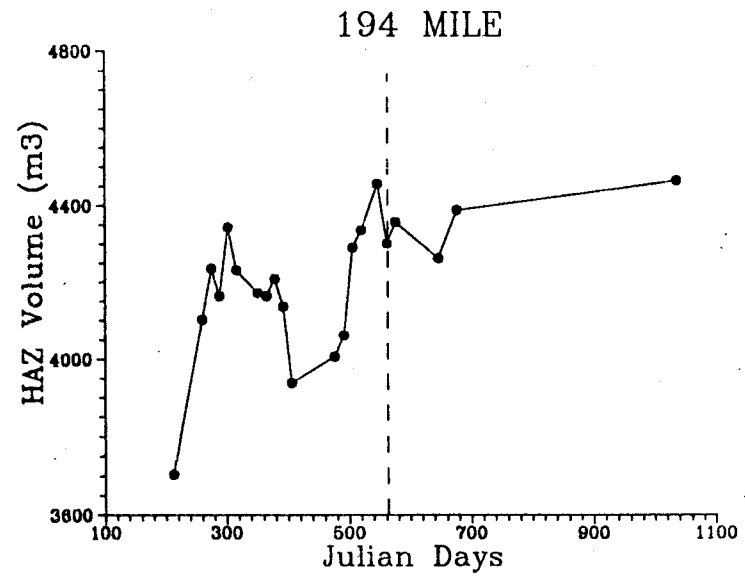

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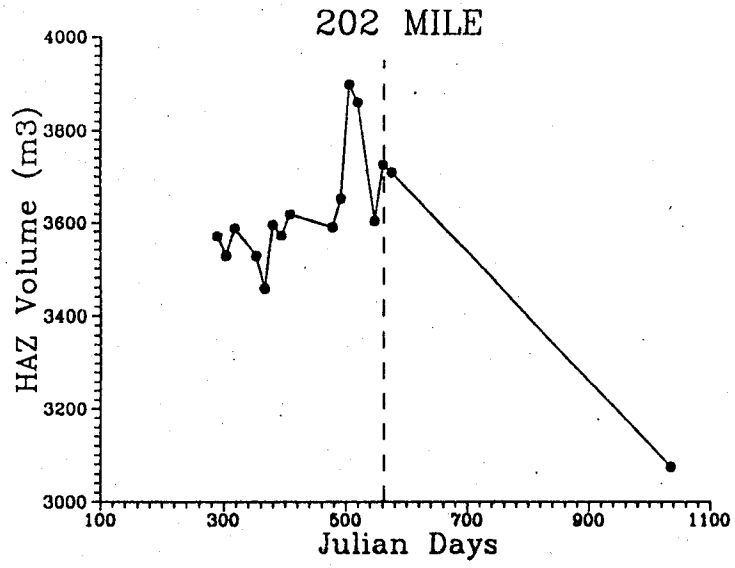

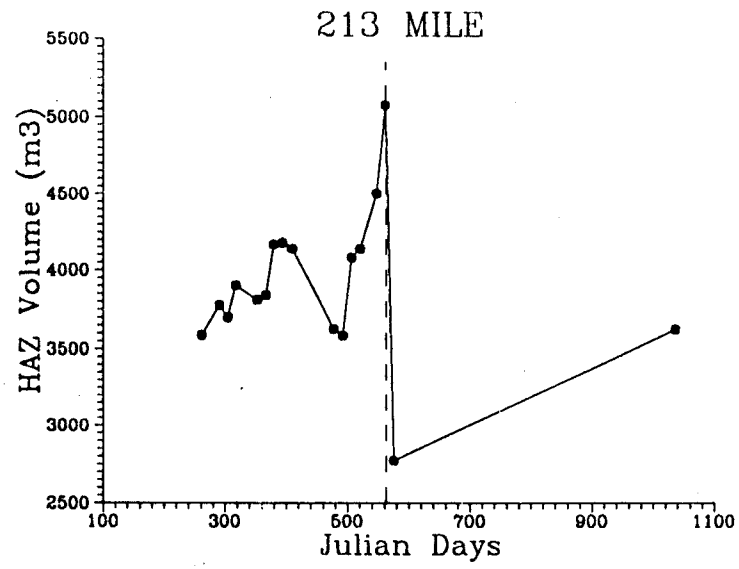

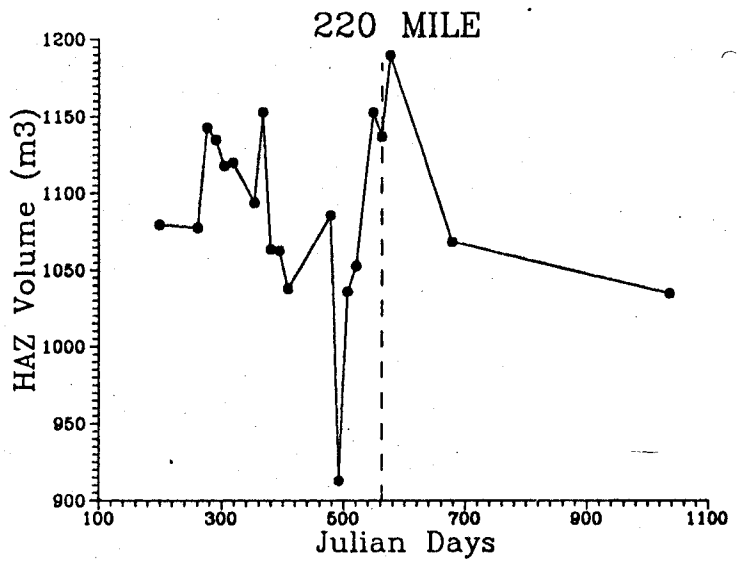

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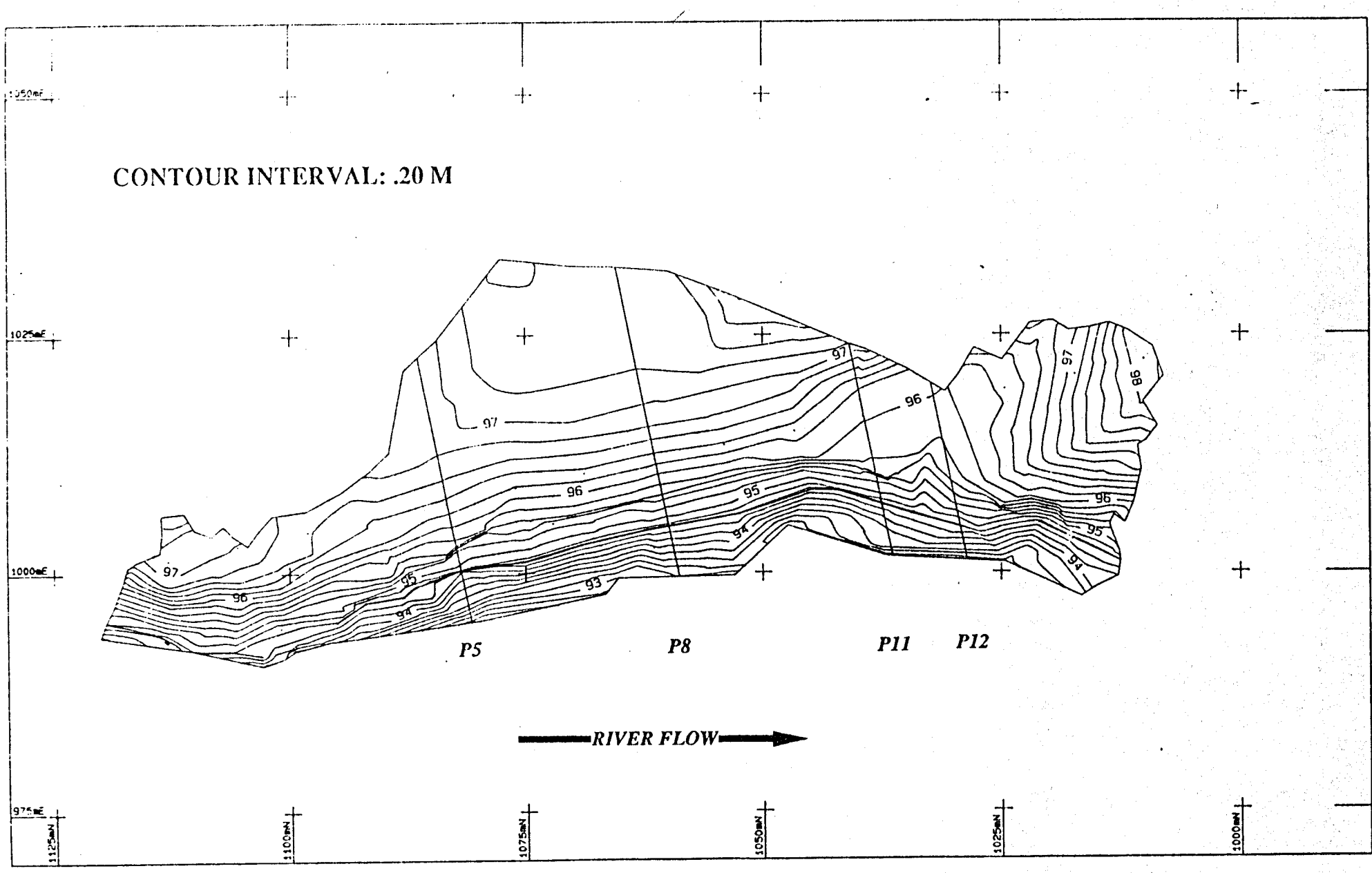
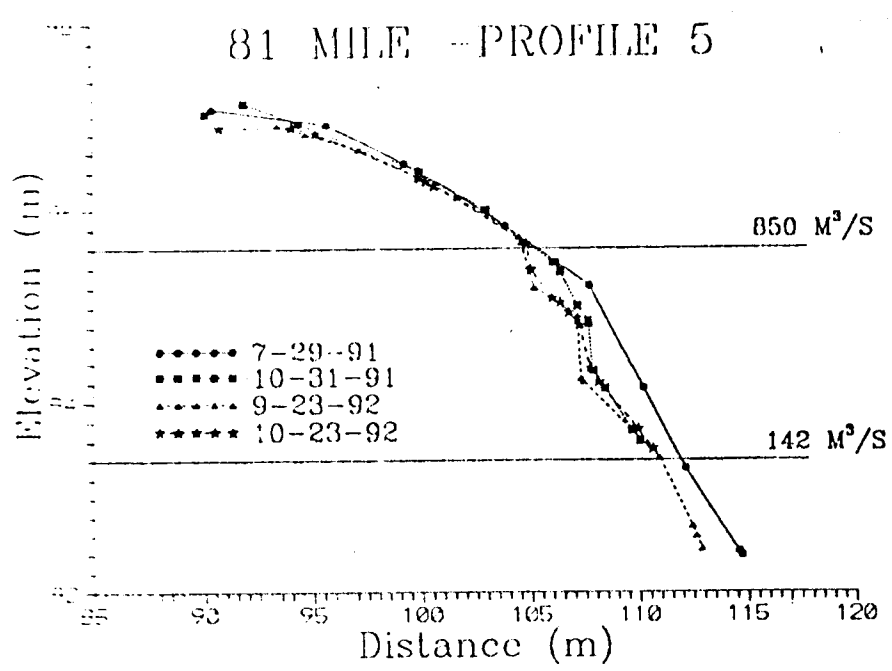
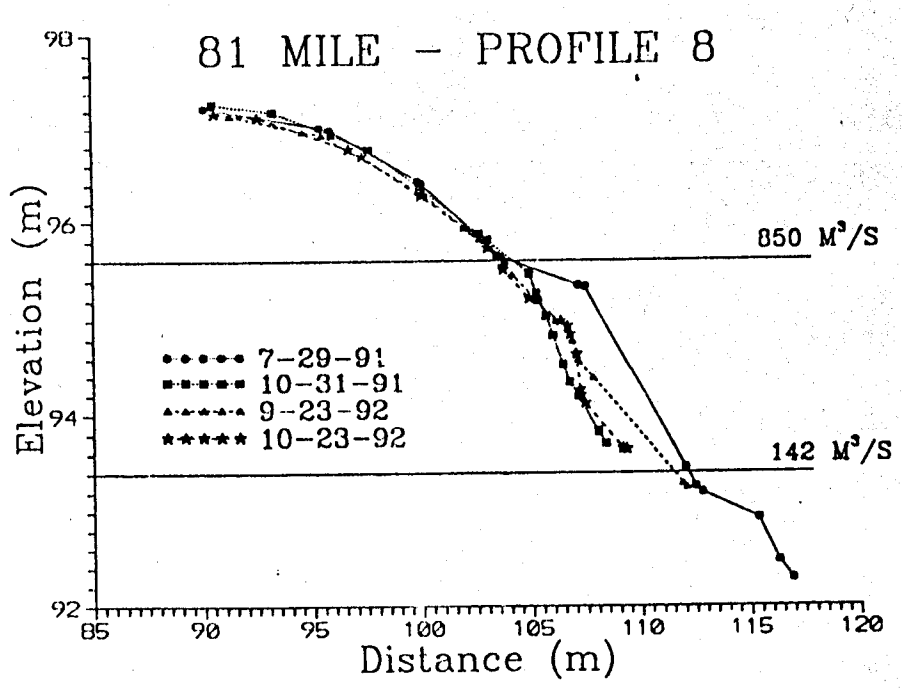
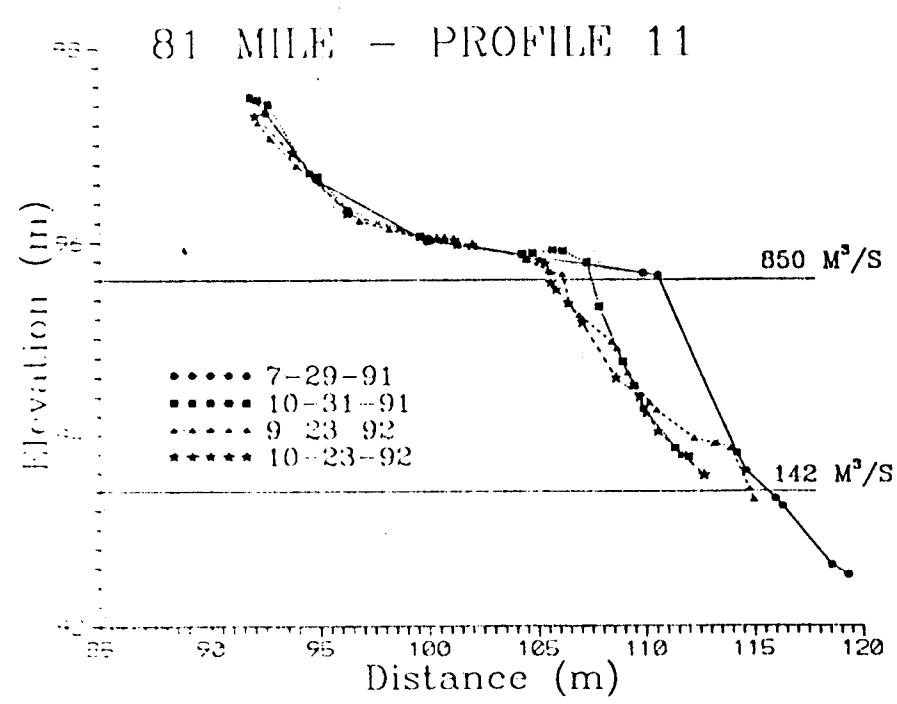








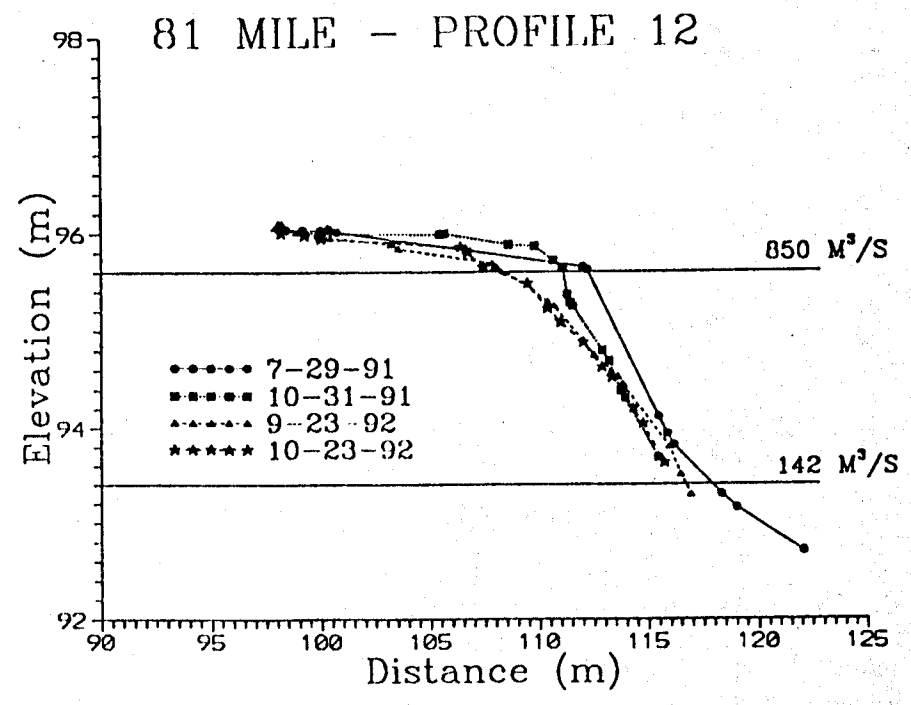
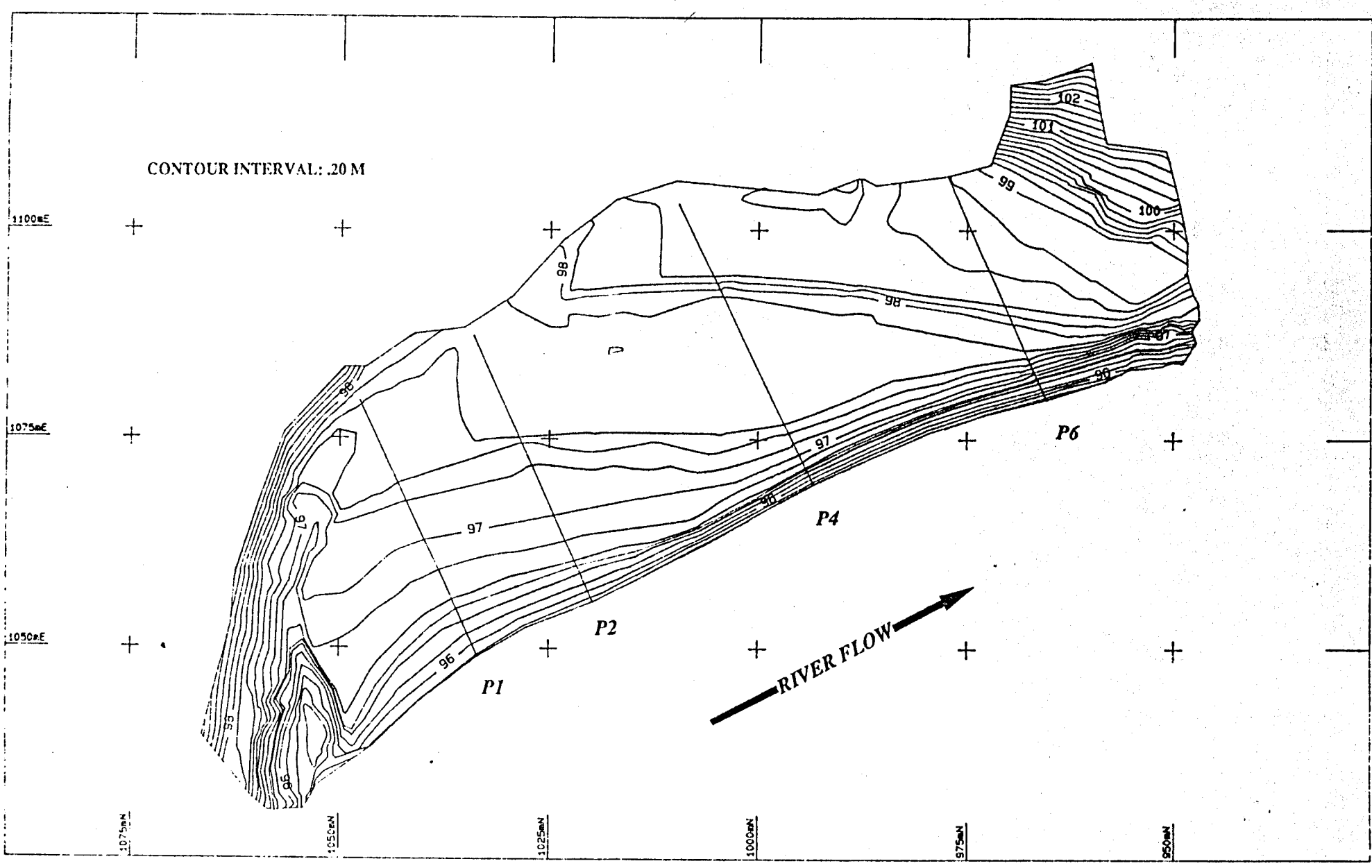
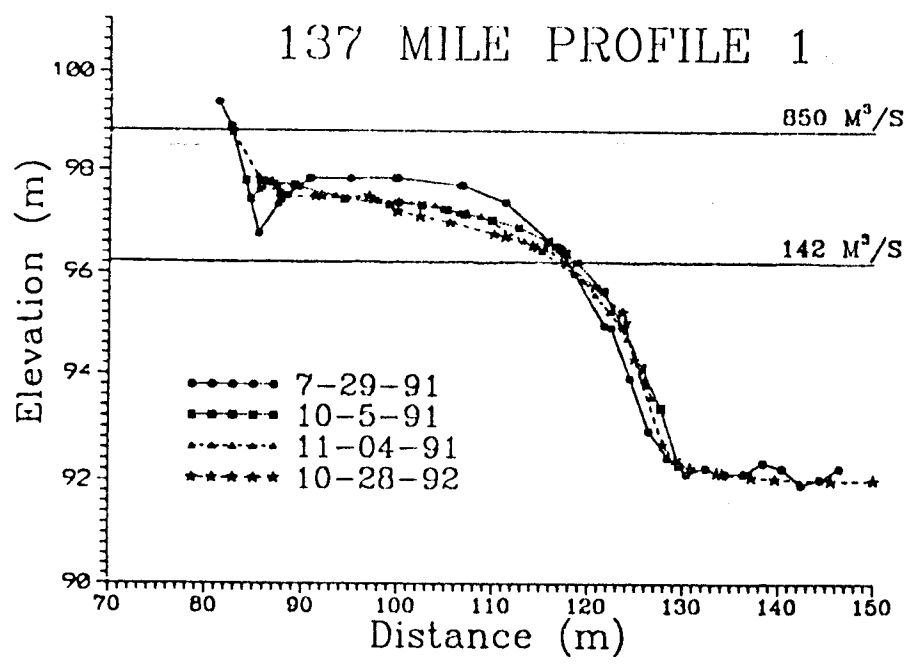
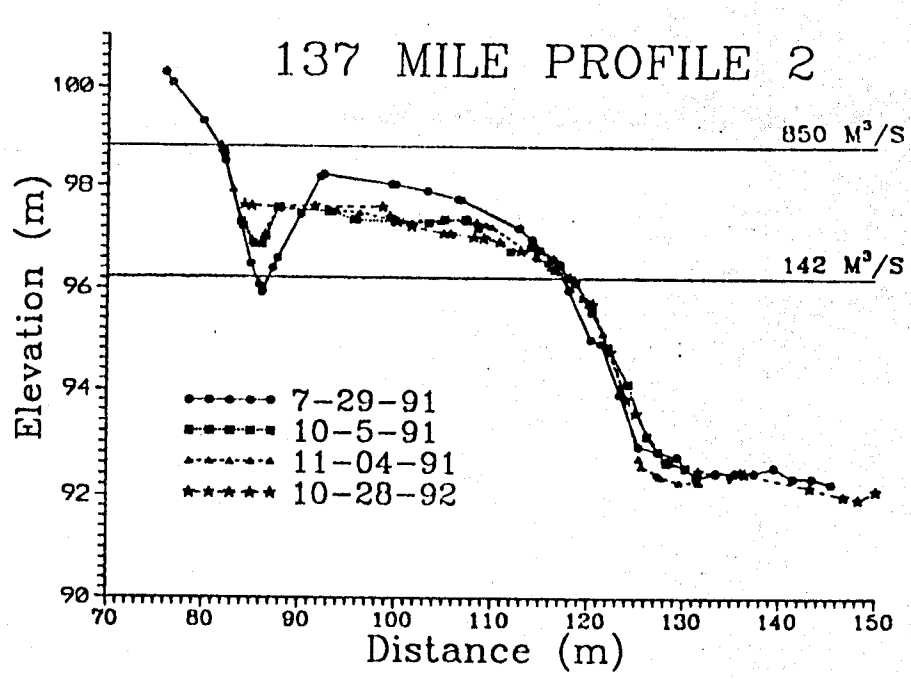
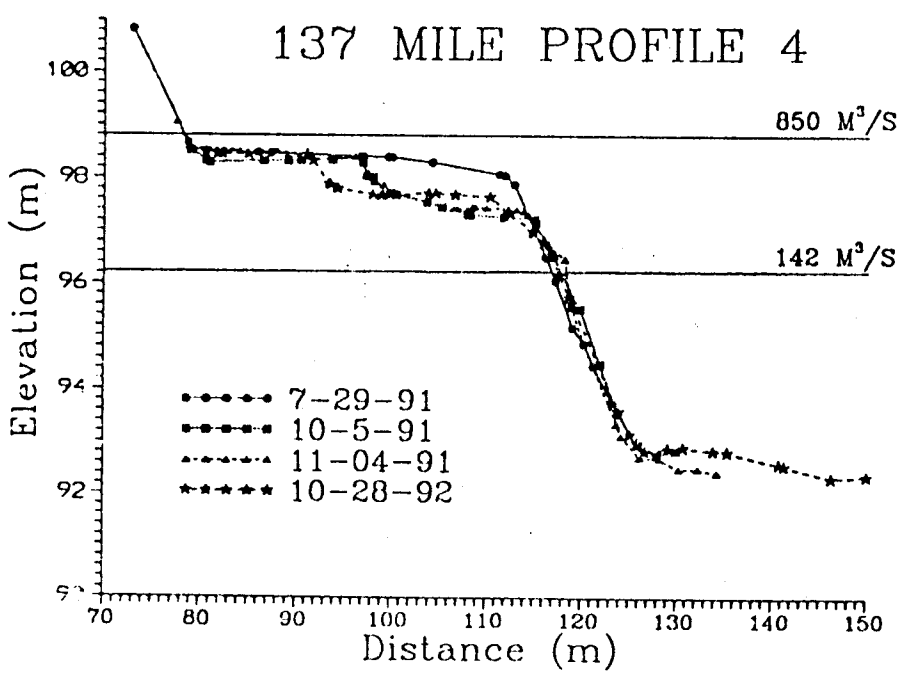


Figure 3. Site map and selected profiles from 81 mile "grapevine camp".









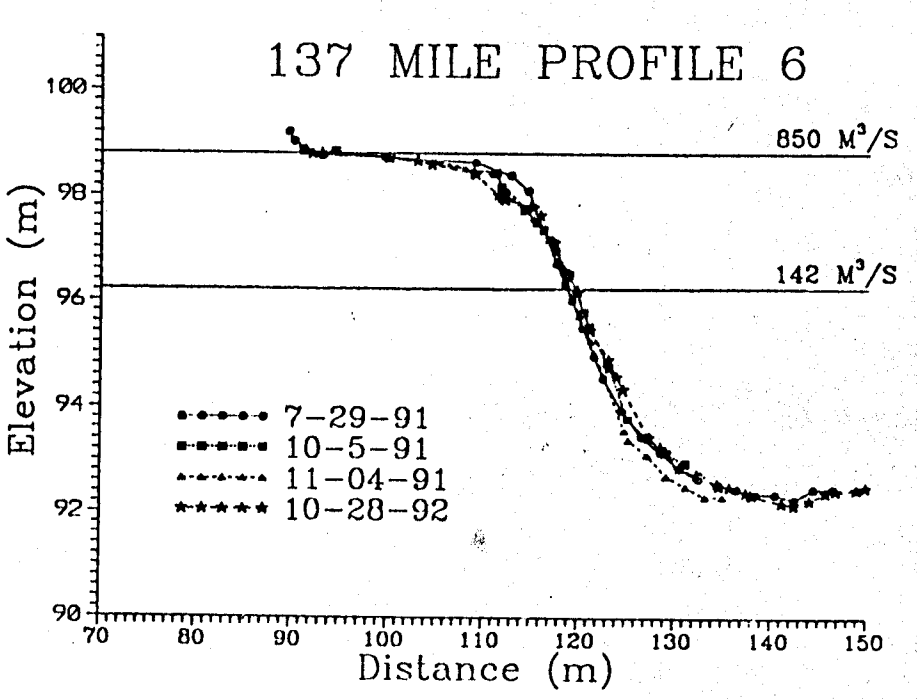
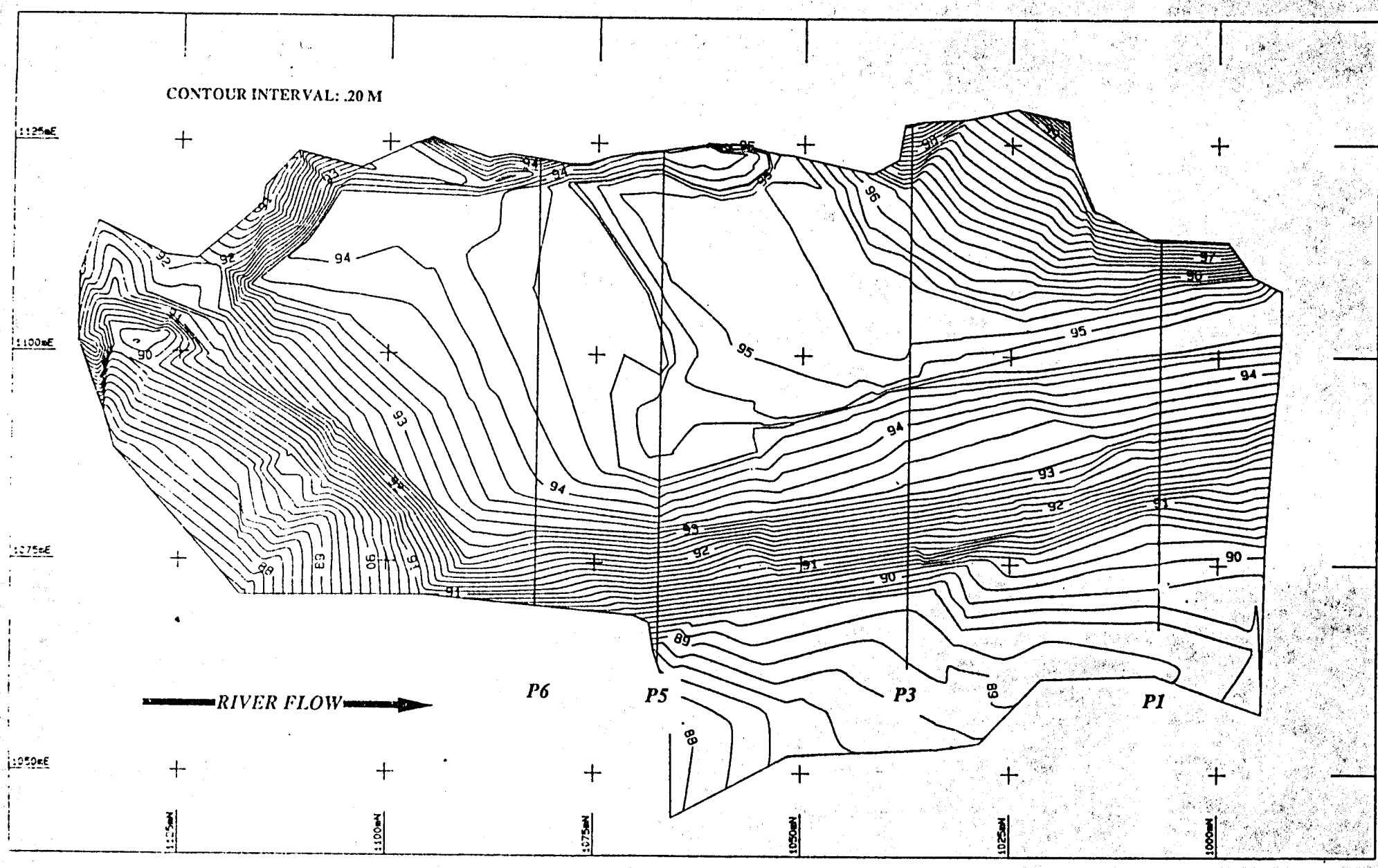
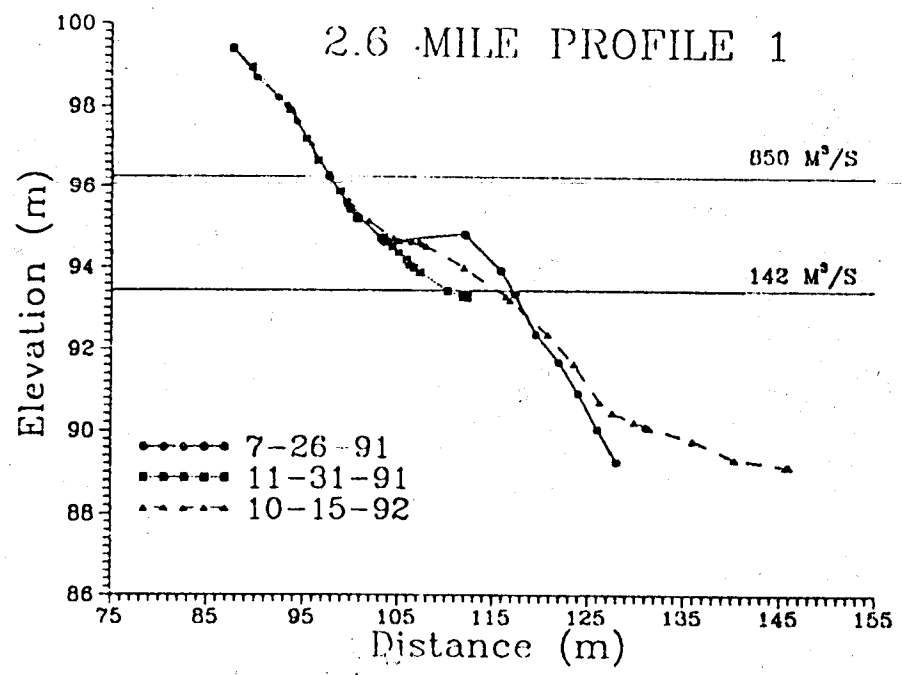
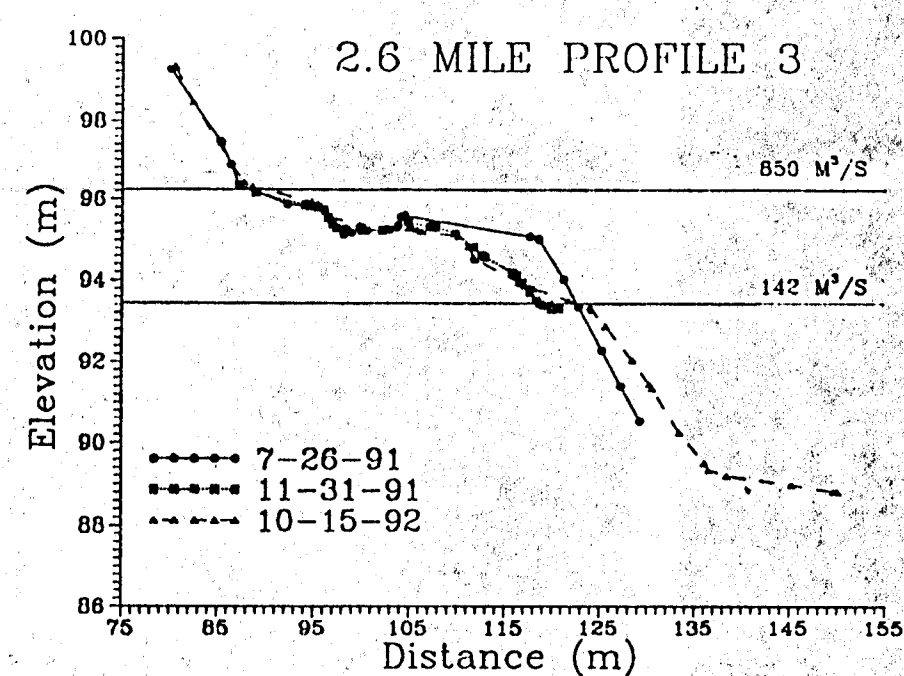
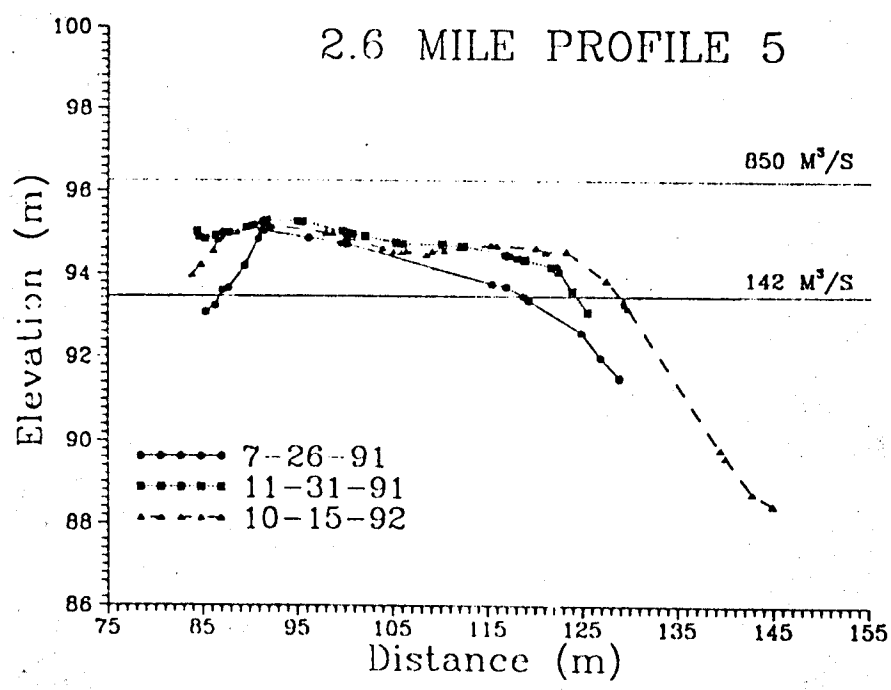


Figure 4. Site map and selected profiles from 137 mile.









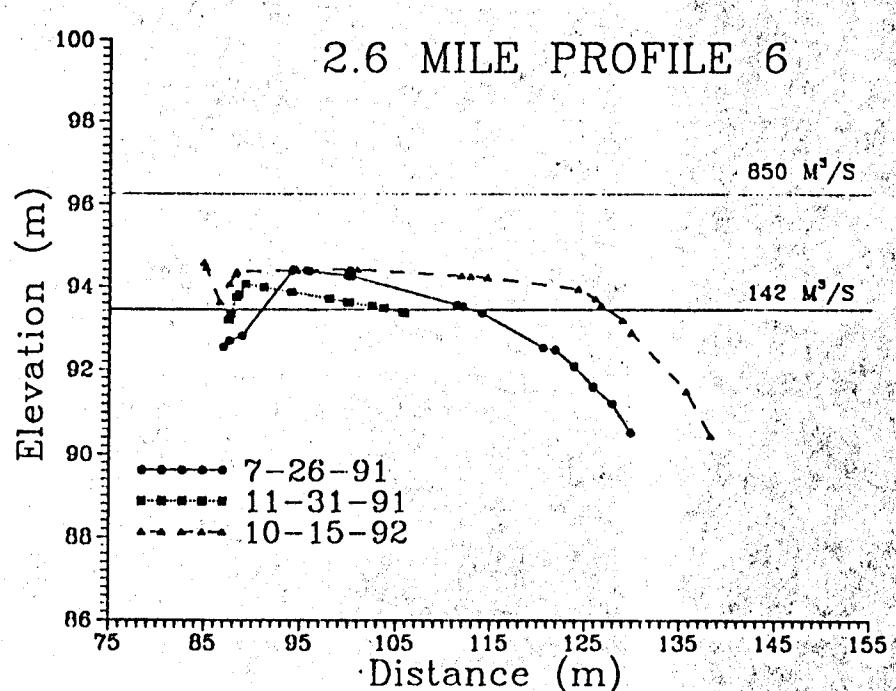
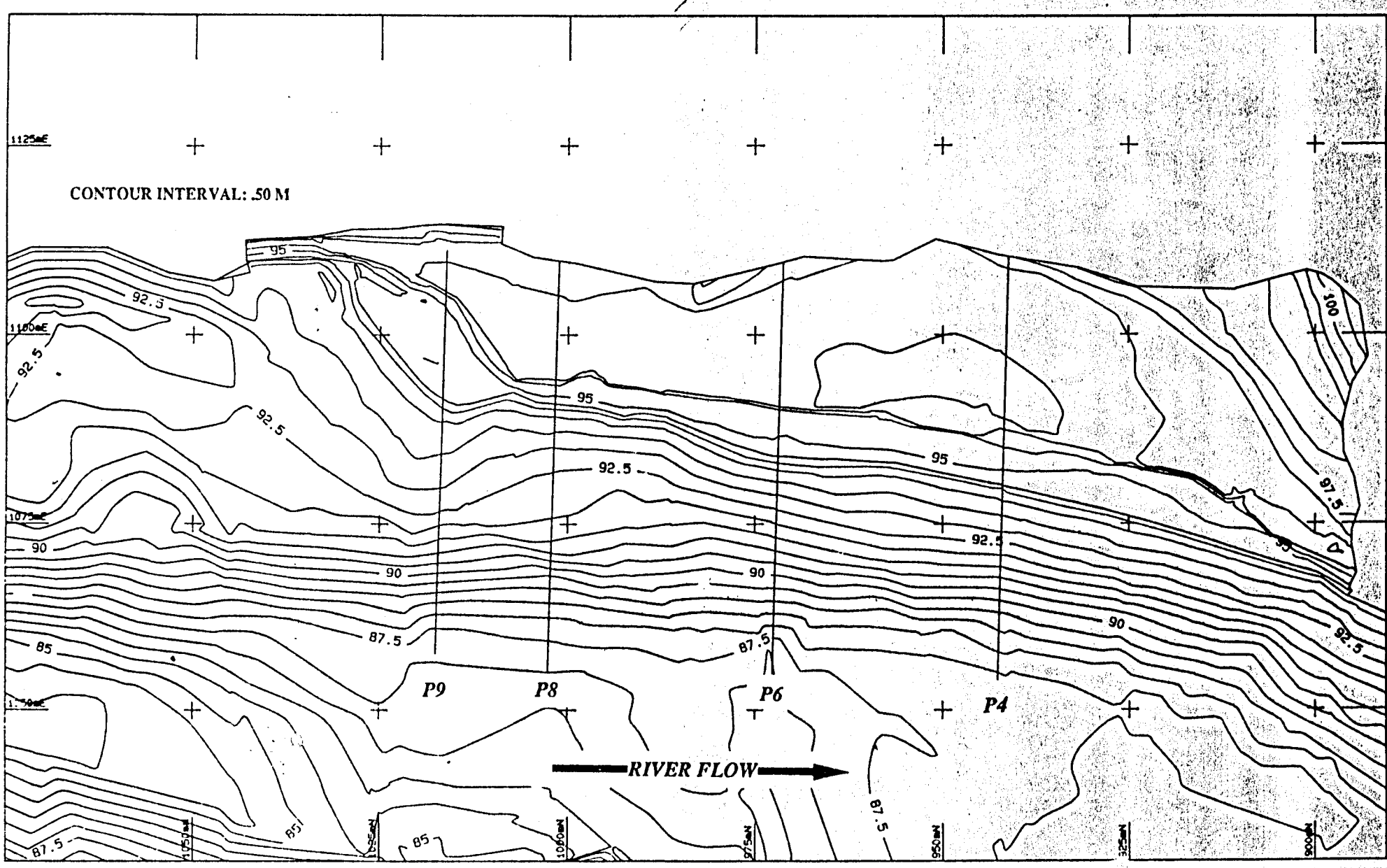
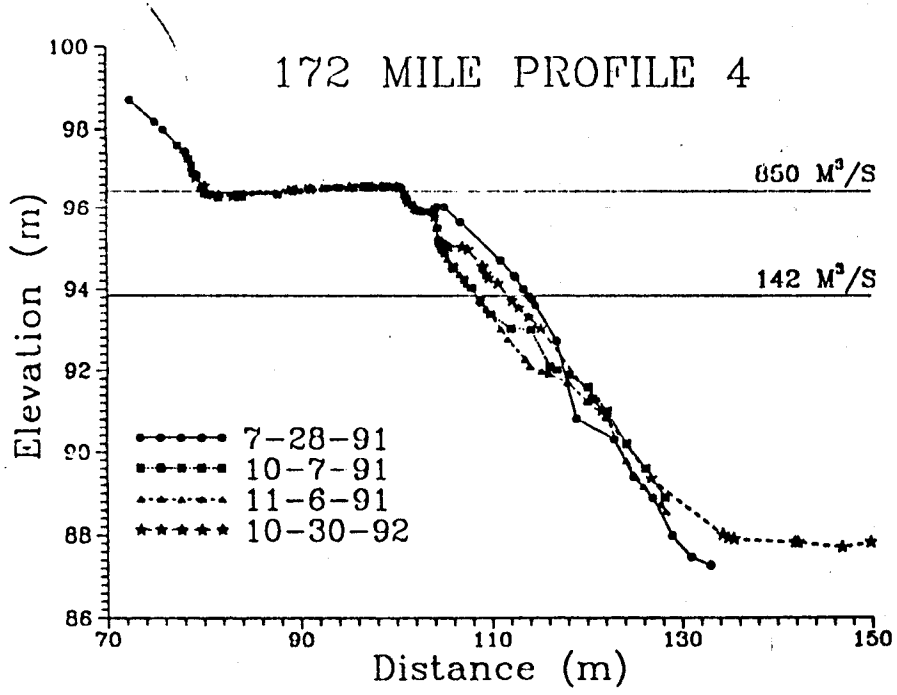
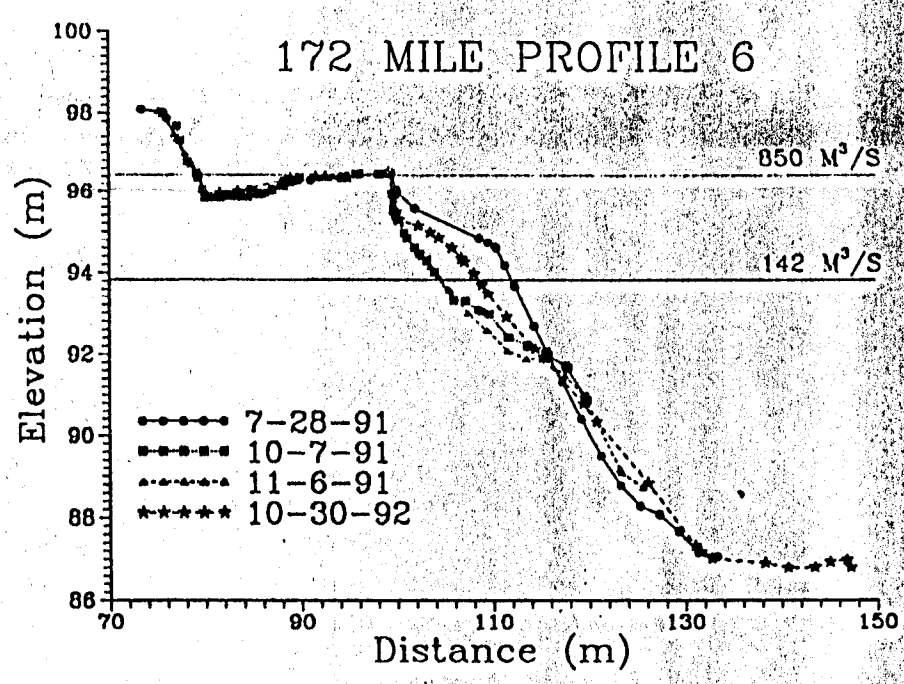
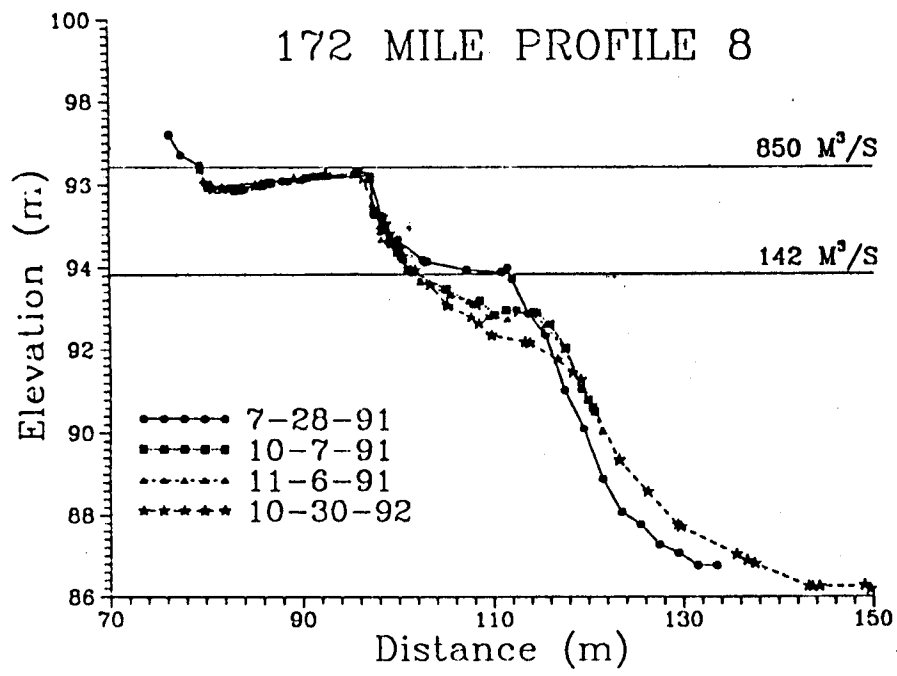


Figure 5. Site map and selected profiles from 2.6 mile.









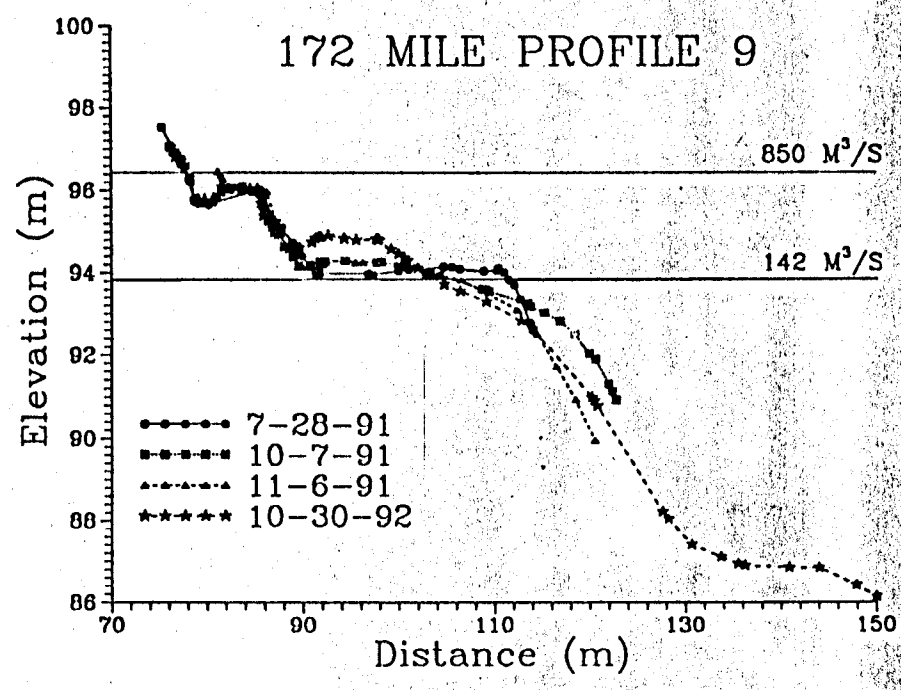


Figure 6. Site Map and selected profiles from 172 mile.

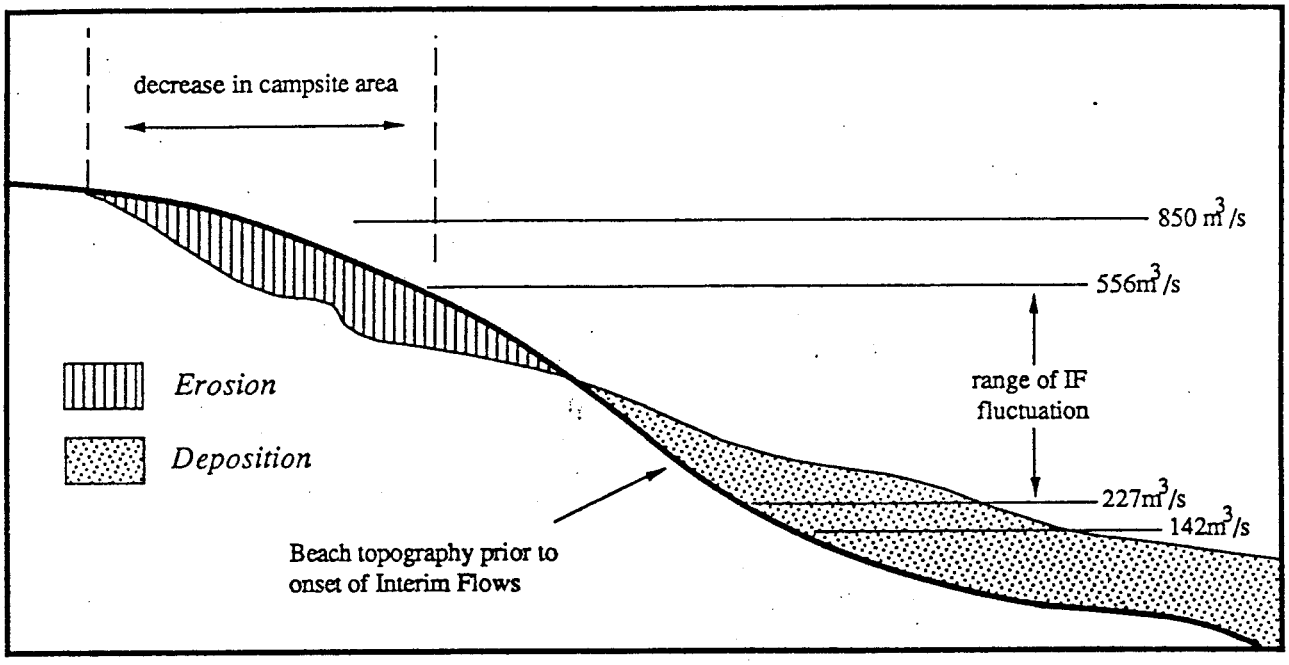


Figure 7. Schematic cartoon diagram (not to scale) illustrating erosional and depositional relationships during interim flows.