JERRY R. JONES & ASSOCIATES, INC.
ENGINEERS · PLANNERS · SURVEYORS

PERIPHERIAL AREAS C AND D
CONCEPT STORM DRAINAGE AND STORM DRAIN PLAN
FOR THE CITY OF PHOENIX

Prepared By

Jerry R. Jones & Associates, Inc.

JJA Job No. 289-017

September 1989

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REMARKS

DRAFT REPORT
APACHE WASH
PERIPHERIAL AREAS C AND D
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COP Index No. ST-886408

SUBJECT: Apache Wash preliminary report review

TO: ~~AMM~~ A FROM: TWH DATE: 11/1/89

I have reviewed the Apache Wash preliminary report. Although they have addressed our previous comments, there are a few things I would like to note about the study.

- The subbasin delineations and routings used in this study seem akward. Not exactly wrong, but certainly not how I would have subdivided the watershed. (For example, note the shape of subbasin F) Some of the language used in the preliminary report also seems akward and in some cases it is difficult to follow what is being said. Presumably, the writing will be improved in the final report.

- The materials submitted during the study were messy and contained errors that should have been corrected before review. I would not be suprised if other errors existed in the calculations of the subbasin parameters.

- I have no further specific comments to send to the City of Phoenix regarding this study, but if we send a letter, I would not state that the FCD is satisfied with the study. The impression that I get after reviewing this report is similar to what I would expect if I suddenly found myself in a room full of one-armed proffesional tennis players: - it's possible, but something doesn't seem quite right".

1-800-424-5003
Mrs. Henry
9-5

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C:

SCOT 1 = 175724 12-5-89

SCOT 2 = 175686 12-06-89

Red: 1 SCOT = 171342 11-29-89

EXECUTIVE SUMMARY

This study is being performed under the guidelines of the General Plan Peripheral Areas C and D . Its goal is to produce a plan which will solve existing problems and plan drainage concepts for the City of Phoenix and Maricopa County for new development in the study area. The results of the plan will be used for the City of Phoenix Capitol Improvement Program.

The Apache Wash Basin is about 29 miles square in area of which approximately 9 square miles are within the boundaries of the City of Phoenix. Due to the large portions of the watershed within Maricopa County and other governmental and private interests, a steering committee was formed to help direct this study. This study covers the following five cases; Case I, Existing Watershed Condition Model; Case II, Future Watershed Condition Model; Case III, Conceptual Drainage Plan; Case IV Conceptual Storm Drain Plan; and, Case V, Combination of Conceptual Drainage Plan and Storm Drain Plan with design and construction cost estimate.

Cases I and III utilized the U.S. Army Corps of Engineers Computer Model HEC I to compute runoff values. Case IV used the Modified Rational Method as contained in the Storm Drain Design Manual by the City of Phoenix to calculate flow values. Floodplains were determined using approximate field techniques and simple hydraulic calculations. Information on flooding problems was obtained from a report issued by the Flood Control District on the storm event of 28 August, 1988 and field investigations. This report was used as the main source of information for problem identification. The report identified the areas which were analyzed with four different mitigation options.

During the process of the study, criteria evolved regarding the determination of problem areas and methods for the solutions. If a channel and overbank system has the capacity to hold the 100 year storm without overflowing into another channel system then the channel system was deemed to be adequate and no provisions were made to improve it. This was directed by the City of Phoenix. The Flood Control District had the following criteria. Identify a skeleton stormwater management alternative which can be implemented at the lowest possible cost to resolve identified or known flooding problems. FCD

The Conceptual Drainage and Storm Drain Plan recommends that the property acquisition alternative be implemented by future projects. The property can easily be converted to desert parks and open space which is a preferred use based upon the New River and Peripheral Area C and D Planning Studies. Carefree Highway culverts will be upgraded to handle the 100 year flow when the road is upgraded. Carefree Highway will also need five storm drain systems. Happy Valley Road will require a culvert crossing. Dove Valley Road will require a bridged crossing of the Apache Wash and two storm drain systems. The 18th Street alignment needs a bridged crossing of the Apache Wash, one storm drain and roadway drain system. The 30th Street alignment needs two storm drain systems. Culverts

The costs for improvements above Carefree Highway will be the responsibility of the Flood Control District of Maricopa County. The remainder of the improvements including Carefree Highway will be handled by the Capitol Improvement Program of the City of Phoenix. No improvements are proposed for the Cave Buttes Recreational Area. The cost for the proposed improvements above Carefree Highway is $400,000.00. The cost for the Carefree Highway culverts is $8,449,900.00 and, the storm drain/roadway drains for the remainder of the basin is $8,128,000.00. The total cost for improvements for Carefree Highway and to the south is $16,577,900.00.

This study also produced a General Area Drainage Policy which addresses the needs of the developer and natural resources agencies. The Policy suggests that overbank areas of the floodplain be encroached and developed as much as possible while the main channel with the dense desert vegetation would remain in its natural state.

INTRODUCTION

The Apache Wash Basin is located partly in the City of Phoenix and partly in Maricopa County, approximately 9 of the 29 square miles of the basin is located in the City of Phoenix. This study is being done for Planning Areas C and D in the City of Phoenix. The upstream areas of the basin in Maricopa County will affect the City of Phoenix. Carefree Highway is the border between Maricopa County and the City of Phoenix. In an effort to go beyond planning documents, the City of Phoenix has initiated the Conceptual Drainage and Storm Drain Plans for the Peripheral Areas C and D. The Conceptual Drainage Plan will identify inadequate drainage elements and recommend solutions. The Conceptual Storm Drain will size preliminary drains for existing and proposed roadways. The Conceptual Storm Drain Plan focuses on roadways within the City of Phoenix. The Conceptual Storm Drain Plan will include areas of the basin in Maricopa County. The results of these plans will become part of the City of Phoenix Capitol Improvement Plan for proposed roadways in the area.

The City of Phoenix has formed a steering committee to help develop these plans and have input from agencies and large landowners impacted by this study. The steering committee held monthly meetings with representatives from the following entities: City of Phoenix; Parks, Recreation and Library; Water and Wastewater Department; Planning; Storm Drain Section; Floodplain Management Section; Deputy City Engineer; and Development Services; and also from the Flood Control District of Maricopa County; Arizona State Land Department; and Landmark American Corporation. When the study is complete it will be presented in a public meeting for local residents.

Steering Commitee

The following is a summary of the General Plan, Planning Areas C and D and the New River Land Use Plan. The guidelines and goals of these plans were followed as closely as possible for each phase of the study.

In the General Plan for Phoenix (1985-2000) four peripheral planning areas were identified and designated for special study independent of the process that led to the development of the General Plan. Two of these areas, consisting of approximately 111 largely undeveloped square miles, are in the far north and are generally referred to as the land above the Central Arizona Project Canal (CAP). These areas have been designated Peripheral Areas C and D. Areas C and D consist largely of undeveloped Sonoran desert and mountainous lands featuring natural drainageways.

Its purpose is to serve as a guide for community growth and as a directive to the City as to development opportunities in the area. The Plan sets guidelines to assist in the decision making process regarding the course and the nature of area development.

The General Plan represents a composite and a balancing of numerous elemements: planning and development policies, land use, transportation, open space and trails, public facilities, water resources and facilities and wastewater facilities and drainage. The Planning and Development Policies and Open Space and Trails Sections of the General Plan provide the necessary background guidelines for this study.

PLANNING AND DEVELOPMENT POLICIES

The Plan Philosophy has been devised as a means of blending people, structures, and the existing desert into a harmonious and aesthetically pleasing community.

To implement the goals that are associated with preserving the unique character of the area while providing for desired growth and quality development, a series of planning and development policies were prepared to serve as guidelines for developing and carrying out the General Plan. These policies which effect drainage concerns are as follows:

1. Where appropriate and feasible, the existing environment should be maintained by preserving and protecting desert washes, mountain slopes and native Sonoran vegetation and wildlife. A portion of each development site plan should be set aside as natural desert preserve.

2. To the extent possible, street designs should follow and utilize the existing natural topographic features of the area. Extensive cross cuts of washes and other drainage features should be avoided.

3. Major or dominant drainage channels (washes) should, to the maximum extent possible, be preserved in their natural state without alteration of their present alignment.

4. Native vegetation and wildlife to be preserved within major channels.

5. Offsite runoff in the post-development condition shall not exceed the pre-development condition.

6. In areas where public safety necessitates the alteration of a natural wash, the new design shall match the natural appearance as closely as possible.

OPEN SPACE AND TRAILS PLAN

The unique combination of natural and man-made features of the area offer an unsurpassed opportunity to create an integrated and highly diverse network of distinctive recreational opportunities, open space and trails. The open space resources are a key element in creating the environmentally compatible development pattern and the outdoor-oriented lifestyle that are desired in Areas C and D. A major component of the open space system is:

MAJOR WASHES, PATHS AND TRAILS AND TRANSMISSION LINE CORRIDORS - Major washes that are maintained for drainage purposes and developer provided pedestrian and equestrian trails and bicycle paths, provide the opportunity to create an extensive, interconnected trail system leading to major destinations in the planning area.

PLAN OF ACTION

The General Plan is a guide to the development of Areas C and D, describing the types, locations and characters of development the City desires. In this section the Plan of Action is outlined, it serves as the vehicle to guide future decision-making, developmental activity and Plan refinements.

The Plan of Action identifies strategies the City will institute, promote and encourage to maximize the development opportunities in Areas C and D.

The Plan of Action includes:

- Preservation of Unique Desert Open Areas
- Design and Character Elements
- Phasing of Development
- Development Strategy
- Infrastructure Financing
- Intergovernmental Cooperation
- Plan Updating
- Other Recommendations
- Preservation of Unique Desert Open Space

PRESERVATION OF UNIQUE DESERT OPEN SPACE

In addition to efforts to preserve hillsides, washes and scenic corridors along major thoroughfares, efforts will be made to secure desert open areas for permanent open space. If possible, an attempt should be made to link these open space areas by natural washes or park areas to allow for movement of wildlife and water flows.

DESIGN AND CHARACTER ELEMENTS

A subcommittee of the Areas C and D Advisory Committee was formed to develop a set of design and character elements. The purpose of these elements is to provide guidelines for shaping the man-made environment by ensuring that man's activities in the planning area are compatible with and complementary of the unique and sensitive characteristics of the area. The design and character elements are currently general guidelines. The guidelines which most significantly impacts this study is the vegetation element. Natural vegetation shall be maintained wherever possible. Revegetation with approved plant material shall occur in areas disturbed by construction activities. Vegetation should not be used that has the following potentially destructive characteristics: profuse and/or noxious pollen, excessive height, weed-like characteristics of excessive growth, high water demands, and other similar traits.

NEW RIVER LAND USE PLAN: MARICOPA COUNTY

The formulation of a realistic and implementable Land Use Plan for the New River Planning Area is predicated upon the definition of a set of comprehensive goals and policies. The Land Use goals and Policies are presented in three subject areas:

Natural Resources
Socio-Economic Development
Land Use

The following are generalized definitions which should be referred to as a guide when reading this chapter of the New River Land Use Plan.

GOAL: A desired end which, if pursued over the long-term, will ultimately result in the attainment of a desired living environment.

POLICY: A means to attain the established goals. Policies prescribe or represent a course of action.

The goals and policies are intended to set the stage for public and private actions geared to guide orderly and planned growth within the New River Planning Area and its fringe; promote high quality residential, commercial, and industrial development; and continue to improve and expand transportation and public facilities for the planning area.

The policies listed here are applicable to this study only. What follows is not a complete list.

NEW RIVER GOALS AND POLICIES

A. Physical Characteristics

GOAL: Permit developments which are compatible with natural environmental features and which do not lead to its destruction.

Policy A-2: In the review of land development applications encourage land uses and development designs that are compatible with environmentally sensitive areas such as parks, open space, floodplains, hillsides, wildlife habitat, scenic areas, and unstable geologic and soil conditions.

B. Hydrology

GOAL: Protect and preserve existing water resources and minimize flood hazards.

Policy B-1: In the review of land development applications encourage cooperation with the Flood Control District to minimize land development conflicts and achieve compatibility with the development and implementation of Area Drainage Master Studies and other relevant investigation.

Policy B-4: In the review of land development applications encourage developments which maximize recharges of groundwater supplies and utilize treated wastewater for water amenities and irrigation.

Policy B-5: In the review of land development applications encourage the use of drought tolerant and low water consumptive landscape materials.

Policy B-6: In the review of land development applications discourage the location of structures which would increase waterponding and sheetflow in areas of extremely flat land and areas susceptible to sheetflow.

C. Vegetation and Wildlife

GOAL: Preserve existing habitat areas of threatened or endangered wildlife species.

Policy C-1: In the review of land development applications encourage the protection of threatened and endangered species in the review of applications for land development.

Policy C-2: In the review of land development applications support preservation practices in the Palo Verde-Saguaro Community.

Policy C-3: In the review of land development applications encourage the use of replacement vegetation that is primarily indigenous to the Palo Verde-Saguaro Community for land developments which disturb that community.

D. Archaeology

GOAL: Protect the County's historical and archaeological resources.

SOCIO-ECONOMIC DEVELOPMENT

A. Commercial/Industrial Development

GOAL: Permit major commercial and job employment centers where the labor force and infrastructure exist or are expanding.

GOAL: In developments with densities greater than one dwelling unit per acre create a land use environment that generates a diversified economic base which fosters varied employment opportunities, and encourages business formation and expansion.

LAND USE

A. Land Use

GOAL: Create orderly, efficient, and functional development patterns. Create high quality residential, commercial, and industrial land developments that are compatible with adjacent land uses.

Policy A-1.1: Residential development shall be discouraged at suburban or greater intensities (exceeding one dwelling unit per acre) unless part of a planned community, therefore preserving the existing rural character of the New River Planning Area.

B. Transportation

GOAL: Establish a circulation system that provides for the safe, convenient and efficient movement of goods and people throughout Maricopa County.

Policy B-5: In the review of land development applications support the County Highway Department's efforts to provide for all-weather travel over washes on County roads.

Policy B-6: In the review of land development applications encourage the location of drought tolerant landscaping along new and existing major roadways, thereby enhancing the visual character of public transportation routes.

C. Public Facilities and Utilities

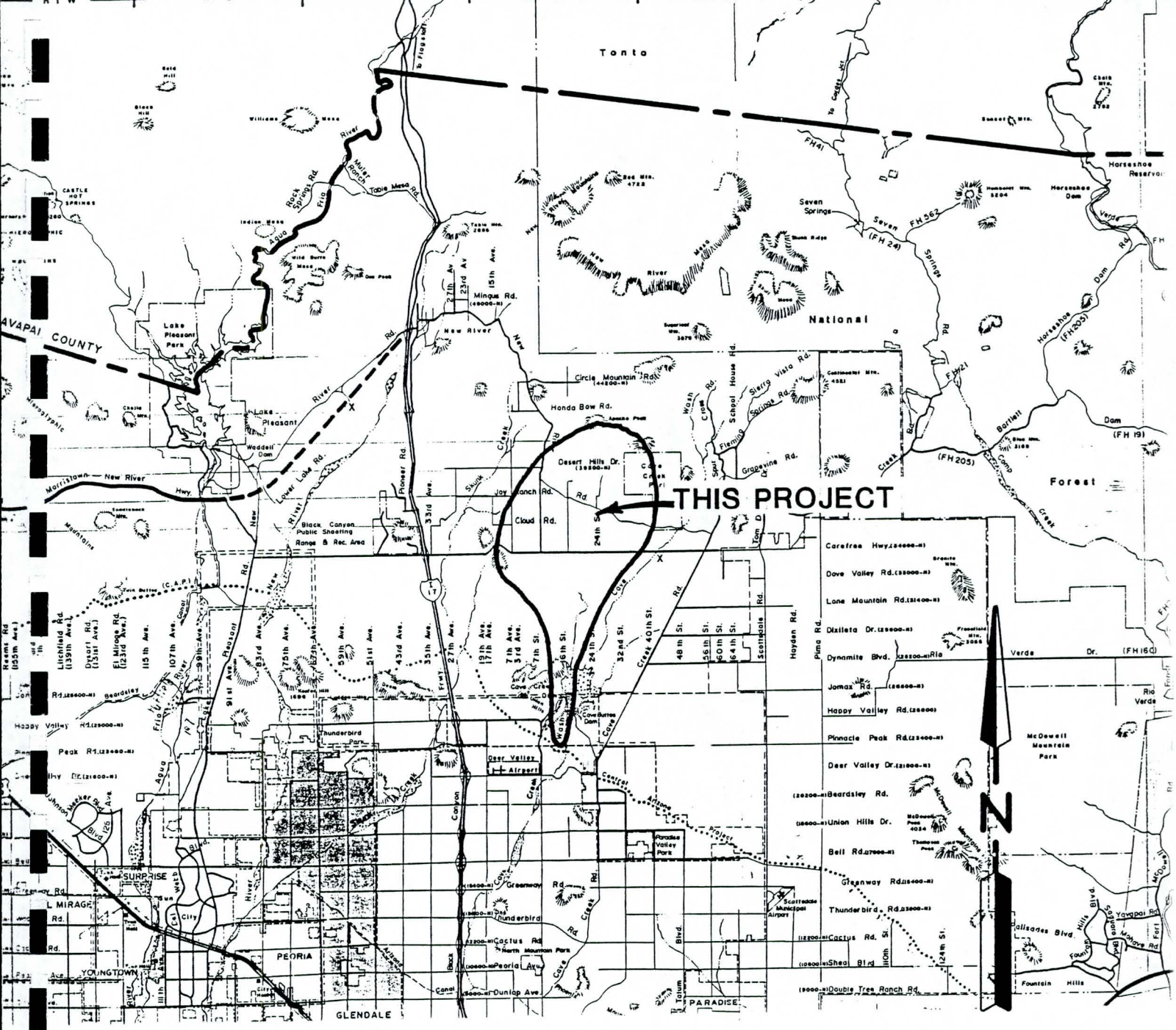
GOAL: Provide for a functional, efficient and cost effective system of utilities, facilities and services to serve county population and employment centers.

Policy C-1: In the review of land development applications continue to establish and maintain a system of park and recreational facilities to serve the residents of the County.

Policy C-2: In the review of land development applications encourage the inclusion of private open space and recreational opportunities to meet the needs of occupants in large and/or high density residential developments.

Policy C-4: In the review of land development applications preserve natural drainageways as linear open space corridors leading to various water channels.

Policy C-4.1: Where possible and appropriate, in the design and construction of new development, preserve natural drainageways, and more specifically New River and Skunk Creek as linear open space corridors.



APACHE WASH LOCATION MAP

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OBJECTIVES

The purpose of this work is to develop a Conceptual Drainage Plan (CDP) and a Conceptual Storm Drain Plan (CSDP). The CDP will be developed in such a manner that its results will be used as a guideline for the development of the area with respect to floodplains. The plan will point out floodprone areas with the establishment of approximate floodprone boundaries. This will alert developers of possible flooding potential. These boundaries will define areas which special attention must be given to development. The plan will set out a scheme for the mitigation of existing flooding problems. The mitigation of these problems would most likely be undertaken by the Flood Control District of Maricopa County and/or the City of Phoenix when funds become available. Costs for each mitigation measure will be developed as part of the study. The plan will ultimately recommend alternate flood control methods for floodplain development and regulation.

The CSDP will provide a guide for the development of a roadway infrastructure system with respect to drainage. This plan will contain two areas of concentration. One area deals with drainage intercepted by the roadway and the other the drainage which passes under the roadway through culverts or bridges. The sizes of storm drains carrying runoff from offsite areas and pavement drainage will be determined in the first part of the plan. The second component deals with sizing of culverts/bridges for the 100-year storm flow event for Carefree Highway, Dove Valley Road and Happy Valley Road. A cost estimate for the recommended solutions and storm drain will be prepared from the results of the CDP and CSDP. The results of both the CDP and CSDP will be used for the City of Phoenix Capitol Improvement Plan.

Hydrology Criteria.

- 100 yr - 24 hr for CDP
- 2 yr - 24 hr for CSDP
- SCS type II
- IN = 30 Min. computation Interval.
- SCS Unit Hydrograph
  compare to emperical methods.
- Lag Time: Pima County Hydrology Time of Concentration method
- Routing: Kinematic Wave techniques.
- CN: SCS, TR-55, 1986
- Soils; Pore Cover Density; Desert shrub

PROCEDURES

HYDROLOGY:

Several field investigations were undertaken to check flow patterns, drainage elements, cover densities, basin roughness, channel slopes and new construction activities. The adjacent study area boundaries of Skunk Creek and East Biscuit Flat were checked with this study and found to be compatable. The effects of stock tanks were not included in this study due to their negligable effects.

Adjacent Studies.

The Conceptual Drainage Plan (CDP) utilized the HEC 1 computer program to quantify flow values. The CDP uses the 24 hour - 100 year storm and the CSDP used the 2 year storm. The CSDP used the hydrologic guidelines set forth by the Storm Drain Design Manual by the City of Phoenix.

The CDP used a Soil Conservation Service (SCS) Type II rainfall distribution with a 30 minute computational interval in conjunction with the SCS Hydrology Method. This method was compared with the emperical methods to check the accuracy for application (see results section). As a result of this comparison, the Pima County Hydrology Time of Concentration Method was chosen to produce the lag value for the hydrograph generation. Kinematic wave techniques are used for hydrograph translation.

The Runoff Curve Numbers (RCNs) were obtained from the SCS TR-55, (1986) hydrology method. From the field investigations, a poor cover density rating was chosen for the Desert Shrub RCN classification. The impervious values for each watershed were reflected in the third field of the LS record - SCS curve number loss rate in the HEC-1 computer model. The other available RCNs for this study are from the Residential District Classification, average lot size 1 acre and the Western Desert Urban Area Classification, natural desert landscaping (pervious areas only). The RCNs are listed on Table I.

TABLE I
RUNOFF CURVE NUMBERS
HYDROLOGIC SOIL TYPE

TYPE	B	C	D
Desert Shrub	77	85	88
Residential District 1 Acre Lot Size	68	79	84
Western Desert Urban Area Natural Desert Landscaping	77	85	88

The RCN's for the Residential District would produce lower runoff values then the Desert Shrub and the Western Desert Urban Area Classifications. The higher RCN's were chosen for their conservative results and there the two classifications with the same RCN's equally describe the watershed conditions. Therefore, the Desert Shrub classification was chosen. This classification is the only one of the three which accounted for varying cover densities.

The CSDP used the hydrology method that will be used when the detailed design is completed for the construction documents. This will assure that the results from this study will accurately reflect detailed design study values. This hydrology method is a modified Rational Method and is described in the Storm Drain Design Manual (Ref. 6).

The pervious and impervious portions of the runoff equation were used in the calculations. The infiltration rate is 0.05 in/hr. The watersheds were assumed to be developed at the zoning designation of RE-43, which has an associated impervious value of 15%. The flow travel times were calculated using 3 ft/sec for flat areas and 4 ft/sec for steep areas. The velocities were used to develop a time of concentration. The flow values calculated with this method are for the 2 year storm event.

The flow values developed for use to size new channel structures were taken from the existing condition HEC-1 model. Some flow values were needed between concentration points established in the model. Those flow values were determined using an average flow value per area based upon the HEC-1 results in this area. The Table VII Soils Data and Table VIII Time Lag Calculation are contained in the hydrologies and hydraulic data; calculation and cross section portion of the appendix.

HYDRAULICS:

The approximate floodplain limits were developed using hand surveyed cross sections. The channel bottom width was measured as well as the slope. The side slopes, overbank ground slopes and Manning's roughness coefficient were estimated in the field using engineering judgement. There were 26 channel cross sections obtained in the field which were used to delinate the floodprone areas.

The floodplain limits are established for flow values over 1,000 CFS using the normal depth computation of the Manning's equation. The approximate Floodplain Limits and Channel Cross Section Map is depicted on a 1":2,000 foot scale map (See Appendix). The data provided on this map is for information and planning purposes only and should not be used for setting construction limits of adjacent houses or structures. The floodplain limits were stopped at the Cave Butte Recreation area. This area and the area downstream is mapped by the Federal Emergency Management Agency (FEMA). These FEMA maps are located in the appendix.

The culverts and bridges were sized to convey the 100 year flows, the storm drains were designed to convey the 2 year flow event. The pipes and box culverts were sized using inlet control and the Hydraulic Engineering Circular No. 5. Bridge openings were sized for minimal floodplain constriction. The headwater for the pipe or box culverts were assumed to be 1 foot above the top of the structure opening. The channel sections were sized using the normal depth computation of the Manning's equation.

The storm drains are located in roadway sections which cannot drain into a nearby outfall channel via gutter or roadway ditches. The storm drains are carried to the nearest channel crossing the road and if deep enough are used as an outfall. Storm drains are sized assuming full pipe flow, a slope of 0.3% and an 8 foot cover depth over the pipe. Storm drain systems in the City of Phoenix generally have lateral pipes at half and full mile roadways along the main storm drain. Lateral pipes were not used due to developed flow patterns and the long and narrow shape of the contributing basins.

During the steering committee meetings it was decided that a small pipe would be placed at the end of the storm drain system to take low flows away from roadway. This pipe would travel about a 1/2 mile down the outfall channel. This would keep non-native vegetation from establishing along the roadway which leads to a maintenance and safety problem. After further reflection this concept would not be feasible because right-of-way must be aquired for the placement of the pipe.

STUDY CASES

Computer/hydrologic models will be used as the basis for the development of the following case scenarios.

CASE I (Existing Condition)

Develop the hydrologic model for the existing watershed condition for the Design Storm.

CASE II (Futur Condition)

Develop the hydrologic model for the future watershed condition for the Design Storm. Use the "General Plan - Peripheral Areas C and D", "General Plan for Phoenix 1985-2000", and Maricopa County Planning documents to determine the level of development for the future condition.

CASE III (Alternative 5)

Develop the hydrologic model for the future condition for the Design Storm with recommended system of channels, detention basins, shallow flooding areas; or other structural or non-structural measures to route the design flood to the outlet(s).

CASE IV (~~Fro~~ Future Recommended Alternativ)

Develop the hydrologic model for the future condition with a recommended storm drain system for the Design Storm.

CASE V

Develop the hydrologic model for the future condition with the recommended system of 100 year flood routing augmented by a 2 year storm drain system.

During the course of the C and D Drainage Studies, it became apparent that the effects of retention (Case II) could not be accurately quantified. As a result it was requested by the City of Phoenix that the hydrology for Case I be used for Cases III, IV and V, and Case II was deleted from the scope of work.

COST ESTIMATES

The cost estimates are based on ADOT's Cost Index 1988 and General Cost Data developed by Jerry R. Jones & Associates, Inc. The culverts were estimated to $6.5xsq. ft. of opening x length. Pipes and culverts are assumed to be 100 feet long. Pipes are Reinforced Concrete (RCP) Class III, 48" @ $75/ LF and 36" @ $65/LF. All bridges are assumed to be 80 feet wide and $55/SF of deck.

RESULTS

CASE NO. I: EXISTING WATERSHED CONDITIONS

The goal of Case I was the development of existing hydrology. This is to be used as the basis for Cases III, IV, and V. The results of this model were verified through independant hydrologic calculations.

The hydrologic models used for the verifications are:

1) HEC 1 SCS Hydrograph SCS Lag Method
2) HEC 1 Soil Conservation Service runoff model (utilizing PCDOT - Time of Concentration Method)
3) The Pima County Department of Transportation (PCDOT) hydrology method
4) U.S. Army Corps of Engineers (USACOE) flood data Phoenix area (Empirical Data)
5) U.S. Department of Agriculture (USDA) Walnut Gulch Regional Flood Frequency Relationships
6) U.S. Bureau of Reclamation/Flood Control District of Maricopa County (Preliminary Hydrology Manual) S Graph Method.

The first method was used as a base for comparison. The first method resulted in the lowest flow values. The USDA (5) and USBR/FCDMC (6) methods produced the highest results. The PCDOT (3) and the USACOE (4) values were about 40% of the USDA (5) and USBR/FCDMC (6) values. The USBR/FCDMC (6) flow values produced travel velocities of 20 feet/second which is excessive. The SCS HEC 1 (PCDOT) (2) produced flow values about 25% higher than PCDOT (3), USACOE (4) values. The SCS HEC 1 (PCDOT) (2) was chosen to model the existing hydrology conditions because it produced the highest justifiable flow values. This method yielded travel velocities in the order of 10 feet/second which consequently produces slightly higher flow values. The following table summarizes the results of this study.

Book

- Cors Scot stale

- Tipton Con bug Feb 1985

Rainfall Runoff Modeling

Joe Tram

- Cora Fernandez

Joe Romen

- P-86 Pima County FCD

log

TABLE II III

RUNOFF VERIFICATION SUMMARY

METHOD	(Basin 12,1.89 Mi2) LAG	VEL.	Q	(Basin 30,0.5 Mi2) LAG	VEL.	Q	(Basin 50,1.15 Mi2) LAG	VEL.	Q
HEC1 (SCS)	0.72	2.9	2,023 (1)	1.35	2.5	315	0.78	6.2	445 Selected
HEC1 (PCDOT)	0.41	5	3,001	0.34	10	796	0.69	7	1,182
PCDOT	0.41	5	1,977 (2)	0.34	10	595	0.69	7	876
USACOE	N/A	N/A	1,417	N/A	N/A	500	N/A	N/A	920
USDA	N/A	N/A	3,464	N/A	N/A	1,298	N/A	N/A	2,436
USBR/FCDMC	0.13	26	4,843	0.11	30.9	1,181	0.19	25	2,259

Notes (1)-(2) Basin 12 consists of steep mountainous and flat valley sections. (1) Method uses an average slope value 0.07 ft/ft. and (2) uses a weighted slope value of 0.0168 ft/ft. The flow computation for (1) is artifically high and should compare with relative value differences as shown by basins 30 and 50 for the same methods. This value (1) would be close to 800 CFS if a weighted slope value is used in the lag calculation. This method does not account for variable slope components in one watershed.

Units Lag-Hours, Vel.-Velocity Ft/Sec Q-CFS

HEC1 SCS Lag=i**0.8 (S+1)**0.7/1900y**0.5
Where i=Hydraulic Length S=1,000/CN-10
y=Slope in %: From Guide to SCS Method P. 19

HEC1 (PCDOT) - Uses Lag (TL) Calculated From Pima County Department of Transportation (PCDOT) Hydrology Method and TL=0.6 TC Pima County

USACOE - Regression Analysis See Plot ASCE

USDA-Walnut Gulch - Regression Analysis From Flood Frequency Estimates in Southeastern Arizona by Broughton, Renard, Stone 1987
Q100 Env.=2,700 D** (0.736-0.082LOGD) 2200
Where D=Drainage Area in Miles Square
See Attached Chart

ASCE P471- 1984 old one
473 477 - Revised 87 Converted to Eng befor to Use.

USBR/MCFCD Lag=26(n) (LcxLca)**0.33/(S)**1/2 S,in Ft/Mile

20F/S

18

The flow values quantified by the hydrology analysis were used to develop approximate floodplain boundaries for flow values above 1,000 CFS as requested by the Flood Control District of Maricopa County (FCDMC). These floodplain limits closely match the reports of flooding in the area. The majority of the development in the watersheds is above Carefree Highway, within Maricopa County. The City of Phoenix does not have any flooding complaints in this area.

The Flood Control District has a report on the flooding event of 28 August, 1988 (Ref. 17). This report is the most comprehensive record of flooding problems in the Apache Wash Study area. These flows were generated by approximately a 10-year storm event. Several field investigations were made to verify the report and check the new floodprone delineation.

There were five residences which were impacted by the flooding event. Three residences were on the Jonathan Wash near 3rd Street and Galvin (Basin 70 & 80). One was on the 10th Street Wash on Cloud Road (Basin 50) and the other at 14th Street Wash on Cloud Road (Basin 41). This information was used as a guide for the development of alternatives for use in Case III.

II

TABLE III
FLOW VALUE SUMMARY

EXISTING CONDITIONS 100-YEAR STORM

Basin Designation	Flow Value CFS	Drainage Area
70	2331	2.00
80	1242	1.20
G	1438	0.76
60	743	0.44
50	1229	1.15
44	1157	0.62
43	2332	1.39
42	114	0.11
41	1275	0.89
40	691	0.56
30	718	0.50
F	2146	2.45
25	3067	1.41
24	5481	2.91
23	3150	1.71
22	850	0.51
21	712	0.51
20	840	0.68
14	2387	1.25
13	216	0.15
12	3775	1.89
11	1915	1.36
10	1199	0.96
E	1614	1.42
D	2290	1.20
C	2331	1.17
2	1256	1.06
1	885	0.91
B	1090	0.46
A	856	0.48

CASE NO. II: FUTURE WATERSHED CONDITIONS

Future retention effects were not quantified in this section. This case was deleted as requested by the City of Phoenix.

CASE NO. III: CONCEPTUAL DRAINAGE PLAN

The content of the drainage solutions greatly depends upon the existing channel conveyance system. The Apache Wash Basin consists of incised channel systems which is defined from its beginning in mountainous terrain to the Cave Buttes Dam where all channels eventually terminate. This basin generally does not contain alluvial fans and distributed flow conveyance systems. The majority of other study areas in Planning Areas C and D exhibit these channel systems.

The incised channel systems is composed of a main channel low flow area and a shallow sloping overbank area. The appendix contains the surveyed cross sections. The cross section was formed by smaller more frequent flow events. Currently, due to development, the channels above Carefree Highway are in the process of degrading.

During the course of the study, criteria was developed from the Steering Committee process for the recommended basin design systems. The Flood Control District provided the following input regarding the area above Carefree Highway.

Based on the guidelines outlined in The General Policies Concerning the Allocation of Fiscal Resources to Accomplish the District's Functions and Responsiblities, the following objectives need to be accomplished by this study in the portion of Apache Wash Watershed within the District's jurisdiction:

1. To identify a skeleton stormwater management alternative which can be implemented at the lowest possible cost to resolve identified or known flooding problems. It will also be used as a guide for planning the orderly development of a stormwater management system for the study area based on the following criteria:

(A) The 100-year recurrence interval will be used to delineate floodplains of major washes (i.e. Q100=1000 cfs). Sizing of flood control facilities and detention/retention basins will be adequate to accomplish the objectives of the plan and not be tied to a recurrence interval runoff frequency.

(B) Natural drainage features in undeveloped and sparsely developed areas will be considered as the point of departure in the planning and design of the component parts of the storm water system.

Additional criteria was developed for the City of Phoenix portion of the study. The criteria dealt with two items; existing and proposed roadways and existing channels. The first set of criteria govern for roadways, while the second set handles channels. The drainage culverts under the existing Carefree Highway are sized to convey the 100-year storm discharge. The proposed 18th Street alignment, 30th Street alignment, Dove Valley Road alignment, Happy Valley Road, Northeast Outer Loop and the Carefree Highway will have storm drains sized to convey the 2-year storm discharge. A summary containing the size and costs of the structures is presented in Case No. 5.

Roadways Criteria by COP.

The channel criteria defines which channels should be modified or left alone. If flows are contained in a single defined channel system, then the channels should be required to remain in their natural state, as directed by C.O.P. In other areas where alluvial fans or distributed flows occur, channel systems must be constructed to contain flows in an identifiable area. In areas which contain undefined channels or contain floodprone residences, mitigation measures were proposed to solve these problems.

Channels Criteria by COP

MITIGATION MEASURES:

Mitigation measures north of Carefree Highway were studied using criteria presented by the Flood Control District. The items used for mitigation were channelization, regional detention/retention basins, future development and property acquisition. The costs for each alternate are on Table IV at the end of this section. See the Mitigation Measures Map for location of the studied areas.

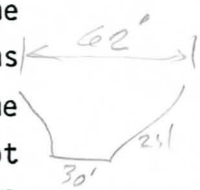
JONATHAN WASH

The approximate floodplain width of the Jonathan Wash in the vicinity of the 3 floodprone residences is about 500 feet. The area is in the general vicinity of 3rd Street and Galvin. The floodplain is shaped by a 100-year flow value of approximately 3,573 CFS. This flow value is produced by adding basins 70 and 80.

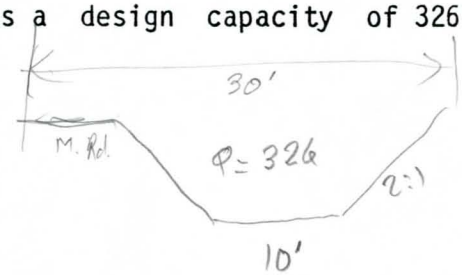
1) CHANNELIZATION

An extensive channel system is needed to capture runoff in this area due to the width of the floodplain and several tributaries in the area. The channel system will be designed for the 100-year flow event. This channel system consists of three sections A, B, and C. Section A is designed to carry 1,242 CFS from basin 80 and 2,095 CFS from basin 70. This channel starts a quarter mile south of Cloud Road on Central and proceeds to the south for approximately 1,500 ft. At this point, the channel turns southeast and travels to Galvin Street about 1,500 ft. in length. The channel section has a 30 ft. bottom width with 2:1 side slopes. A 10 foot easement will be needed for maintenance. The total top width is about 62 ft. The channel consists of 6" concrete lining.

$Q_1 = 1242$
$Q_2 = 2095$
2095
3,347
A

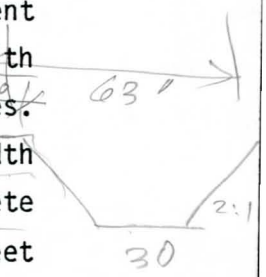


Section B starts at Central Avenue and Galvin Street and runs along Galvin to the confluence with Section A channel. This channel is 1,500 ft. long and has a 10 foot bottom width with 2:1 side slopes. The channel width is about 30 feet which includes a 10 foot maintenance easement. The channel would be constructed from 6" concrete. It has a design capacity of 326 CFS.



At the confluence of Section A and B a box culvert will be provided to convey the flows under Galvin Street. Seven 10'x 5' reinforced concrete box culverts (RCBCs) are needed to adequately convey the flows under the roadway.

From these culverts, the channel progresses along the same alignment toward the southeast for about 4,000 feet, to just upstream of 7th Street. Section C is terminated just beyond the residential structures. This section is designed to carry 3,573 CFS in a 30 foot bottom width channel with 2:1 side slopes. The channel would consist of 6" concrete lining. The right-of-way needed for this section is about 63 feet including a 10 foot maintanence easement. Another 7-10'x 5' box culvert is needed for the 3rd Street crossing of Section C. The total cost of this channel system is approximately $2,655,000.00



2) REGIONAL DETENTION/RETENTION BASIN

About 1/2 mile upstream of these residences there is just over 1 section of undeveloped State of Arizona land. This area was investigated for the possible placement of a regional retention basin. The floodplain in this area is wide and shallow, therefore a large structure would be needed to capture the flow to be placed in a retention/detention basin. Regional retention basins are detrimented to the channel/sediment transport balance. Retention basins trap all sediment inflows which greatly accelerate downstream erosion. In the Apache Wash Basin these basins would produce more harm than good. Detention basins should be used because of the possible flushing action of low flow events. In this particular area there is not sufficient topographic relief to efficiently construct a detention basin. Therefore, this alternation was not considered as a suitable mitigation measure.

3) FUTURE DEVELOPMENT

Another alternative which will reduce flooding in the area deals with the development of the upstream property. Assuming that the State Land Department sells the land to a single developer, the development must follow the drainage guidelines set by the Flood Control District. The guidelines call for the complete retention of the 100-year storm 2-hour storm. The State Land area was taken out of the existing hydrology model which uses a 100-year 24-hour storm. This would approximately estimate the effects of retention on the system.

A flow reduction of 930 CFS is caused by taking out about three-fourths of a section of land upstream of this point. The existing flow value is 3,573 CFS and the developed condition will generate only 2,643 CFS. The flooding would be reduced but not eliminated. The exact effects of this alternative will have to be studied in detail beyond the level of this project. This alternative does not have a cost, and does not have a known date of implementation. This alternative is essentially a do-nothing solution.

4) PROPERTY ACQUISITION

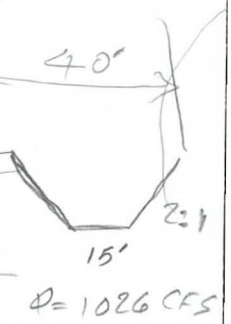
As suggested by the General Plan Peripheral Areas C and D efforts should be made to secure desert open areas for permanent open space. The three residences could be purchased and the buildings sold to help defray the purchase expense. This area contains a mature mesquite bousque produced by a low stock dam just upstream of 3rd Street on the main wash. The area could serve as a regional desert park with riparian vegetation which provides habitat for several species of desert animals. The market value per residence based upon recent real estate listings in the Apache Peak News would not exceed $100,000.00. Selling the structures would recover at least 30% of the acquisition price. There has been recent activity of house moving in the Apache Wash area. Upon detailed study of the floodplain there could be more residences in this area which would benefit from these flood mitigation measures. The total cost of purchasing the three residence should not exceed $300,000.00.

10TH STREET WASH

This is the second floodprone area. The residence at 831 E. Cloud Road is located adjacent to the 10th Street Wash. The lot was regraded at a lower elevation than the existing ground, which placed the building pad in the overbank of the wash. The flow event of 28 August, 1988 produced 2 feet of ponding inside the house. Four mitigation measures were researched for this site. The results are as follows:

1) Channelization

A channelization scheme for this site would start with 6-6'x4' RCBCs on Cloud Road and the 10th Street Wash. The channel would then progress in a southeasterly direction to 10th Street. The 10th Street wash crosses Cloud Road approximately 1,000 feet west of 10th Street. The channel cross section would consist of 6" concrete lining at a 15 foot bottom width with 2:1 side slopes. A 40 foot right-of-way would be needed for the channel and maintenance easement.



This channel would convey the 100-year flood event of 1,026 CFS and would floodproof the subject site and would also reduce flooding on lands to the south of the subject site. This scheme would benefit 2 residences. The cost for this channel system is $322,500.00

2) Regional Detention Basin

This alternative was not feasible due to a lack of large consolidated undeveloped land in the watershed. Without a large parcel of land with one owner, the process of constructing a large regional detention basin is greatly hindered. The site location in regards to the entire watershed reduces the effectiveness of a regional detention basin. The site is located approximately in the lower 1/3 of the basin. The highest reduction of flow values is immediately downstream of a detention basin located in the upper half of the watershed. This watershed also has poor topographical definition to efficiently construct a detention basin.

3) Future Development

The reduction of flow produced by upstream development would not significantly reduce the flows to effectively solve this problem. The effect of future development will slightly reduce the frequency of flooding.

4) Property Acquisition

The activity is possible. It is a small lot surrounded by other houses, which could make a good location for a park. The lot has been totally graded and has little or no habitat value. The cost to purchase this property would not exceed $100,000.00. The structure could be sold and relocated to a site in the general area.

14TH STREET WASH

The residence at 1239 E. Cloud Road was flooded by over 1 foot of water during the flood event of 28 August, 1988. Since the flooding event, the property owner has installed a +3 foot high block wall on the perimeter of the property. This action would presumable flood proof this residence. No mitigation measures were studies for this site.

TABLE IV
CHANNEL COST ESTIMATE SUMMARY

Mitigation Area No. 1: Jonathan Wash	
1) Channelization	$2,655,000.00
2) Regional Detention/Retention Basins	N/A
3) Future Development	0.00
4) Property Acquisition	$300,000.00
Mitigation Area No. 2: 10th Street Wash	
1) Channelization	$322,500.00
2) Regional Detention/Retention Basins	N/A
3) Future Development	0.00
4) Property Acquisition	$100,000.00

CASE IV: CONCEPTUAL STORM DRAIN PLAN

The goal of Case IV is to develop a hydrologic model for the future condition with a recommended storm drain system for the design storm. The 2-year storm event is the design storm for this case. The duration of the storm event is equal to the time of concentration for each basin. This assumption is inherent in the use of the rational method. All contributing areas were assumed to be 1 residence per acre type development.

The traditional method of storm drain layout for the City of Phoenix consists of mile street trunk line storm drains with laterals at half and full mile intersections. This method was developed because of a lack of defined drainage channels in flat urban areas. The Apache Wash contains many large channels and smaller collector tributary channels which provide for positive drainage to the Cave Buttes Reservoir. The channels are the product of relatively steep unfarmed terrain.

Due to this terrain, traditional square mile drainage areas which are typical in urbanized area of the City are not modelled in this fashion for the Apache Wash. When development occurs existing drainage patterns/channels will be used to receive storm runoff. The runoff will not be redirected to go to a mile road storm drain. Therefore, the only instance a storm drain will be utilized is the condition when existing runoff directly impacts an existing or proposed roadway. This runoff is not contained in a channel but is generally overland flow which would eventually enter a channel beyond the location of the roadway.

A storm drain which is used to drain only roadway pavement is considered to be a roadway drain. The proposed roadway alignments of 18th Street and 30th Street (as intersected at Carefree Highway) follow ridge lines, which are generally not impacted by offsite flows. The culvert crossings for Carefree Highway, the 18th Street alignment, Dove Valley Road and Happy Valley will be included as part of this Case. Currently in the study area there are 16 structures which convey flows under Carefree Highway.

To bring this roadway up to a 100 year design standard, 15 new structure will be necessary in place of the existing structures. Dove Valley Road, Happy Valley Road, the 18th Street and 30th Street alignments as well as the Northeast Outerloop are planned roadways and have no existing structures in the study area. No structures are sized for the Northeast Outerloop facility which is under the control of the Arizona Department of Transportation (ADOT). Dove Valley Road will have bridge structure for the Apache Wash Crossing. Happy Valley Road and the 18th Street alignment will also have one bridge structure for the Apache Wash Crossing. See Table V Culvert Summary at the end of this section and the Carefree Highway Drainage Map in the Appendix.

The 30th Street alignment has one culvert crossing approximately 1000 feet north of the Northeast Outerloop alignment. Carefree Highway contains five separate storm drain systems. See Table VI Storm Drain/Roadway Drainage Summary at the end of this section and the Storm Drain/Roadway Drainage Map in the Appendix. One of these systems C-1 drains back into Cave Creek Wash which is a variation from existing conditions. The redirected flow will not effect flow values in Cave Creek Wash. The other alternatives for this flow would be to take it west into Basin 11. This additional flow would have a significant impact upon this wash. The 18th Street alignment has one storm drain system. Dove Valley Road and the 30th Street alignment each have two storm drain systems. Happy Valley Road does not have a storm drain or roadway drain system. The storm drain, roadway drain summary sheet contains proposed sizes and costs. The layout of these proposed systems is contained in the Storm Drain Map.

TABLE V
CAREFREE HIGHWAY CULVERT SUMMARY

EXISTING CULVERT	DRAINAGE AREAS DES.	D.A. (A.C.)	CFS/AC	FLOW VALUE (CFS)	EXISTING CAPACITY	REQUIRED STRUCTURE	CULVERT COST
A 1-30" CMP	A	82.6	2.5	206.5	35	1-8'x4' RCBC	20,800
B 2-36" CMPs	B	5.2	2.5	13	104	1-36" RCP	6,500
C 4-12x6"RCBC	50	--	--	1229	2016	Ext. Keep 70'	187,200
D 1-36" CMP	D	6.9	2.5	17.3	52	1-36" RCP	6,500
E 10x5' RCBC	40	--	--	4263	420	100' Bridge	440,000
F 1-36" CMP	F	14.7	2.5	36.8	52	1-36" RCP	6,500
G 2-48" CMPs	G	275	2.5	687.5	196	2-10"x5" RCBC	65,000
H 2-48" CMPS	30	--	--	718	196	2-10"x5" RCBC	65,000
I 1-36" CMP	I-J	151	2.5	--	52+196	Combined with J	
J 2-48" CMPs	I-J	151	2.5	377.5	248	1-8'x4' RCBC	20,800
K 30" EQ	K	24.8	2.5	62	35	1-48" RCP	7,500
L 2-36 CMPs		--	--	--	392+104		
4-48 CMPs	21	323	2.5	712	496	2-10'x5' RCBC	65,000
L 2-1-36 EQ	K	24.8	2.5	114.8	52	2-48" RCP	15,000
M 3-10"x5" RCBC	22T	329	2.5	11,280	1,260	400' Bridge	1,760,000
N 4-48 COMP	11	--	--	1,915	392	100' Bridge	440,000
O 2-10x5"	12,13,14	--	--	5,956	840	200' Bridge	880,000
18th Street	FT	--	--	12,088	N/A	400' Bridge	1,760,000
Dove Valley A/W (1)	10t	--	--	31,208	N/A	500' Bridge	2,200,000
Dove Valley C/C (2)	2	--	--	1,256	N/A	100' Bridge	440,000
Happy Valley	A	203	2.78	564	N/A	2-8'x4' RCBC	41,600
30th Street	15E	54.5	2.5	136.3	N/A	3-48" RCPS	22,500
						TOTAL	8,449,900

(1) Apache Wash Crossing

(2) Cave Creek Crossing

TABLE VI
STORM DRAIN/ROADWAY DRAIN
COST SUMMARY

BASIN	PIPE LENGTH	SIZE	Q (CFS)	COST/FT	TOTAL
C-1	4,000 FT	54"	107.6	137.74	550,960.00
C-2	3,500 FT	39"	43	92.15	322,525.00
C-3	1,500 FT	54"	92	137.74	206,610.00
C-4	900 FT	36"	27.4	83.42	75,078.00
C-5	5,000 FT	78"	304	224.07	1,120,350.00
C-6	12,500 FT	54"	115	137.74	1,721,750.00
15-A	1,400 FT	42"	54.6	100.88	141,232.00
15-B	3,400 FT	54"	113.2	137.74	468,316.00
15-C	1,500 FT	54"	99.2	137.74	206,610.00
15-D*	3,000 FT		28.9		
15-E	4,500 FT	54"	95.6	137.74	619,830.00
18th St	6,000 FT	24"	109	62.08	372,480.00

*Areas 15-D and 15-E are combined.

SUBTOTAL	$5,805,741.00
Design, Construction Administration & Management (40%)	$2,322,296.40
TOTAL	$8,128,037.40

CASE V: COMBINATION, CONCEPTUAL DRAINAGE AND STORM DRAIN PLAN

This case deals with the combined effects of the Conceptual Drainage Plan and the Conceptual Storm Drain Plan. Assuming that the solution which would have the greatest effect on the hydraulic characteristics of the basin is implemented; its effects combined with the storm drain scheme would not significantly impact the existing Case I Model.

There are many reasons for this result. The proposed channel improvements are very local and do not effect flows on the main branch of the Apache Wash. The existing detention effects of the undersized culverts on Carefree Highway are negligable because the elevation of roadway is so close to the top of the culverts. The storm drain/roadway drain will not impact the flow values because these structures are located in the lower portions of the basin. The flows handled by the 2 year systems with small drainage areas are much less than the 100 year flows with large drainage areas.

RECOMMENDATIONS

This section will contain two topics; the Conceptual Drainage Plan and Conceptual Storm Drain Plan, and a General Area Drainage Policy. The second section is needed to help guide the development of a drainage network in the Apache Wash Basin.

Conceptual Drainage Plan

It is recommended for the two mitigation areas that properties be purchased and used for public recreation purposes. This is the most effective-least cost alternative for each area. This alternative follows the guidelines of the General Plan, Peripherial Area C and D Planning Study and the New River Area Plan more closely than any other alternative.

Conceptual Storm Drain Plan

Is is recommended that the plan outlined in the results section be implemented for the Apache Wash Basin. The culverts for Carefree Highway are sized for the 100 year storm which is higher than the usual design criteria for a road. The 100-year storm event will be used by adjacent developments for design. The use of a lesser storm for the culverts could possibly create a flooding problem upstream of the structures. The 100-year storm is used in order to blend in with future development. New structures will have to be placed in the road when it is upgraded in the future to handle the increased traffic demands. The additional monies needed to upgrade the structure should be allocated to the improved roadway system when it occurs.

Carefree HWY Culverts

The costs for the culverts and bridges for Dove Valley Road, Happy Valley Road, 18th Street and 30th Street alignments are relatively small because either the length of the roadway is short or the road is aligned on a ridge line.

255-0072

The costs for the storm drain and roadway drainage are also relatively small due to the small drainage area per mile of roadway. Storm drains were placed only when necessary.

GENERAL AREA DRAINAGE POLICY

The General Area Drainage Policy combines the goals of the planning doucments and the realities of development and construction. The development community wants to maximize developable areas. The planning and natural resource agencies wants to maintain the natural desert environment as much as possible. The General Area Drainage Policy tries to achieve common ground for each interest.

A brief hydraulic analysis of the average channel section showed that the majority of the 100 year storm is conveyed by the overbank area. From field observations, the majority of the dense desert vegetation is located within five feet from the top of the low flow channel bank. The overbank areas can be characterized as sparcely vegetated and having little or no habitat value for desert animal species. The policy is basically the recommendation of a channel section for drainageway improvement. The development communities needs can be addressed by increasing the hydraulic efficiency of the overbank areas. This can be done by excavation at a flat grade from the top of the bank not disturbing vegetation in the bank area. Since the overbank flow area will become more efficient, the edge of the floodplain can then be moved closer towards the bank, yielding the developer more buildable land. The vegetation along the banks will remain in its present condition providing the basis for a green belt recreational system which also would include a bike path in the overbank areas. These overbank areas could also be used for other recreational features, such as horseback riding, volleyball, baseball and golf. This type of channel section with very limited bank protection is a practical alternative which tries to fulfill the needs of all interested parties.

REFERENCES

1) General Plan Peripheral Areas C and D, City of Phoenix Planning Department, October 1987

2) New River Land Use Plan Maricopa County, June 1988

3) HEC 1 Generalized Computer Program, U.S. Army Corps of Engineers, Davis California, Revised 1985

4) Flood Insurance Rate Map, Maricopa County Arizona and Incorporated Areas. Panels 795 and 1210 of 4350, National Flood Insurance Program, April 15, 1988

5) Drainage Regulation for the Unicorporated Area of Maricopa County, Arizona, Flood Control District of Maricopa County, Arizona

need 6) Storm Drain Design Manual, Storm Drains with Paving of Major Streets, City of Phoenix, Revised July 1987.

7) Preliminary Draft, Maricopa County Hydrology Manual, Flood Control District of Maricopa County, December 1988

8) Design of Gravity Dams, United States Department of the Interior Bureau of Reclamation, Denver, Colorado, 1976

9) Flood Frequency Estimates in Southern Arizona by Walter Broughton, Ken Renard and J. Stone, Joural of Irrigation and Drainage Engineering Volume 113 No. 4, November 1987

10) Precipitation - Frequency Atlas of the Western United States, Volume VIII-Arizona, National Oceanic and Atmospheric Administration, Atlas 2.

11) S-Graph Study Contract FCD 86-36 Flood Control District of Maricopa County, Arizona by George Sabol Brigiton, Colorado, November 1987

12) Comparison of Estimated Peak Discharges for the 100-year Rainfall with Existing Watershed Conditions and Recorded Peak Discharges for Rainfall Floods in Phoenix and Vicinity, Gila River Basin, New River and Phoenix City Streams, Arizona Design Memoradum No. 2 Hydrology, Part 1 Table 15 USACOE LA District, October 1974

13) Soil Survey of Maricopa County, Arizona, Central Part United States Department of Agriculture Soil Conservation, September 1977

14) Hydrology Manual for Engineering Design and Floodplain Management within Pinal County, Arizona, Pinal County Department of Transportation and Flood Control District, September 1979

15) Apache Peak News, Chelsey International, Inc., Volume 1 No. 10, August 1989

16) Hydraulic Engineering Circular No. 5 Hydraulic Charts for the Selection of Highway Culverts, 1965

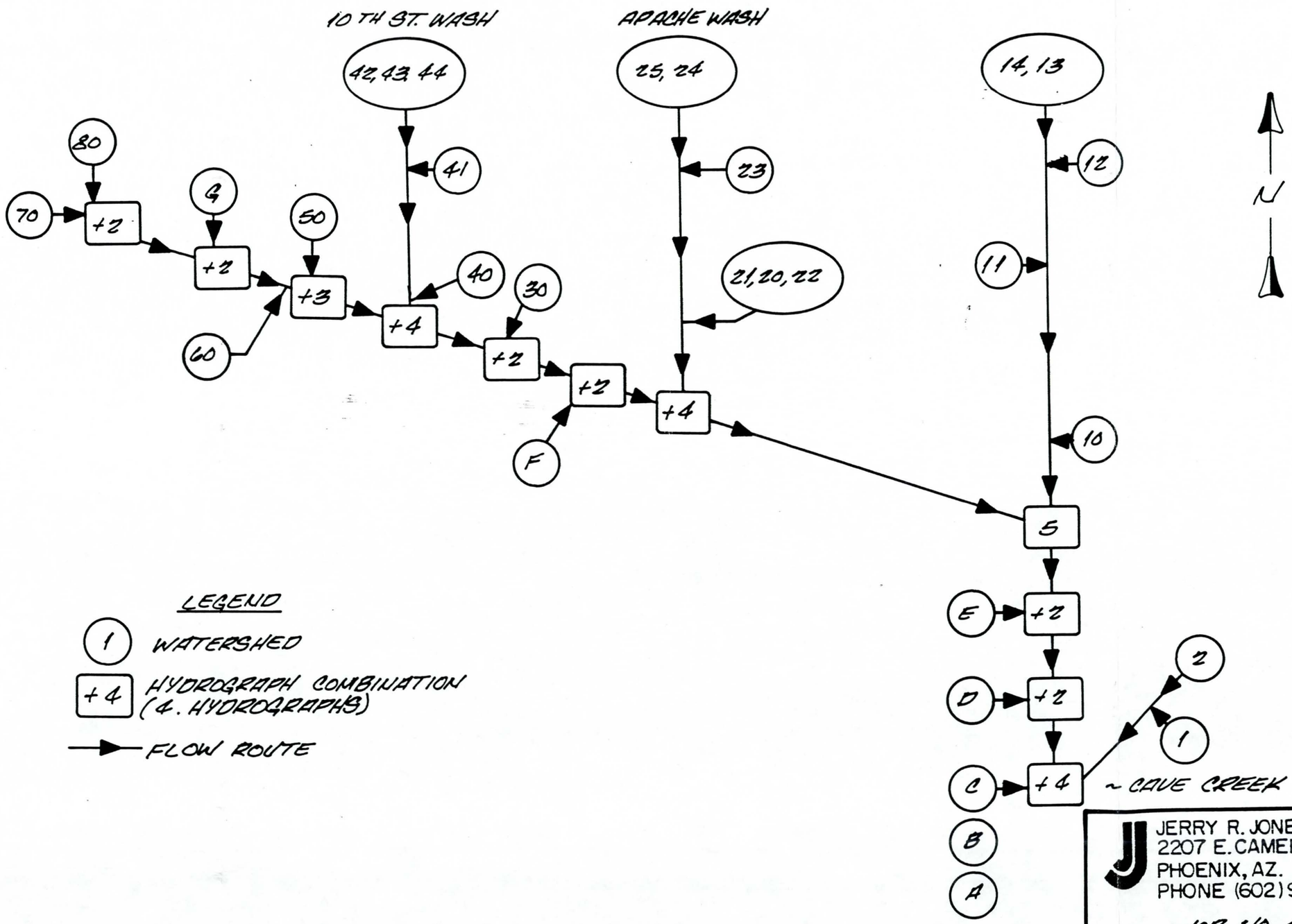
17) Interoffice Memorandum, Flooding Problem of August 28, 1988 File: 80-9-00-9-09/88 by A.M.M., Flood Control District of Maricopa County, September 2, 1988

18) A Guide to Hydrologic Analysis SCS Methods by Richard H. McCuen, Prentice-Hall Inc., New Jersey 1982

APPENDIX

HEC 1 COMPUTER MODELS

APACHE WASH
HEC 1 SCHEMATIC DIAGRAM



LEGEND

(1) WATERSHED

[+4] HYDROGRAPH COMBINATION (4. HYDROGRAPHS)

→ FLOW ROUTE

JERRY R. JONES & ASSOC., INC.
2207 E. CAMELBACK RD., SUITE 302
PHOENIX, AZ. 85016
PHONE (602) 956-9850

JOB NO. 289-019

HEC 1 COMPUTER MODEL
EXISTING CONDITIONS

```
*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*          FEBRUARY 1981            *
*        REVISED 30 OCT 81          *
*                                   *
*  RUN DATE      7-A    TIME     09:0 *
*                                   *
*************************************
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*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
*  THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*       DAVIS, CALIFORNIA 95616     *
*  (916) 440-3285 OR (FTS) 448-3285 *
*                                   *
*************************************
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X     X  XXXXXXX   XXXXX          X
X     X  X       X     X        XX
X     X  X       X               X
XXXXXXX  XXXX     X       XXXXX   X
X     X  X       X               X
X     X  X       X     X         X
X     X  XXXXXXX   XXXXX         XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE. THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. SEE SEPTEMBER 1981 INPUT DESCRIPTION FOR NEW DEFINITIONS.

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   HEC1 EXISTING WATERSHED FILE AWT.DAT CASE 1
  2           ID   APACHE WASH EXISTING DEVELOPMENT
  3           ID   REVISED FOR PCDOT TIME OF CONC. & FCDMC COMMENTS  6-21-89
              *DIAGRAM
  4           IT      10 15FEB89             145
  5           IO       5       0

  6           KK    70   SCS METHOD
  7           KM     RUNOFF FROM AREA 70
  8           BA    2.00
  9           IN      30
 10           PB     4.6
 11           PC       0   0.005   0.009    0.01   0.013   0.019   0.021   0.028   0.032   0.044
 12           PC   0.057     0.1    0.66   0.745   0.776     0.8   0.816   0.830   0.840   0.850
 13           PC   0.861   0.868   0.878   0.884   0.891     0.9   0.905   0.912   0.919   0.923
 14           PC   0.930   0.934   0.939   0.944   0.950   0.958   0.961   0.963   0.969   0.971
 15           PC   0.974   0.979   0.981   0.985   0.989   0.991   0.993   0.996     1.0
 16           LS       0    84.9       1
 17           UD    0.59

 18           KK    80
 19           KM     RUNOFF FROM AREA 80
 20           BA     1.2
 21           PB     4.6
 22           LS       0    83.6       1
 23           UD    0.66

 24           KK    80T
 25           KM     COMBINE RUNOFF FROM 70,80
 26           HC       2

 27           KK    G
 28           KM    ROUTE 80T TO AREA G
 29           RK    3000   0.005    0.03            TRAP       0       5

 30           KK     G
 31           KM    RUNOFF FROM AREA G
 32           BA    0.76
 33           PB     4.6
 34           LS       0    85.1       5
 35           UD    0.22

 36           KK     GT
 37           KM    COMBINE RUNOFF FROM 70,80,G
 38           HC       2

 39           KK    50
 40           KM    ROUTE G TO AREA 50
 41           RK    1500   0.005    0.03            TRAP       2       4
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  42          KK    60
  43          KM    RUNOFF FROM AREA 60
  44          BA    0.44
  45          PB     4.6
  46          LS       0      83       1
  47          UD    0.24

  48          KK   50T
  49          KM    ROUTE TO 50T
  50          RK    1500   0.008   0.025           TRAP      2       3

  51          KK   50
  52          KM     RUNOFF FROM AREA 50
  53          BA    1.15
  54          PB     4.6
  55          LS       0    84.3     1.5
  56          UD    0.66

  57          KK   50T
  58          KM    COMBINE 60,50,GT
  59          HC       3

  60          KK   40
  61          KM    ROUTE 50TA TO AREA 40
  62          RK    1000   0.005   0.025           TRAP     10       3

  63          KK  44,3,2
  64          KM    RUNOFF FROM 42,43,44
  65          BA    2.12
  66          PB     4.6
  67          LS       0    84.8       1
  68          UD    0.21

  69          KK   40
  70          KM    ROUTE 43,44 TO 40
  71          RK   11000   0.067    0.03           TRAP      5       5

  72          KK   41
  73          KM    RUNOFF FROM AREA 41
  74          BA    0.89
  75          PB     4.6
  76          LS       0    83.7     1.5
  77          UD    0.38

  78          KK    40
  79          KM    ROUTE 41T TO 40
  80          RK    6500   0.006   0.03           TRAP      5       4

  81          KK    40
  82          KM    RUNOFF FROM AREA 40
  83          BA    0.56
  84          PB     4.6
  85          LS       0    82.2       2
  86          UD    0.46
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  87          KK   40T
  88          KM   COMBINE 40,43,44,42,50TA
  89          HC      4

  90          KK  30
  91          KM   ROUTE 40TA TO AREA 30
  92          RK   3000   0.004  0.025          TRAP      10       3

  93          KK   30
  94          KM   RUNOFF FROM AREA 30
  95          BA   0.50
  96          PB    4.6
  97          LS      0    84.3     1.2
  98          UD   0.39

  99          KK   30T
 100          KM   COMBINE 40TA AND 30
 101          HC      2

 102          KK  F
 103          KM   ROUTE 30T TO POINT F
 104          RK   6000  0.0025   0.025          TRAP      12       3

 105          KK   F
 106          KM   RUNOFF FROM AREA F
 107          BA   2.45
 108          PB    4.6
 109          LS      0    84.9       1
 110          UD   0.90

 111          KK   FT
 112          KM   COMBINE 30T AND F
 113          HC      2

 114          KK  24,25
 115          KM   RUNOFF FROM 24,25
 116          BA   4.32
 117          PB    4.6
 118          LS      0    86.1       1
 119          UD   0.26

 120          KK  20
 121          KM   ROUTE 25 TO AREA 20
 122          RK  25000  0.0092    0.03          TRAP       8       5

 123          KK   23
 124          KM   RUNOFF FROM 23
 125          BA   1.71
 126          PB    4.6
 127          LS      0    85.5       1
 128          UD   0.25
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 129          KK    20
 130          KM    ROUTE 23 TO 20
 131          RK   16000   0.007    0.03            TRAP       8       5

 132          KK  20,1,2
 133          KM    RUNOFF FROM AREA 20,21,22
 134          BA    1.70
 135          PB     4.6
 136          LS       0    84.5       1
 137          UD    0.80

 138          KK    20T
 139          KM    COMBINE RUNOFF FROM 20,21,22,23,24,FT
 140          HC       4

 141          KK    10
 142          KM    ROUTE TO 10
 143          RK    1000   0.004   0.025           TRAP      12       3

 144          KK  14,13
 145          KM     RUNOFF FROM AREA 14,13
 146          BA    1.40
 147          PB     4.6
 148          LS       0    85.9       1
 149          UD    0.36

 150          KK   10
 151          KM    ROUTE 13,14 TO 10
 152          RK   11000   0.007    0.03            TRAP      12       5

 153          KK    12
 154          KM    RUNOFF FROM AREA 12
 155          BA    1.89
 156          PB     4.8
 157          LS       0    86.4
 158          UD    0.26

 159          KK    10
 160          KM    ROUTE 12 TO AREA 10
 161          RK   11000   0.007    0.03            TRAP      12       5

 162          KK    11
 163          KM    RUNOFF FROM AREA 11
 164          BA    1.36
 165          PB     4.6
 166          LS       0    85.6
 167          UD    0.45

 168          KK    10
 169          KM    ROUTE 11 TO AREA 10
 170          RK   13000   0.003   0.025            TRAP      12       3
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  171         KK    10
  172         KM    RUNOFF FROM BASIN 10
  173         BA    0.96
  174         PB     4.6
  175         LS       0    85.7       1
  176         UD    0.55

  177         KK    10T
  178         KM    COMBINE 10,11,12,13,14,20T
  179         HC       5

  180         KK    E
  181         KM    ROUTE 10T TO POINT E
  182         RK   13000   0.003   0.025           TRAP      12       3

  183         KK    E
  184         KM    RUNOFF FROM AREA E
  185         BA    1.42
  186         PB     4.6
  187         LS       0    84.6
  188         UD    0.60

  189         KK    ET
  190         KM    COMBINE 10T AND E
  191         HC       2

  192         KK    D
  193         KM    RUNOFF FROM AREA D
  194         BA    1.20
  195         PB     4.6
  196         LS       0    86.8
  197         UD    0.26

  198         KK    DT
  199         KM    COMBINE D AND ET
  200         HC       2

  201         KK    DTR
  202         KM    ROUTE TO POINT C
  203         RK    8000   0.003   0.025           TRAP      12       3

  204         KK    C
  205         KM    RUNOFF FROM AREA C
  206         BA    1.17
  207         PB     4.6
  208         LS       0    86.3
  209         UD    0.21

  210         KK    2
  211         KM    RUNOFF FROM AREA 2
  212         BA    1.06
  213         PB     4.6
  214         LS       0    87.7
  215         UD    0.68
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 216          KK    1
 217          KM    ROUTE TO 1,C
 218          RK   17000   0.006   0.025           TRAP      12       3

 219          KK    1
 220          KM    RUNOFF FROM AREA 1
 221          BA    0.91
 222          PB     4.6
 223          LS       0    85.5
 224          UD    0.80

 225          KK    1T
 226          KM    COMBINE 1,2,DT,C
 227          HC       4

 228          KK    B
 229          KM    RUNOFF FROM AREA B
 230          BA    0.46
 231          PB     4.6
 232          LS       0    87.0
 233          UD    0.15

 234          KK    A
 235          KM    RUNOFF FROM AREA A
 236          BA    0.48
 237          PB     4.6
 238          LS       0    84.7
 239          UD    0.24
 240          ZZ
```

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
LINE      (V) ROUTING          (---#) DIVERSION
NO.       (.) CONNECTOR        ()---) RETURN OF DIVERTED FLOW

 6        70
             .
             .
18           .        80
             .           .
             .           .
24        80T ............
             V
             V
27        G
             .
             .
30           .        G
             .           .
             .           .
36         GT ............
             V
             V
39        50
             .
             .
42           .        60
             .           V
             .           V
48           .       50T
             .           .
             .           .
51           .           .       50
             .           .          .
             .           .          .
57       50T  ........................
             V
             V
60        40
             .
             .
63           .      44,3,2
             .           V
             .           V
69           .       40
             .           .
             .           .
72           .           .       41
             .           .          V
             .           .          V
78           .           .       40
             .           .          .
             .           .          .
81           .           .          .       40
             .           .          .          .
             .           .          .          .
87        40T ....................................
             V
             V
90        30
             .
             .
93           .        30
```

```
 99      30T ............
            V
            V
102     F
            .
            .
105         .       F
            .         .
            .         .
111     FT ............
            .
            .
114         .     24,25
            .         V
            .         V
120         .     20
            .         .
            .         .
123         .         .     23
            .         .        V
            .         .        V
129         .         .     20
            .         .        .
            .         .        .
132         .         .        .    20,1,2
            .         .        .        .
            .         .        .        .
138     20T ................................
            V
            V
141     10
            .
            .
144         .     14,13
            .         V
            .         V
150         .     10
            .         .
            .         .
153         .         .     12
            .         .        V
            .         .        V
159         .         .     10
            .         .        .
            .         .        .
162         .         .        .    11
            .         .        .       V
            .         .        .       V
168         .         .        .    10
            .         .        .       .
            .         .        .       .
171         .         .        .       .       10
            .         .        .       .         .
            .         .        .       .         .
177     10T ............................................
            V
            V
180     E
            .
            .
183         .       E
            .         .
            .         .
189     ET ............
```

```
 92          .        D
             .          .
             .          .
 98       DT  ............
            V
            V
201       DTR
             .
             .
204          .        C
             .          .
             .          .
210          .          .       2
             .          .         V
             .          .         V
216          .          .       1
             .          .         .
             .          .         .
219          .          .         .       1
             .          .         .         .
             .          .         .         .
225       1T  ...................................
             .
             .
228          .        B
             .          .
             .          .
234          .          .       A
```

(XXX) RUNOFF ALSO COMPUTED AT THIS LOCATION

```
*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*          FEBRUARY 1981            *
*        REVISED 30 OCT 81          *
*                                   *
* RUN DATE      7-A    TIME     09:0 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
* (916) 440-3285 OR (FTS) 448-3285  *
*                                   *
*************************************
```

```
                    HEC1 EXISTING WATERSHED FILE AWT.DAT CASE 1
                    APACHE WASH EXISTING DEVELOPMENT
                    REVISED FOR PCDOT TIME OF CONC. & FCDMC COMMENTS  6-21-89

5 IO          OUTPUT CONTROL VARIABLES
                   IPRNT          5  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL         0.  HYDROGRAPH PLOT SCALE

  IT          HYDROGRAPH TIME DATA
                    NMIN         10  MINUTES IN COMPUTATION INTERVAL
                   IDATE     15FEB89  STARTING DATE
                   ITIME       0000  STARTING TIME
                      NQ        145  NUMBER OF HYDROGRAPH ORDINATES
                  NDDATE     16FEB89  ENDING DATE
                  NDTIME       0000  ENDING TIME

             COMPUTATION INTERVAL    0.17 HOURS
                  TOTAL TIME BASE   24.00 HOURS

       ENGLISH UNITS
           DRAINAGE AREA          SQUARE MILES
           PRECIPITATION DEPTH    INCHES
           LENGTH, ELEVATION      FEET
           FLOW                   CUBIC FEET PER SECOND
           STORAGE VOLUME         ACRE-FEET
           SURFACE AREA           ACRES
           TEMPERATURE            DEGREES FAHRENHEIT
```

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	70	2331.	6.50	533.	160.	160.	2.00		
HYDROGRAPH AT	80	1242.	6.50	305.	92.	92.	1.20		
2 COMBINED AT	80T	3573.	6.50	838.	253.	253.	3.20		
ROUTED TO	G	3483.	6.50	838.	253.	253.	3.20		
HYDROGRAPH AT	G	1438.	6.00	210.	63.	63.	0.76		
2 COMBINED AT	GT	4022.	6.50	1044.	316.	316.	3.96		
ROUTED TO	50	3987.	6.50	1046.	316.	316.	3.96		
HYDROGRAPH AT	60	743.	6.17	111.	33.	33.	0.44		
ROUTED TO	50T	734.	6.17	111.	33.	33.	0.44		
HYDROGRAPH AT	50	1229.	6.50	300.	91.	91.	1.15		
3 COMBINED AT	50T	5570.	6.50	1457.	440.	440.	5.55		
ROUTED TO	40	5555.	6.50	1458.	440.	440.	5.55		
HYDROGRAPH AT	44,3,2	3996.	6.00	569.	170.	170.	2.12		
ROUTED TO	40	3821.	6.17	565.	170.	170.	2.12		
HYDROGRAPH AT	41	1275.	6.17	229.	69.	69.	0.89		
ROUTED TO	40	1300.	6.33	249.	74.	74.	0.89		
HYDROGRAPH AT	40	691.	6.33	137.	42.	42.	0.56		
4 COMBINED AT	40T	10028.	6.33	2408.	726.	726.	9.12		
ROUTED TO	30	9881.	6.33	2404.	725.	725.	9.12		
HYDROGRAPH AT	30	718.	6.17	131.	40.	40.	0.50		
2 COMBINED AT	30T	10580.	6.33	2536.	765.	765.	9.62		
ROUTED TO	F	10225.	6.50	2525.	762.	762.	9.62		
HYDROGRAPH AT	F	2146.	6.83	647.	196.	196.	2.45		
2 COMBINED AT	FT	12078.	6.50	3172.	958.	958.	12.07		
HYDROGRAPH AT	24,25	8083.	6.17	1211.	361.	361.	4.32		
ROUTED TO	20	7795.	6.33	1194.	359.	359.	4.32		
HYDROGRAPH AT	23	3150.	6.17	470.	140.	140.	1.71		
ROUTED TO	20	3166.	6.33	516.	152.	152.	1.71		

4 COMBINED AT	20T	23766.	6.33	5325.	1604.	1604.	19.80
ROUTED TO	10	23091.	6.33	5332.	1606.	1606.	19.80
HYDROGRAPH AT	14,13	2281.	6.17	389.	116.	116.	1.40
ROUTED TO	10	1751.	6.50	379.	115.	115.	1.40
HYDROGRAPH AT	12	3775.	6.17	565.	168.	168.	1.89
ROUTED TO	10	3365.	6.33	557.	167.	167.	1.89
HYDROGRAPH AT	11	1915.	6.33	371.	111.	111.	1.36
ROUTED TO	10	1861.	6.67	390.	116.	116.	1.36
HYDROGRAPH AT	10	1199.	6.33	263.	79.	79.	0.96
5 COMBINED AT	10T	30673.	6.33	6917.	2083.	2083.	25.41
ROUTED TO	E	30198.	6.50	6860.	2071.	2071.	25.41
HYDROGRAPH AT	E	1614.	6.50	373.	112.	112.	1.42
2 COMBINED AT	ET	31812.	6.50	7219.	2183.	2183.	26.83
HYDROGRAPH AT	D	2290.	6.17	343.	102.	102.	1.20
2 COMBINED AT	DT	32809.	6.50	7532.	2285.	2285.	28.03
ROUTED TO	DTR	31245.	6.67	7547.	2287.	2287.	28.03
HYDROGRAPH AT	C	2331.	6.00	329.	98.	98.	1.17
HYDROGRAPH AT	2	1256.	6.50	309.	92.	92.	1.06
ROUTED TO	1	1224.	6.67	304.	91.	91.	1.06
HYDROGRAPH AT	1	885.	6.67	245.	74.	74.	0.91
4 COMBINED AT	1T	33906.	6.67	8384.	2550.	2550.	31.17
HYDROGRAPH AT	B	1090.	6.00	133.	39.	39.	0.46
HYDROGRAPH AT	A	856.	6.17	128.	38.	38.	0.48

```
** NORMAL END OF HEC-1 ***
$1
$ delete for0*.dat;*
MILLER      job terminated at  7-AUG-1989 09:06:02.56

Accounting information:
Buffered I/O count:          59      Peak working set size:   630
Direct I/O count:           161      Peak page file size:    1349
Page faults:                982      Mounted volumes:           0
Charged CPU time:    0 00:00:34.43   Elapsed time:     0 00:00:49.49
```

HEC 1 COMPUTER MODEL
REDUCED AREA BASINS 70 AND 80

```
*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*          FEBRUARY 1981            *
*        REVISED 30 OCT 81          *
*                                   *
*  RUN DATE       7-A    TIME      09:1 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*    U.S. ARMY CORPS OF ENGINEERS   *
*  THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*       DAVIS, CALIFORNIA 95616     *
*  (916) 440-3285 OR (FTS) 448-3285 *
*                                   *
*************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X       X     X        XX
X     X  X       X              X
XXXXXXX  XXXX     X       XXXXX  X
X     X  X       X              X
X     X  X       X     X        X
X     X  XXXXXXX   XXXXX        XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE. THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. SEE SEPTEMBER 1981 INPUT DESCRIPTION FOR NEW DEFINITIONS.

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   HEC1 EXISTING WATERSHED FILE AWT2.DAT CASE 1
  2           ID   APACHE WASH EXISTING DEVELOPMENT 70,80 REVISED FOR DEVELOPMENT
  3           ID   REVISED FOR PCDOT TIME OF CONC. & FCDMC COMMENTS  6-21-89
              *DIAGRAM
  4           IT      10 15FEB89            145
  5           IO       5       0

  6           KK    70   SCS METHOD
  7           KM     RUNOFF FROM AREA 70
  8           BA    1.54
  9           IN      30
 10           PB     4.6
 11           PC       0   0.005   0.009    0.01   0.013   0.019   0.021   0.028   0.032   0.044
 12           PC   0.057     0.1    0.66   0.745   0.776     0.8   0.816   0.830   0.840   0.850
 13           PC   0.861   0.868   0.878   0.884   0.891     0.9   0.905   0.912   0.919   0.923
 14           PC   0.930   0.934   0.939   0.944   0.950   0.958   0.961   0.963   0.969   0.971
 15           PC   0.974   0.979   0.981   0.985   0.989   0.991   0.993   0.996     1.0
 16           LS       0    84.9       1
 17           UD    0.59

 18           KK    80
 19           KM     RUNOFF FROM AREA 80
 20           BA    0.82
 21           PB     4.6
 22           LS       0    83.6       1
 23           UD    0.66

 24           KK    80T
 25           KM     COMBINE RUNOFF FROM 70,80
 26           HC       2

 27           KK    G
 28           KM    ROUTE 80T TO AREA G
 29           RK    3000   0.005    0.03           TRAP       0       5

 30           KK     G
 31           KM    RUNOFF FROM AREA G
 32           BA    0.76
 33           PB     4.6
 34           LS       0    85.1       5
 35           UD    0.22

 36           KK     GT
 37           KM    COMBINE RUNOFF FROM 70,80,G
 38           HC       2

 39           KK    50
 40           KM    ROUTE G TO AREA 50
 41           RK    1500   0.005    0.03           TRAP       2       4
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  42          KK   60
  43          KM   RUNOFF FROM AREA 60
  44          BA   0.44
  45          PB    4.6
  46          LS      0      83       1
  47          UD   0.24

  48          KK  50T
  49          KM   ROUTE TO 50T
  50          RK   1500   0.008   0.025           TRAP       2       3

  51          KK  50
  52          KM    RUNOFF FROM AREA 50
  53          BA   1.15
  54          PB    4.6
  55          LS      0    84.3     1.5
  56          UD   0.66

  57          KK  50T
  58          KM   COMBINE 60,50,GT
  59          HC      3

  60          KK  40
  61          KM   ROUTE 50TA TO AREA 40
  62          RK   1000   0.005   0.025           TRAP      10       3

  63          KK 44,3,2
  64          KM   RUNOFF FROM 42,43,44
  65          BA   2.12
  66          PB    4.6
  67          LS      0    84.8       1
  68          UD   0.21

  69          KK  40
  70          KM   ROUTE 43,44 TO 40
  71          RK  11000   0.067    0.03           TRAP       5       5

  72          KK   41
  73          KM   RUNOFF FROM AREA 41
  74          BA   0.89
  75          PB    4.6
  76          LS      0    83.7     1.5
  77          UD   0.38

  78          KK   40
  79          KM   ROUTE 41T TO 40
  80          RK   6500   0.006   0.03           TRAP       5       4

  81          KK   40
  82          KM   RUNOFF FROM AREA 40
  83          BA   0.56
  84          PB    4.6
  85          LS      0    82.2       2
  86          UD   0.46
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 87           KK    40T
 88           KM    COMBINE 40,43,44,42,50TA
 89           HC       4

 90           KK   30
 91           KM    ROUTE 40TA TO AREA 30
 92           RK    3000   0.004  0.025            TRAP      10       3

 93           KK    30
 94           KM    RUNOFF FROM AREA 30
 95           BA    0.50
 96           PB     4.6
 97           LS       0    84.3     1.2
 98           UD    0.39

 99           KK    30T
100           KM    COMBINE 40TA AND 30
101           HC       2

102           KK   F
103           KM    ROUTE 30T TO POINT F
104           RK    6000  0.0025   0.025            TRAP      12       3

105           KK    F
106           KM    RUNOFF FROM AREA F
107           BA    2.45
108           PB     4.6
109           LS       0    84.9       1
110           UD    0.90

111           KK    FT
112           KM    COMBINE 30T AND F
113           HC       2

114           KK   24,25
115           KM    RUNOFF FROM 24,25
116           BA    4.32
117           PB     4.6
118           LS       0    86.1       1
119           UD    0.26

120           KK   20
121           KM    ROUTE 25 TO AREA 20
122           RK   25000  0.0092    0.03            TRAP       8       5

123           KK    23
124           KM    RUNOFF FROM 23
125           BA    1.71
126           PB     4.6
127           LS       0    85.5       1
128           UD    0.25
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 129          KK    20
 130          KM    ROUTE 23 TO 20
 131          RK   16000   0.007    0.03          TRAP      8       5

 132          KK  20,1,2
 133          KM    RUNOFF FROM AREA 20,21,22
 134          BA    1.70
 135          PB     4.6
 136          LS       0    84.5       1
 137          UD    0.80

 138          KK    20T
 139          KM    COMBINE RUNOFF FROM 20,21,22,23,24,FT
 140          HC       4

 141          KK    10
 142          KM    ROUTE TO 10
 143          RK    1000   0.004   0.025          TRAP      12      3

 144          KK  14,13
 145          KM     RUNOFF FROM AREA 14,13
 146          BA    1.40
 147          PB     4.6
 148          LS       0    85.9       1
 149          UD    0.36

 150          KK   10
 151          KM    ROUTE 13,14 TO 10
 152          RK   11000   0.007    0.03          TRAP      12      5

 153          KK    12
 154          KM    RUNOFF FROM AREA 12
 155          BA    1.89
 156          PB     4.8
 157          LS       0    86.4
 158          UD    0.26

 159          KK   10
 160          KM    ROUTE 12 TO AREA 10
 161          RK   11000   0.007    0.03          TRAP      12      5

 162          KK    11
 163          KM    RUNOFF FROM AREA 11
 164          BA    1.36
 165          PB     4.6
 166          LS       0    85.6
 167          UD    0.45

 168          KK    10
 169          KM    ROUTE 11 TO AREA 10
 170          RK   13000   0.003   0.025          TRAP      12      3
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 171          KK    10
 172          KM    RUNOFF FROM BASIN 10
 173          BA    0.96
 174          PB     4.6
 175          LS       0    85.7       1
 176          UD    0.55

 177          KK    10T
 178          KM    COMBINE 10,11,12,13,14,20T
 179          HC       5

 180          KK    E
 181          KM    ROUTE 10T TO POINT E
 182          RK   13000   0.003   0.025           TRAP      12       3

 183          KK    E
 184          KM    RUNOFF FROM AREA E
 185          BA    1.42
 186          PB     4.6
 187          LS       0    84.6
 188          UD    0.60

 189          KK    ET
 190          KM    COMBINE 10T AND E
 191          HC       2

 192          KK    D
 193          KM    RUNOFF FROM AREA D
 194          BA    1.20
 195          PB     4.6
 196          LS       0    86.8
 197          UD    0.26

 198          KK    DT
 199          KM    COMBINE D AND ET
 200          HC       2

 201          KK    DTR
 202          KM    ROUTE TO POINT C
 203          RK    8000   0.003   0.025           TRAP      12       3

 204          KK    C
 205          KM    RUNOFF FROM AREA C
 206          BA    1.17
 207          PB     4.6
 208          LS       0    86.3
 209          UD    0.21

 210          KK    2
 211          KM    RUNOFF FROM AREA 2
 212          BA    1.06
 213          PB     4.6
 214          LS       0    87.7
 215          UD    0.68
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 216          KK    1
 217          KM    ROUTE TO 1,C
 218          RK   17000   0.006   0.025           TRAP      12       3

 219          KK    1
 220          KM    RUNOFF FROM AREA 1
 221          BA    0.91
 222          PB     4.6
 223          LS       0    85.5
 224          UD    0.80

 225          KK    1T
 226          KM    COMBINE 1,2,DT,C
 227          HC       4

 228          KK    B
 229          KM    RUNOFF FROM AREA B
 230          BA    0.46
 231          PB     4.6
 232          LS       0    87.0
 233          UD    0.15

 234          KK    A
 235          KM    RUNOFF FROM AREA A
 236          BA    0.48
 237          PB     4.6
 238          LS       0    84.7
 239          UD    0.24
 240          ZZ
```

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
OUT
LINE      (V) ROUTING          (---#) DIVERSION
NO.       (.) CONNECTOR        ()---) RETURN OF DIVERTED FLOW

 6        70
             .
             .
18           .        80
             .          .
             .          .
24        80T ............
             V
             V
27        G
             .
             .
30           .        G
             .          .
             .          .
36         GT ............
             V
             V
39        50
             .
             .
42           .        60
             .          V
             .          V
48           .       50T
             .          .
             .          .
51           .          .       50
             .          .          .
             .          .          .
57       50T  ........................
             V
             V
60        40
             .
             .
63           .     44,3,2
             .          V
             .          V
69           .       40
             .          .
             .          .
72           .          .       41
             .          .          V
             .          .          V
78           .          .       40
             .          .          .
             .          .          .
81           .          .          .       40
             .          .          .          .
             .          .          .          .
87         40T ....................................
             V
             V
90        30
             .
             .
93           .        30
```

```
 99      30T ............
            V
            V
102     F
            .
            .
105         .       F
            .         .
            .         .
111     FT  ............
            .
            .
114         .     24,25
            .         V
            .         V
120         .     20
            .         .
            .         .
123         .         .       23
            .         .          V
            .         .          V
129         .         .       20
            .         .          .
            .         .          .
132         .         .          .     20,1,2
            .         .          .          .
            .         .          .          .
138     20T ................................
            V
            V
141     10
            .
            .
144         .     14,13
            .         V
            .         V
150         .      10
            .         .
            .         .
153         .         .       12
            .         .          V
            .         .          V
159         .         .       10
            .         .          .
            .         .          .
162         .         .          .      11
            .         .          .         V
            .         .          .         V
168         .         .          .      10
            .         .          .          .
            .         .          .          .
171         .         .          .          .      10
            .         .          .          .         .
            .         .          .          .         .
177     10T ............................................
            V
            V
180     E
            .
            .
183         .       E
            .         .
            .         .
189     ET  ............
```

```
                .
192             .       D
                .           .
                .           .
198         DT  .............
              V
              V
201         DTR
                .
                .
204             .       C
                .           .
                .           .
210             .           .       2
                .           .           V
                .           .           V
216             .           .       1
                .           .           .
                .           .           .
219             .           .           .       1
                .           .           .           .
                .           .           .           .
225         1T  ...................................
                .
                .
228             .       B
                .           .
                .           .
234             .           .       A
```

(A) RUNOFF ALSO COMPUTED AT THIS LOCATION

```
*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)*
*          FEBRUARY 1981            *
*        REVISED 30 OCT 81          *
*                                   *
* RUN DATE      7-A    TIME     09:1 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*       DAVIS, CALIFORNIA 95616     *
* (916) 440-3285 OR (FTS) 448-3285  *
*                                   *
*************************************
```

```
                    HEC1 EXISTING WATERSHED FILE AWT2.DAT CASE 1
                    APACHE WASH EXISTING DEVELOPMENT 70,80 REVISED FOR DEVELOPMENT
                    REVISED FOR PCDOT TIME OF CONC. & FCDMC COMMENTS  6-21-89

 5 IO         OUTPUT CONTROL VARIABLES
                   IPRNT          5  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                    NMIN         10  MINUTES IN COMPUTATION INTERVAL
                   IDATE     15FEB89  STARTING DATE
                   ITIME       0000  STARTING TIME
                      NQ        145  NUMBER OF HYDROGRAPH ORDINATES
                  NDDATE     16FEB89  ENDING DATE
                  NDTIME       0000  ENDING TIME

             COMPUTATION INTERVAL    0.17 HOURS
                  TOTAL TIME BASE   24.00 HOURS

        ENGLISH UNITS
             DRAINAGE AREA         SQUARE MILES
             PRECIPITATION DEPTH   INCHES
             LENGTH, ELEVATION     FEET
             FLOW                  CUBIC FEET PER SECOND
             STORAGE VOLUME        ACRE-FEET
             SURFACE AREA          ACRES
             TEMPERATURE           DEGREES FAHRENHEIT
```

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	70	1795.	6.50	411.	124.	124.	1.54		
HYDROGRAPH AT	80	848.	6.50	208.	63.	63.	0.82		
2 COMBINED AT	80T	2643.	6.50	619.	187.	187.	2.36		
ROUTED TO	G	2574.	6.50	620.	187.	187.	2.36		
HYDROGRAPH AT	G	1438.	6.00	210.	63.	63.	0.76		
2 COMBINED AT	GT	3113.	6.50	827.	250.	250.	3.12		
ROUTED TO	50	3099.	6.50	828.	250.	250.	3.12		
HYDROGRAPH AT	60	743.	6.17	111.	33.	33.	0.44		
ROUTED TO	50T	734.	6.17	111.	33.	33.	0.44		
HYDROGRAPH AT	50	1229.	6.50	300.	91.	91.	1.15		
3 COMBINED AT	50T	4682.	6.33	1239.	374.	374.	4.71		
ROUTED TO	40	4682.	6.50	1240.	374.	374.	4.71		
HYDROGRAPH AT	44,3,2	3996.	6.00	569.	170.	170.	2.12		
ROUTED TO	40	3821.	6.17	565.	170.	170.	2.12		
HYDROGRAPH AT	41	1275.	6.17	229.	69.	69.	0.89		
ROUTED TO	40	1300.	6.33	249.	74.	74.	0.89		
HYDROGRAPH AT	40	691.	6.33	137.	42.	42.	0.56		
4 COMBINED AT	40T	9360.	6.17	2191.	660.	660.	8.28		
ROUTED TO	30	9355.	6.33	2191.	660.	660.	8.28		
HYDROGRAPH AT	30	718.	6.17	131.	40.	40.	0.50		
2 COMBINED AT	30T	10054.	6.33	2322.	700.	700.	8.78		
ROUTED TO	F	9729.	6.33	2311.	697.	697.	8.78		
HYDROGRAPH AT	F	2146.	6.83	647.	196.	196.	2.45		
2 COMBINED AT	FT	11379.	6.50	2958.	893.	893.	11.23		
HYDROGRAPH AT	24,25	8083.	6.17	1211.	361.	361.	4.32		
ROUTED TO	20	7795.	6.33	1194.	359.	359.	4.32		
HYDROGRAPH AT	23	3150.	6.17	470.	140.	140.	1.71		
ROUTED TO	20	3166.	6.33	516.	152.	152.	1.71		
HYDROGRAPH AT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		

4 COMBINED AT	20T	23288.	6.33	5111.	1539.	1539.	18.96
ROUTED TO	10	22587.	6.33	5118.	1541.	1541.	18.96
HYDROGRAPH AT	14,13	2281.	6.17	389.	116.	116.	1.40
ROUTED TO	10	2066.	6.33	384.	115.	115.	1.40
HYDROGRAPH AT	12	3775.	6.17	565.	168.	168.	1.89
ROUTED TO	10	3365.	6.33	557.	167.	167.	1.89
HYDROGRAPH AT	11	1915.	6.33	371.	111.	111.	1.36
ROUTED TO	10	1861.	6.67	390.	116.	116.	1.36
HYDROGRAPH AT	10	1199.	6.33	263.	79.	79.	0.96
5 COMBINED AT	10T	31001.	6.33	6708.	2018.	2018.	24.57
ROUTED TO	E	30068.	6.50	6652.	2006.	2006.	24.57
HYDROGRAPH AT	E	1614.	6.50	373.	112.	112.	1.42
2 COMBINED AT	ET	31683.	6.50	7012.	2118.	2118.	25.99
HYDROGRAPH AT	D	2290.	6.17	343.	102.	102.	1.20
2 COMBINED AT	DT	32680.	6.50	7325.	2220.	2220.	27.19
ROUTED TO	DTR	31242.	6.50	7349.	2224.	2224.	27.19
HYDROGRAPH AT	C	2331.	6.00	329.	98.	98.	1.17
HYDROGRAPH AT	2	1256.	6.50	309.	92.	92.	1.06
ROUTED TO	1	1224.	6.67	304.	91.	91.	1.06
HYDROGRAPH AT	1	885.	6.67	245.	74.	74.	0.91
4 COMBINED AT	1T	33821.	6.50	8187.	2488.	2488.	30.33
HYDROGRAPH AT	B	1090.	6.00	133.	39.	39.	0.46
HYDROGRAPH AT	A	856.	6.17	128.	38.	38.	0.48

```
** NORMAL END OF HEC-1 ***
101
$ delete for0*.dat;*
MILLER      job terminated at  7-AUG-1989 09:20:00.58

Accounting information:
Buffered I/O count:          59      Peak working set size:   732
Direct I/O count:           169      Peak page file size:    1349
Page faults:                779      Mounted volumes:           0
Charged CPU time:    0 00:00:33.71   Elapsed time:     0 00:00:45.09
```

HEC 1 COMPUTER MODEL
BASIN 40

```
*****************************************
*                                       *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)    *
*            FEBRUARY 1981              *
*          REVISED 30 OCT 81            *
*                                       *
* RUN DATE       7-A    TIME      09:3 *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*  THE HYDROLOGIC ENGINEERING CENTER    *
*          609 SECOND STREET            *
*        DAVIS, CALIFORNIA 95616        *
*  (916) 440-3285 OR (FTS) 448-3285     *
*                                       *
*****************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X       X     X        XX
X     X  X       X              X
XXXXXXX  XXXX     X       XXXXX  X
X     X  X       X              X
X     X  X       X     X        X
X     X  XXXXXXX   XXXXX        XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE. THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. SEE SEPTEMBER 1981 INPUT DESCRIPTION FOR NEW DEFINITIONS.

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   HEC1 EXISTING WATERSHED FILE AWTA.DAT
  2           ID   APACHE WASH EXISTING DEVELOPMENT BASIN 40 COMPOSITE RUN
              XDIAGRAM
  3           IT      10 15FEB89            145
  4           IO       5       0

  5           KK    44
  6           KM     RUNOFF FROM AREA 44
  7           BA    0.62
  8           IN      30
  9           PB     4.6
 10           PC       0   0.005   0.009    0.01   0.013   0.019   0.021   0.028   0.032   0.044
 11           PC   0.057     0.1    0.66   0.745   0.776     0.8   0.816   0.830   0.840   0.850
 12           PC   0.861   0.868   0.878   0.884   0.891     0.9   0.905   0.912   0.919   0.923
 13           PC   0.930   0.934   0.939   0.944   0.950   0.958   0.961   0.963   0.969   0.971
 14           PC   0.974   0.979   0.981   0.985   0.989   0.991   0.993   0.996     1.0
 15           LS       0    84.7
 16           UD    0.21

 17           KK   42T
 18           KM   ROUTE TO 42T
 19           RK    2000     0.1    0.03           TRAP       5       5

 20           KK    43
 21           KM    RUNOFF FROM 43
 22           BA    1.39
 23           PB     4.6
 24           LS       0    85.2       1
 25           UD    0.33

 26           KK    42T
 27           KM   ROUTE 44 TO 42T
 28           RK    1500   0.016    0.03           TRAP       5       4

 29           KK   42
 30           KM    RUNOFF FROM 42
 31           BA    0.11
 32           PB     4.6
 33           LS       0    80.5       1
 34           UD    0.53

 35           KK   42T
 36           KM   COMBINE 44,43,42
 37           HC       3

 38           KK   41T
 39           KM   ROUTE TO 41T
 40           RK    4200   0.010    0.03           TRAP       5       4

 41           KK    41
 42           KM    RUNOFF FROM AREA 41
 43           BA    0.89
 44           PB     4.6
 45           LS       0    83.7     1.5
 46           UD    0.38
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  47          KK   41T
  48          KM    COMBINE 40T,41
  49          HC       2

  50          KK    40T
  51          KM    ROUTE 41T TO 40
  52          RK    6500   0.006   0.03           TRAP      5       4

  53          KK    40
  54          KM    RUNOFF FROM AREA 40
  55          BA    0.56
  56          PB     4.6
  57          LS       0    82.2       2
  58          UD    1.81

  59          KK    40T
  60          KM    COMBINE 40,41T
  61          HC       2
  62          ZZ
```

```
*****************************************
*                                       *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)    *
*            FEBRUARY 1981              *
*          REVISED 30 OCT 81            *
*                                       *
*  RUN DATE       7-A    TIME      09:3 *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*  THE HYDROLOGIC ENGINEERING CENTER    *
*          609 SECOND STREET            *
*        DAVIS, CALIFORNIA 95616        *
*  (916) 440-3285 OR (FTS) 448-3285     *
*                                       *
*****************************************
```

```
                    HEC1 EXISTING WATERSHED FILE AWTA.DAT
                    APACHE WASH EXISTING DEVELOPMENT BASIN 40 COMPOSITE RUN

 4 IO        OUTPUT CONTROL VARIABLES
                  IPRNT          5  PRINT CONTROL
                  IPLOT          0  PLOT CONTROL
                  QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT        HYDROGRAPH TIME DATA
                   NMIN         10  MINUTES IN COMPUTATION INTERVAL
                  IDATE     15FEB89  STARTING DATE
                  ITIME       0000  STARTING TIME
                     NQ        145  NUMBER OF HYDROGRAPH ORDINATES
                 NDDATE     16FEB89  ENDING DATE
                 NDTIME       0000  ENDING TIME

             COMPUTATION INTERVAL    0.17 HOURS
                  TOTAL TIME BASE   24.00 HOURS

       ENGLISH UNITS
           DRAINAGE AREA          SQUARE MILES
           PRECIPITATION DEPTH    INCHES
           LENGTH, ELEVATION      FEET
           FLOW                   CUBIC FEET PER SECOND
           STORAGE VOLUME         ACRE-FEET
           SURFACE AREA           ACRES
           TEMPERATURE            DEGREES FAHRENHEIT
```

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	44	1157.	6.00	165.	49.	49.	0.62		
ROUTED TO	42T	1101.	6.00	165.	50.	50.	0.62		
HYDROGRAPH AT	43	2332.	6.17	377.	113.	113.	1.39		
ROUTED TO	42T	2259.	6.17	378.	113.	113.	1.39		
HYDROGRAPH AT	42	114.	6.33	25.	8.	8.	0.11		
3 COMBINED AT	42T	3445.	6.17	568.	170.	170.	2.12		
ROUTED TO	41T	3184.	6.17	567.	170.	170.	2.12		
HYDROGRAPH AT	41	1275.	6.17	229.	69.	69.	0.89		
2 COMBINED AT	41T	4460.	6.17	796.	239.	239.	3.01		
ROUTED TO	40T	4212.	6.33	788.	238.	238.	3.01		
HYDROGRAPH AT	40	259.	7.83	129.	41.	41.	0.56		
2 COMBINED AT	40T	4263.	6.33	916.	279.	279.	3.57		

*** NORMAL END OF HEC-1 ***

```
$ delete for0*.dat;*
MILLER       job terminated at  7-AUG-1989 09:39:32.90

Accounting information:
Buffered I/O count:          56      Peak working set size:   805
Direct I/O count:            87      Peak page file size:    1349
Page faults:                784      Mounted volumes:           0
Charged CPU time:     0 00:00:12.52  Elapsed time:     0 00:00:27.34
```

HEC 1 COMPUTER MODEL
BASIN 20

```
**************************************
*                                    *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1) *
*          FEBRUARY 1981             *
*        REVISED 30 OCT 81           *
*                                    *
*  RUN DATE       7-A    TIME     08:5 *
*                                    *
**************************************
```

```
**************************************
*                                    *
*    U.S. ARMY CORPS OF ENGINEERS    *
*  THE HYDROLOGIC ENGINEERING CENTER *
*          609 SECOND STREET         *
*        DAVIS, CALIFORNIA 95616     *
*  (916) 440-3285 OR (FTS) 448-3285  *
*                                    *
**************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X       X     X        XX
X     X  X       X              X
XXXXXXX  XXXX    X       XXXXX  X
X     X  X       X              X
X     X  X       X     X        X
X     X  XXXXXXX   XXXXX        XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE. THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. SEE SEPTEMBER 1981 INPUT DESCRIPTION FOR NEW DEFINITIONS.

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   HEC1 EXISTING WATERSHED FILE AWTB.DAT
  2           ID   APACHE WASH EXISTING DEVELOPMENT BASIN 20 COMPOSITE RUN
              ↓DIAGRAM
  3           IT      10 15FEB89            145
  4           IO       5       0

  5           KK    25   SCS METHOD
  6           KM     RUNOFF FROM AREA 25
  7           BA    1.41
  8           IN      30
  9           PB     4.6
 10           PC       0   0.005   0.009    0.01   0.013   0.019   0.021   0.028   0.032   0.044
 11           PC   0.057     0.1    0.66   0.745   0.776     0.8   0.816   0.830   0.840   0.850
 12           PC   0.861   0.868   0.878   0.884   0.891     0.9   0.905   0.912   0.919   0.923
 13           PC   0.930   0.934   0.939   0.944   0.950   0.958   0.961   0.963   0.969   0.971
 14           PC   0.974   0.979   0.981   0.985   0.989   0.991   0.993   0.996     1.0
 15           LS       0    85.7       1
 16           UD    0.17

 17           KK    24
 18           KM    RUNOFF FROM 24
 19           BA    2.91
 20           PB     4.6
 21           LS       0    86.3       1
 22           UD    0.26

 23           KK   24T
 24           KM    COMBINE 24,25
 25           HC       2

 26           KK    23T
 27           KM    ROUTE TO 23
 28           RK    9500  0.0092    0.03           TRAP       8       5

 29           KK    23
 30           KM    RUNOFF FROM 23
 31           BA    1.71
 32           PB     4.6
 33           LS       0    85.5       1
 34           UD    0.25

 35           KK    23T
 36           KM    COMBINE 24T,23
 37           HC       2

 38           KK    22T
 39           KM    ROUTE  TO 22T
 40           RK    8000   0.007    0.03           TRAP       8       5

 41           KK    22
 42           KM    RUNOFF FROM AREA 22
 43           BA    0.51
 44           PB     4.6
 45           LS       0    85.5       1
 46           UD    0.34
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  47          KK    22T
  48          KM    COMBINE RUNOFF FROM 22,23T
  49          HC       2

  50          KK    20T
  51          KM    ROUTE TO 20T
  52          RK    8500   0.005    0.03           TRAP      10       5

  53          KK   21
  54          KM    RUNOFF FROM 21
  55          BA    0.51
  56          PB     4.6
  57          LS       0    85.1       2
  58          UD    0.45

  59          KK    20T
  60          KM     ROUTE TO 20T
  61          RK    7000   0.005    0.03           TRAP       5       5

  62          KK    20
  63          KM    RUNOFF FROM 20
  64          BA    0.68
  65          PB     4.6
  66          LS       0    83.4
  67          UD    0.49

  68          KK    20T
  69          KM    COMBINE 21,22T,20
  70          HC       3
  71          ZZ
```

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
PUT
.INE      (V) ROUTING          (---‡) DIVERSION
NO.       (.) CONNECTOR        ()---) RETURN OF DIVERTED FLOW

 5        25
             .
             .
17           .        24
             .          .
             .          .
23       24T  ............
             V
             V
26       23T
             .
             .
29           .        23
             .          .
             .          .
35       23T ............
             V
             V
38       22T
             .
             .
41           .        22
             .          .
             .          .
47       22T ............
             V
             V
50       20T
             .
             .
53           .       21
             .          V
             .          V
59           .       20T
             .          .
             .          .
62           .          ..       20
             .          .          .
             .          .          .
68       20T ........................
```

***) RUNOFF ALSO COMPUTED AT THIS LOCATION

```
*****************************************
*                                       *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)    *
*          FEBRUARY 1981                *
*        REVISED 30 OCT 81              *
*                                       *
*  RUN DATE      7-A    TIME      08:5 *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*  THE HYDROLOGIC ENGINEERING CENTER    *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*  (916) 440-3285 OR (FTS) 448-3285     *
*                                       *
*****************************************
```

HEC1 EXISTING WATERSHED FILE AWTB.DAT
APACHE WASH EXISTING DEVELOPMENT BASIN 20 COMPOSITE RUN

IO OUTPUT CONTROL VARIABLES

IPRNT	5	PRINT CONTROL
IPLOT	0	PLOT CONTROL
QSCAL	0.	HYDROGRAPH PLOT SCALE

IT HYDROGRAPH TIME DATA

NMIN	10	MINUTES IN COMPUTATION INTERVAL
IDATE	15FEB89	STARTING DATE
ITIME	0000	STARTING TIME
NQ	145	NUMBER OF HYDROGRAPH ORDINATES
NDDATE	16FEB89	ENDING DATE
NDTIME	0000	ENDING TIME

COMPUTATION INTERVAL 0.17 HOURS
TOTAL TIME BASE 24.00 HOURS

ENGLISH UNITS

DRAINAGE AREA	SQUARE MILES
PRECIPITATION DEPTH	INCHES
LENGTH, ELEVATION	FEET
FLOW	CUBIC FEET PER SECOND
STORAGE VOLUME	ACRE-FEET
SURFACE AREA	ACRES
TEMPERATURE	DEGREES FAHRENHEIT

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	25	3067.	6.00	391.	117.	117.	1.41		
HYDROGRAPH AT	24	5481.	6.17	821.	245.	245.	2.91		
2 COMBINED AT	24T	8073.	6.00	1212.	361.	361.	4.32		
ROUTED TO	23T	7941.	6.17	1200.	359.	359.	4.32		
HYDROGRAPH AT	23	3150.	6.17	470.	140.	140.	1.71		
2 COMBINED AT	23T	11091.	6.17	1667.	499.	499.	6.03		
ROUTED TO	22T	10430.	6.17	1654.	496.	496.	6.03		
HYDROGRAPH AT	22	850.	6.17	140.	42.	42.	0.51		
2 COMBINED AT	22T	11280.	6.17	1793.	538.	538.	6.54		
ROUTED TO	20T	10635.	6.33	1776.	534.	534.	6.54		
HYDROGRAPH AT	21	712.	6.33	138.	41.	41.	0.51		
ROUTED TO	20T	688.	6.50	140.	42.	42.	0.51		
HYDROGRAPH AT	20	840.	6.33	171.	52.	52.	0.68		
3 COMBINED AT	20T	12134.	6.33	2086.	628.	628.	7.73		

```
*** NORMAL END OF HEC-1 ***
$
$ delete for0*.dat;*
MILLER      job terminated at  7-AUG-1989 08:53:53.22

  Accounting information:
  Buffered I/O count:          57     Peak working set size:   757
  Direct I/O count:           104     Peak page file size:    1349
  Page faults:                875     Mounted volumes:           0
  Charged CPU time:    0 00:00:12.98  Elapsed time:     0 00:00:19.45
```

HEC 1 COMPUTER MODEL
BASIN 10

```
*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)*
*          FEBRUARY 1981            *
*        REVISED 30 OCT 81          *
*                                   *
* RUN DATE      7-A    TIME     09:0 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
* (916) 440-3285 OR (FTS) 448-3285  *
*                                   *
*************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X       X     X        XX
X     X  X       X              X
XXXXXXX  XXXX     X       XXXXX  X
X     X  X       X              X
X     X  X       X     X        X
X     X  XXXXXXX   XXXXX        XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE. THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. SEE SEPTEMBER 1981 INPUT DESCRIPTION FOR NEW DEFINITIONS.

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   HEC1 EXISTING WATERSHED FILE AWTC.DAT
  2           ID   APACHE WASH EXISTING DEVELOPMENT BASIN 10  COMPOSITE RUN
              *DIAGRAM
  3           IT      10 15FEB89             145
  4           IO       5       0

  5           KK    14
  6           KM     RUNOFF FROM AREA 14
  7           BA    1.25
  8           IN      30
  9           PB     4.6
 10           PC       0   0.005   0.009    0.01   0.013   0.019   0.021   0.028   0.032   0.044
 11           PC   0.057     0.1    0.66   0.745   0.776     0.8   0.816   0.830   0.840   0.850
 12           PC   0.861   0.868   0.878   0.884   0.891     0.9   0.905   0.912   0.919   0.923
 13           PC   0.930   0.934   0.939   0.944   0.950   0.958   0.961   0.963   0.969   0.971
 14           PC   0.974   0.979   0.981   0.985   0.989   0.991   0.993   0.996     1.0
 15           LS       0    86.7
 16           UD    0.25

 17           KK    13T
 18           KM    ROUTE TO 13T
 19           RK    5000   0.016    0.03            TRAP      12       5

 20           KK   13
 21           KM     RUNOFF FROM AREA 13
 22           BA    0.15
 23           PB     4.6
 24           LS       0    78.9
 25           UD    0.24

 26           KK    13T
 27           KM   COMBINE 14,13
 28           HC       2

 29           KK    12
 30           KM    RUNOFF FROM AREA 12
 31           BA    1.89
 32           PB     4.6
 33           LS       0    86.4
 34           UD    0.26

 35           KK    12T
 36           KM   COMBINE 13T,12
 37           HC       2

 38           KK    12T
 39           KM    ROUTE TO AREA 11
 40           RK    3000   0.016    0.03            TRAP      12       5

 41           KK    11
 42           KM    RUNOFF FROM AREA 11
 43           BA    1.36
 44           PB     4.6
 45           LS       0    85.6
 46           UD    0.45
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  47          KK   11T
  48          KM   COMBINE 11,12T
  49          HC      2

  50          KK    11T
  51          KM    ROUTE 11T TO AREA 10
  52          RK    7000   0.006   0.025           TRAP      12       3

  53          KK    10
  54          KM    RUNOFF FROM BASIN 10
  55          BA    0.96
  56          PB     4.6
  57          LS      0    85.7       1
  58          UD    0.55

  59          KK    10T
  60          KM    COMBINE 10,11T
  61          HC      2
  62          ZZ
```

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
LINE      (V) ROUTING          (---#) DIVERSION
  .       (.) CONNECTOR        ()---) RETURN OF DIVERTED FLOW

  5        14
              V
              V
 17        13T
              .
              .
 20           .        13
              .            .
              .            .
 26        13T ............
              .
              .
 29           .        12
              .            .
              .            .
 35        12T ............
              V
              V
 38        12T
              .
              .
 41           .        11
              .            .
              .            .
 47       11T  ............
              V
              V
 50        11T
              .
              .
 53           .        10
              .            .
              .            .
 59        10T ............
```

(*) RUNOFF ALSO COMPUTED AT THIS LOCATION

```
*****************************************
*                                       *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)    *
*           FEBRUARY 1981               *
*         REVISED 30 OCT 81             *
*                                       *
* RUN DATE       7-A    TIME      09:0 *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*  THE HYDROLOGIC ENGINEERING CENTER    *
*          609 SECOND STREET            *
*        DAVIS, CALIFORNIA 95616        *
*  (916) 440-3285 OR (FTS) 448-3285     *
*                                       *
*****************************************
```

```
                    HEC1 EXISTING WATERSHED FILE AWTC.DAT
                    APACHE WASH EXISTING DEVELOPMENT BASIN 10  COMPOSITE RUN

4 IO          OUTPUT CONTROL VARIABLES
                   IPRNT          5  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL         0.  HYDROGRAPH PLOT SCALE

  IT          HYDROGRAPH TIME DATA
                    NMIN         10  MINUTES IN COMPUTATION INTERVAL
                   IDATE     15FEB89  STARTING DATE
                   ITIME       0000  STARTING TIME
                      NQ        145  NUMBER OF HYDROGRAPH ORDINATES
                  NDDATE     16FEB89  ENDING DATE
                  NDTIME       0000  ENDING TIME

             COMPUTATION INTERVAL    0.17 HOURS
                  TOTAL TIME BASE   24.00 HOURS

        ENGLISH UNITS
            DRAINAGE AREA          SQUARE MILES
            PRECIPITATION DEPTH    INCHES
            LENGTH, ELEVATION      FEET
            FLOW                   CUBIC FEET PER SECOND
            STORAGE VOLUME         ACRE-FEET
            SURFACE AREA           ACRES
            TEMPERATURE            DEGREES FAHRENHEIT
```

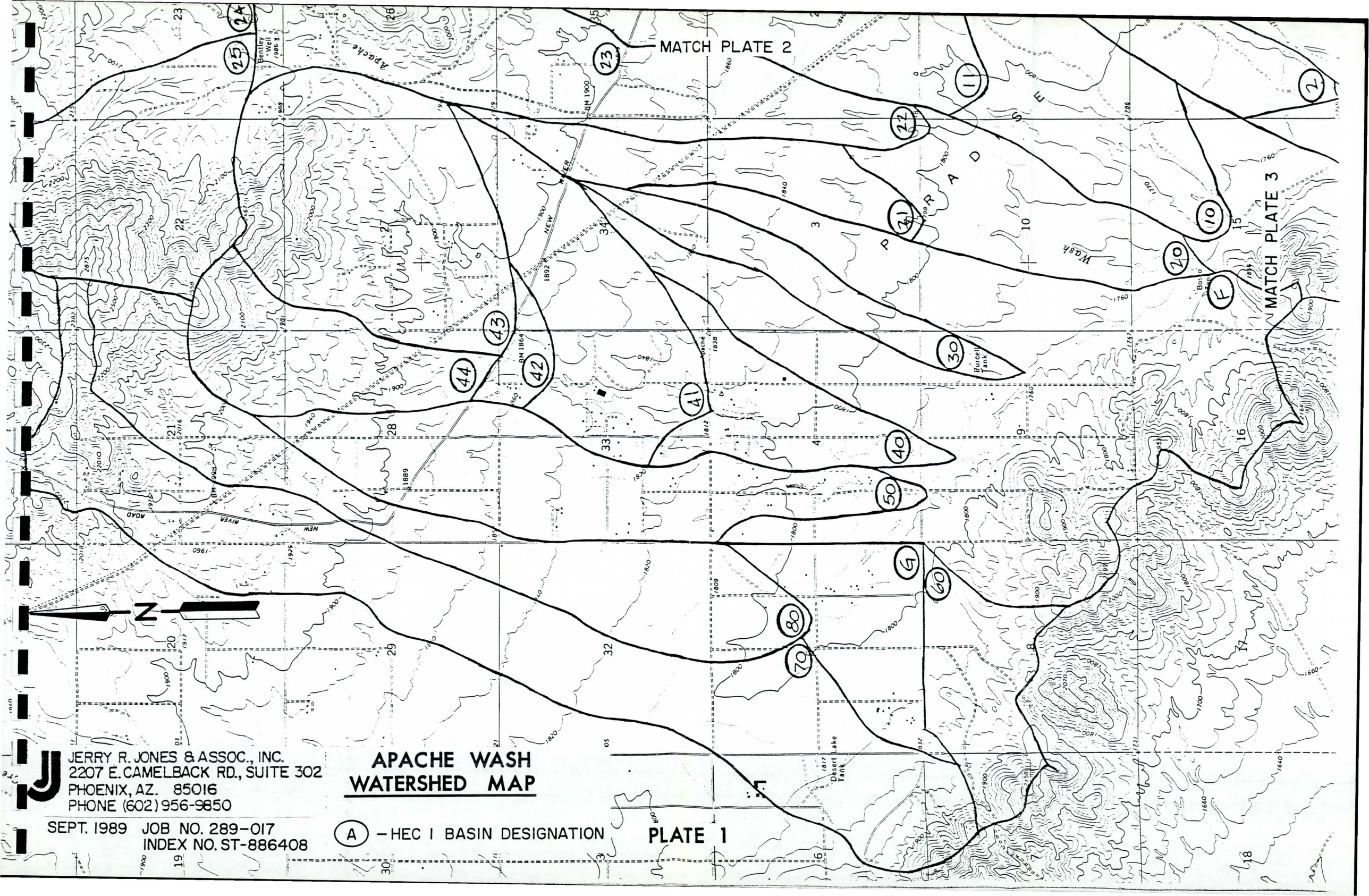
RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	14	2387.	6.17	356.	106.	106.	1.25		
ROUTED TO	13T	2321.	6.17	359.	107.	107.	1.25		
HYDROGRAPH AT	13	216.	6.17	32.	10.	10.	0.15		
2 COMBINED AT	13T	2537.	6.17	391.	117.	117.	1.40		
HYDROGRAPH AT	12	3559.	6.17	533.	159.	159.	1.89		
2 COMBINED AT	12T	6096.	6.17	924.	275.	275.	3.29		
ROUTED TO	12T	5956.	6.17	929.	277.	277.	3.29		
HYDROGRAPH AT	11	1915.	6.33	371.	111.	111.	1.36		
2 COMBINED AT	11T	7721.	6.17	1299.	388.	388.	4.65		
ROUTED TO	11T	7293.	6.33	1300.	388.	388.	4.65		
HYDROGRAPH AT	10	1199.	6.33	263.	79.	79.	0.96		
2 COMBINED AT	10T	8493.	6.33	1564.	467.	467.	5.61		

```
*** NORMAL END OF HEC-1 ***
1
$ delete for0*.dat;*
MILLER      job terminated at  7-AUG-1989 09:09:07.86

Accounting information:
Buffered I/O count:          56      Peak working set size:   707
Direct I/O count:            86      Peak page file size:    1349
Page faults:                800      Mounted volumes:           0
Charged CPU time:    0 00:00:12.03   Elapsed time:     0 00:00:23.47
```

WATERSHED MAP



JERRY R. JONES & ASSOC., INC.
2207 E. CAMELBACK RD., SUITE 302
PHOENIX, AZ. 85016
PHONE (602) 956-9850

APACHE WASH WATERSHED MAP

SEPT. 1989 JOB NO. 289-017
INDEX NO. ST-886408

(A) – HEC I BASIN DESIGNATION

PLATE 1

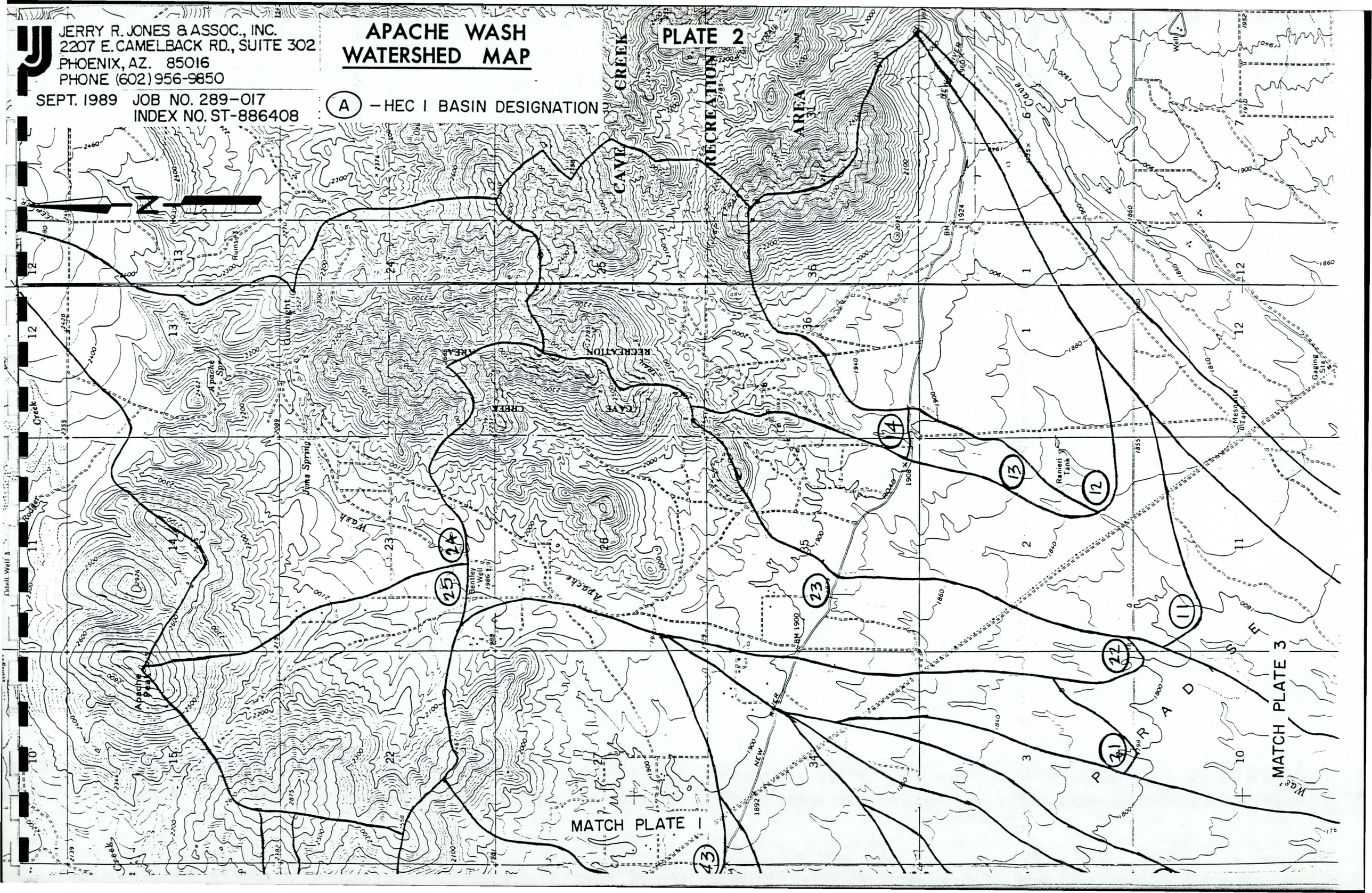
JERRY R. JONES & ASSOC., INC.
2207 E. CAMELBACK RD., SUITE 302
PHOENIX, AZ. 85016
PHONE (602) 956-9850

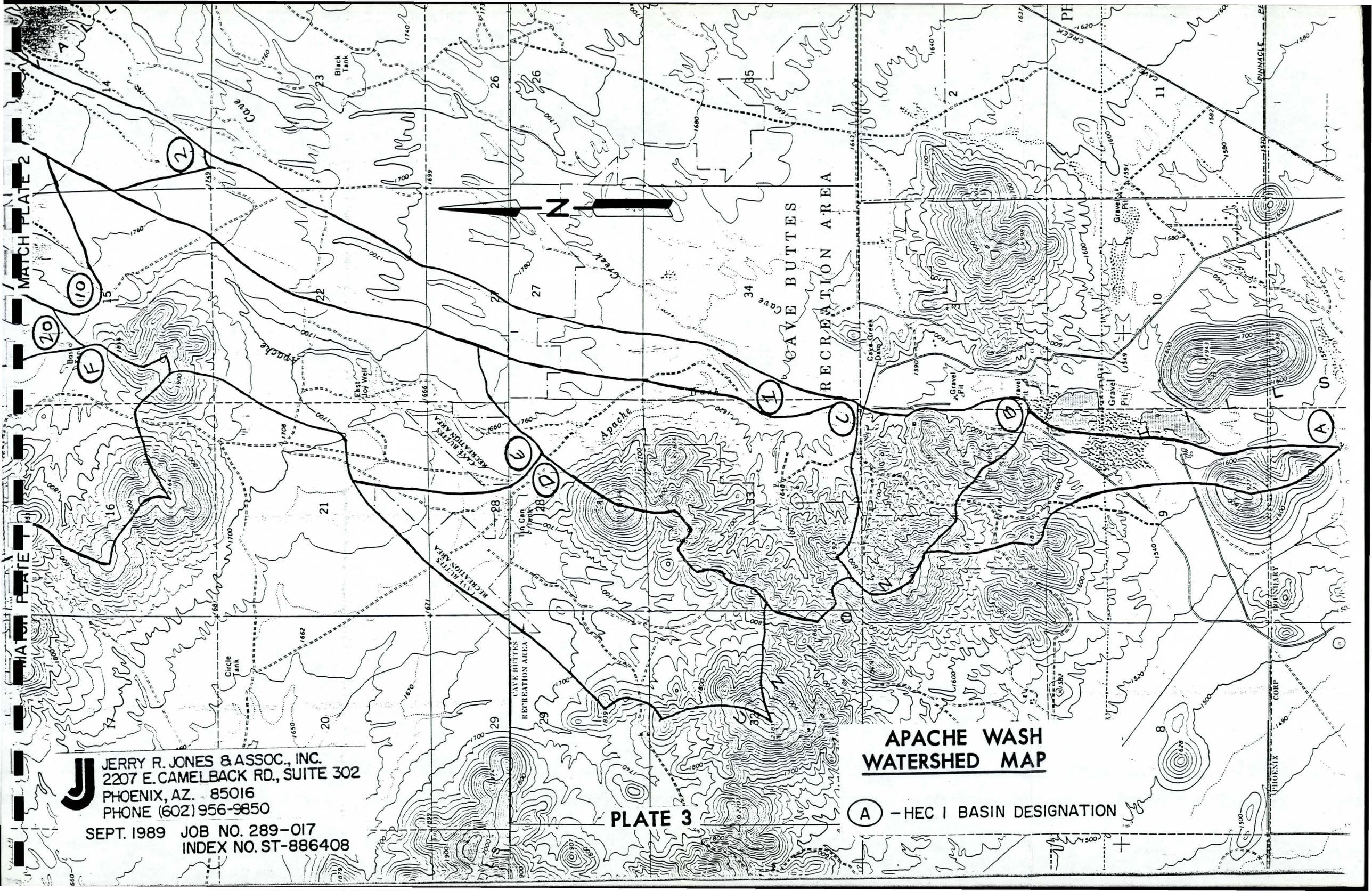
APACHE WASH WATERSHED MAP

PLATE 2

SEPT. 1989 JOB NO. 289-017
INDEX NO. ST-886408

(A) – HEC I BASIN DESIGNATION





APACHE WASH WATERSHED MAP

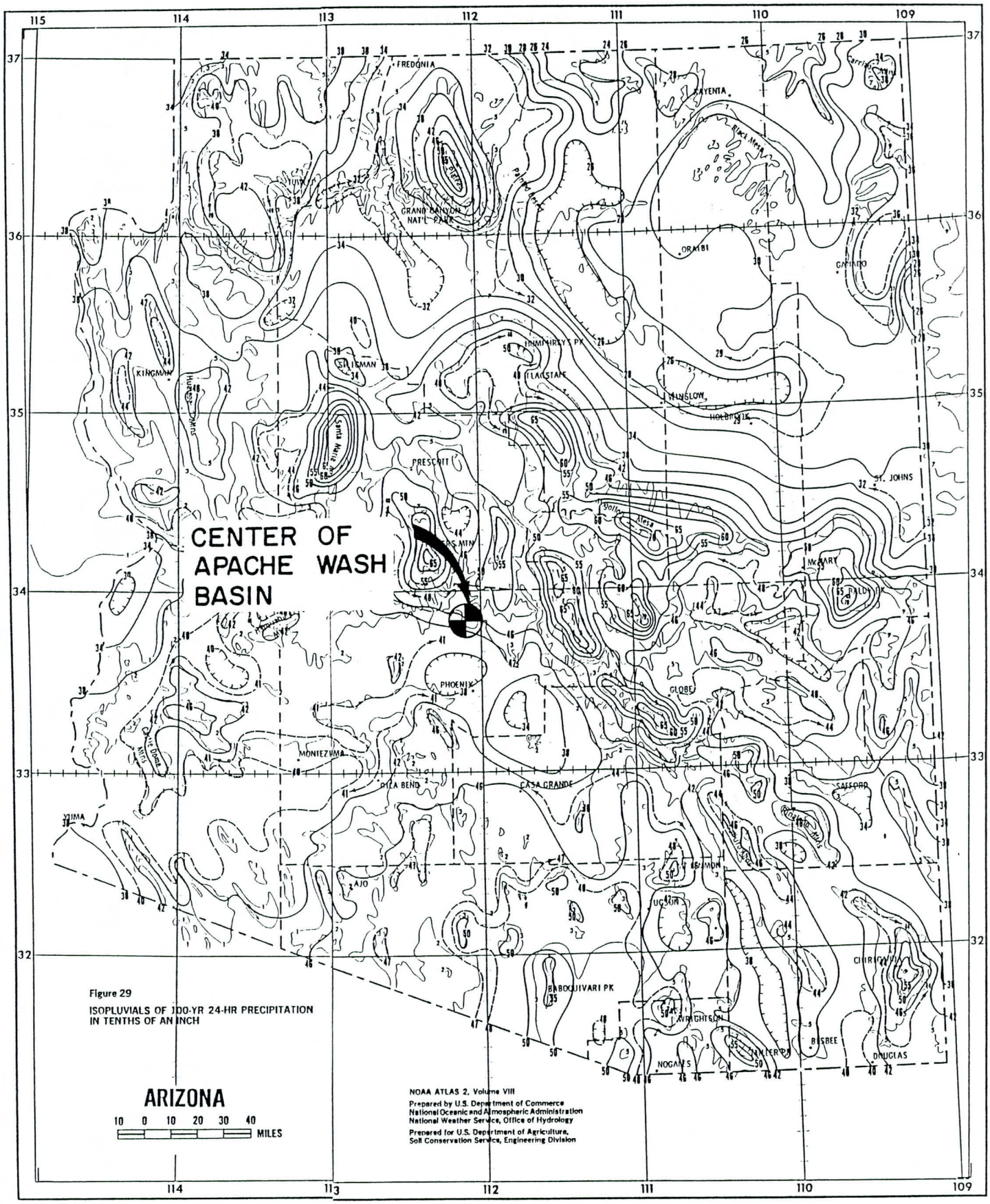
(A) – HEC I BASIN DESIGNATION

PLATE 3

JERRY R. JONES & ASSOC., INC.
2207 E. CAMELBACK RD., SUITE 302
PHOENIX, AZ. 85016
PHONE (602) 956-9850

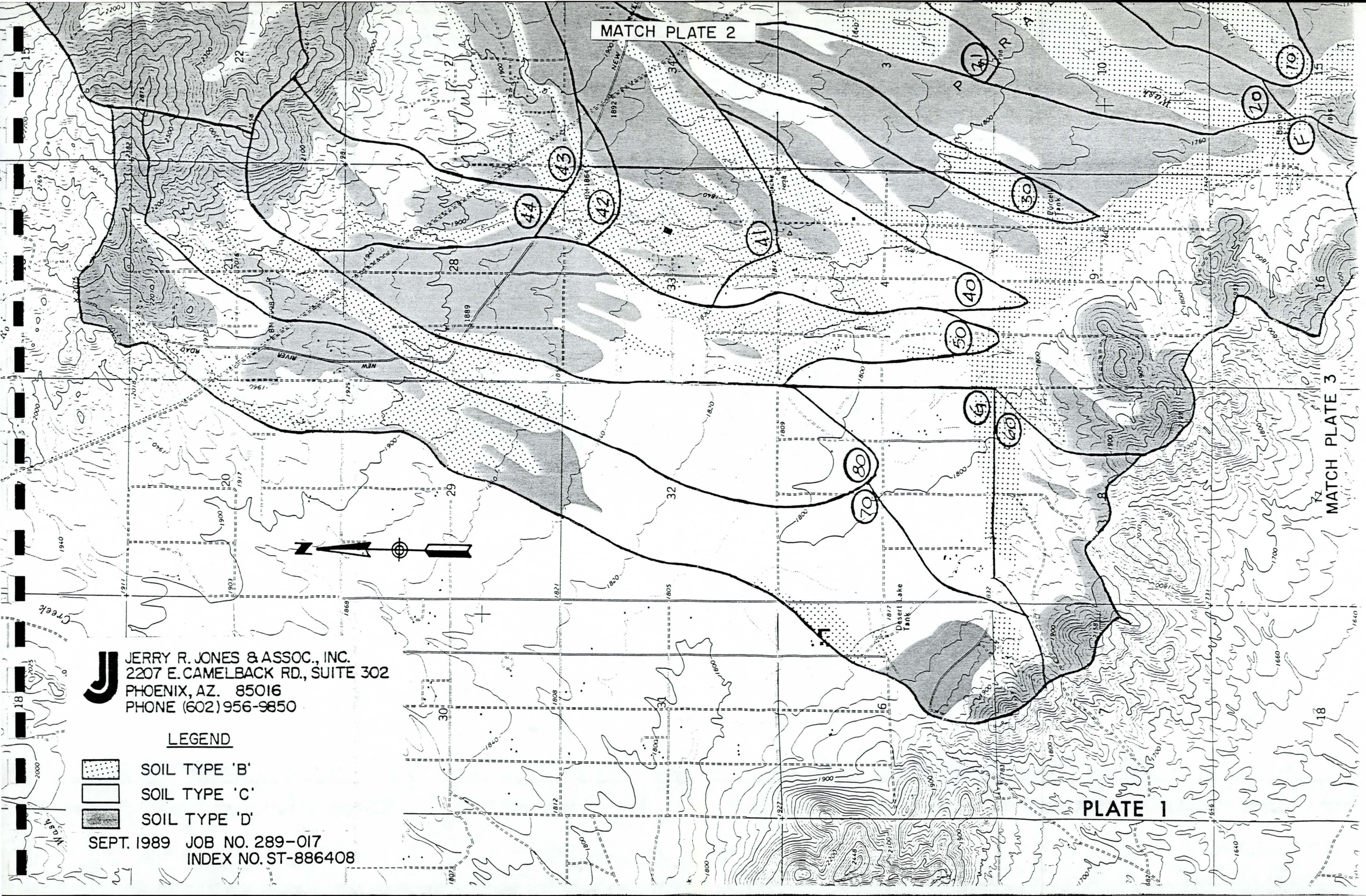
SEPT. 1989 JOB NO. 289-017
INDEX NO. ST-886408

RAINFALL MAP



RAINFALL MAP

SOILS MAP


MATCH PLATE 2
MATCH PLATE 3
PLATE 1
NEW RIVER
Desert Lake Tank
Borcell Tank
10
20
30
40
50
60
70
80
41
42
43
44
F
JERRY R. JONES & ASSOC., INC.
2207 E. CAMELBACK RD., SUITE 302
PHOENIX, AZ. 85016
PHONE (602) 956-9850
LEGEND
SOIL TYPE 'B'
SOIL TYPE 'C'
SOIL TYPE 'D'
SEPT. 1989 JOB NO. 289-017
INDEX NO. ST-886408

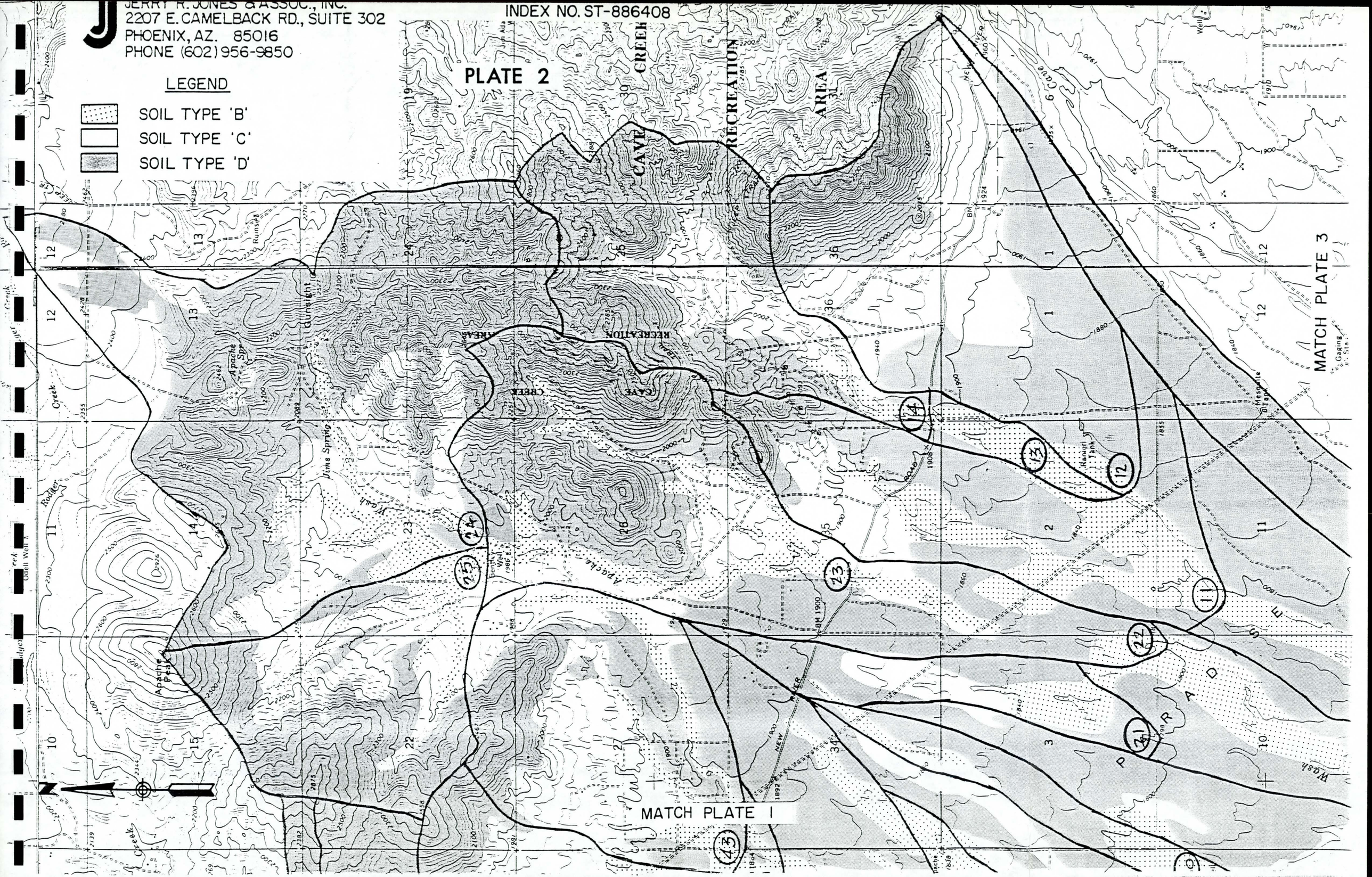
JERRY R. JONES & ASSOC., INC.
2207 E. CAMELBACK RD., SUITE 302
PHOENIX, AZ. 85016
PHONE (602) 956-9850

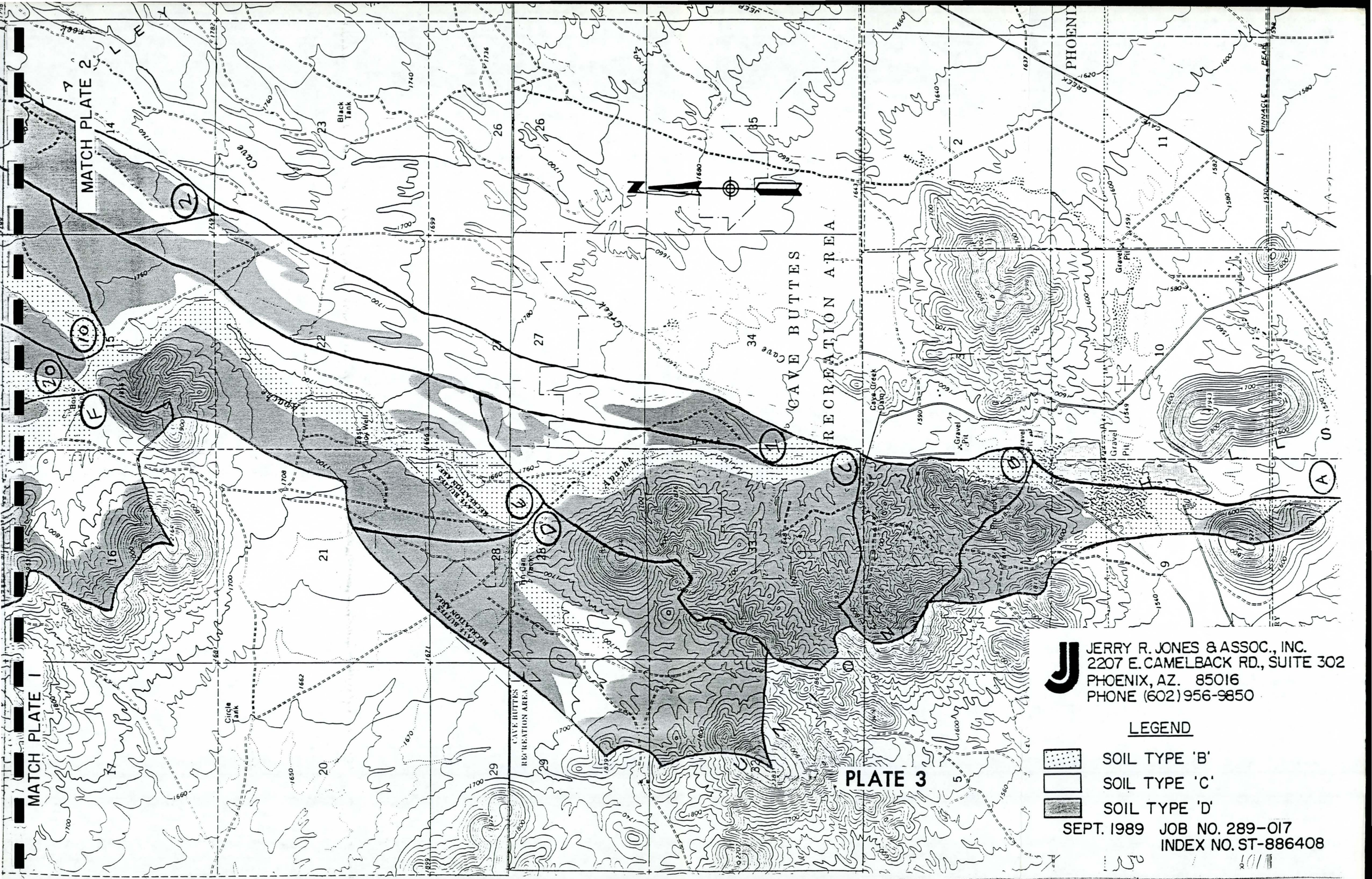
INDEX NO. ST-886408

PLATE 2

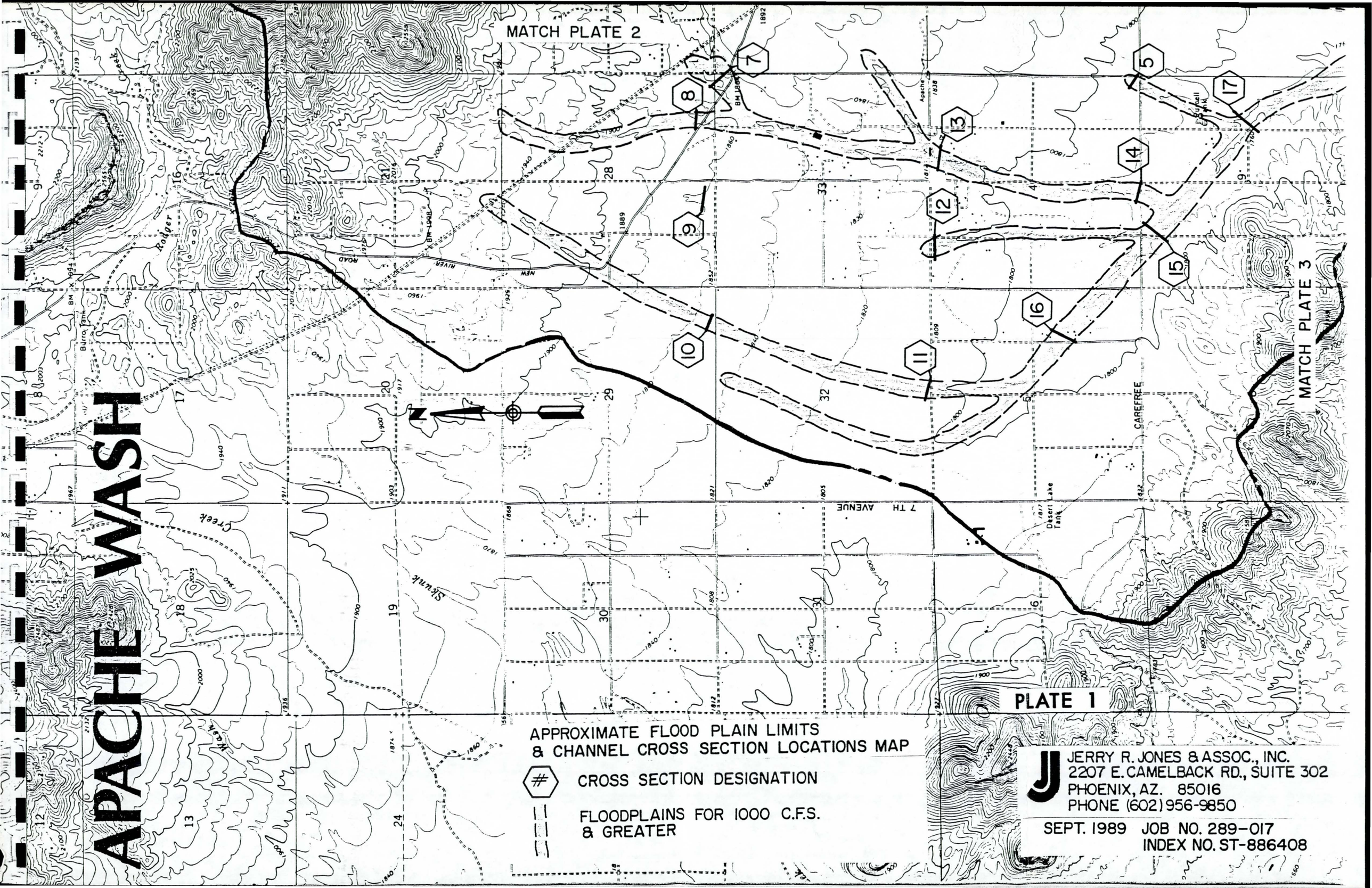
LEGEND

- SOIL TYPE 'B'
- SOIL TYPE 'C'
- SOIL TYPE 'D'




MATCH PLATE 2
MATCH PLATE 1
CAVE BUTTES RECREATION AREA
Cave Creek
Apache
Black Tank
Circle Tank
Cave Creek Dam
Gravel Pit
PINNACLE PEAK
PHOENIX
PLATE 3
JERRY R. JONES & ASSOC., INC.
2207 E. CAMELBACK RD., SUITE 302
PHONEIX, AZ. 85016
PHONE (602) 956-9850
LEGEND
SOIL TYPE 'B'
SOIL TYPE 'C'
SOIL TYPE 'D'
SEPT. 1989 JOB NO. 289-017
INDEX NO. ST-886408

APPROXIMATE FLOODPLAIN LIMITS
AND
CHANNEL CROSS SECTION LOCATIONS


MATCH PLATE 2
MATCH PLATE 3
APACHE WASH
NEW RIVER ROAD
7TH AVENUE
CAREFREE
Rodger Creek
Slenk Creek
Burro Tank
Desert Lake Tank
Apache
Cudell Park
BM 1894
BM 1898
BM 1864
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
PLATE 1
APPROXIMATE FLOOD PLAIN LIMITS
& CHANNEL CROSS SECTION LOCATIONS MAP
# CROSS SECTION DESIGNATION
FLOODPLAINS FOR 1000 C.F.S.
& GREATER
JERRY R. JONES & ASSOC., INC.
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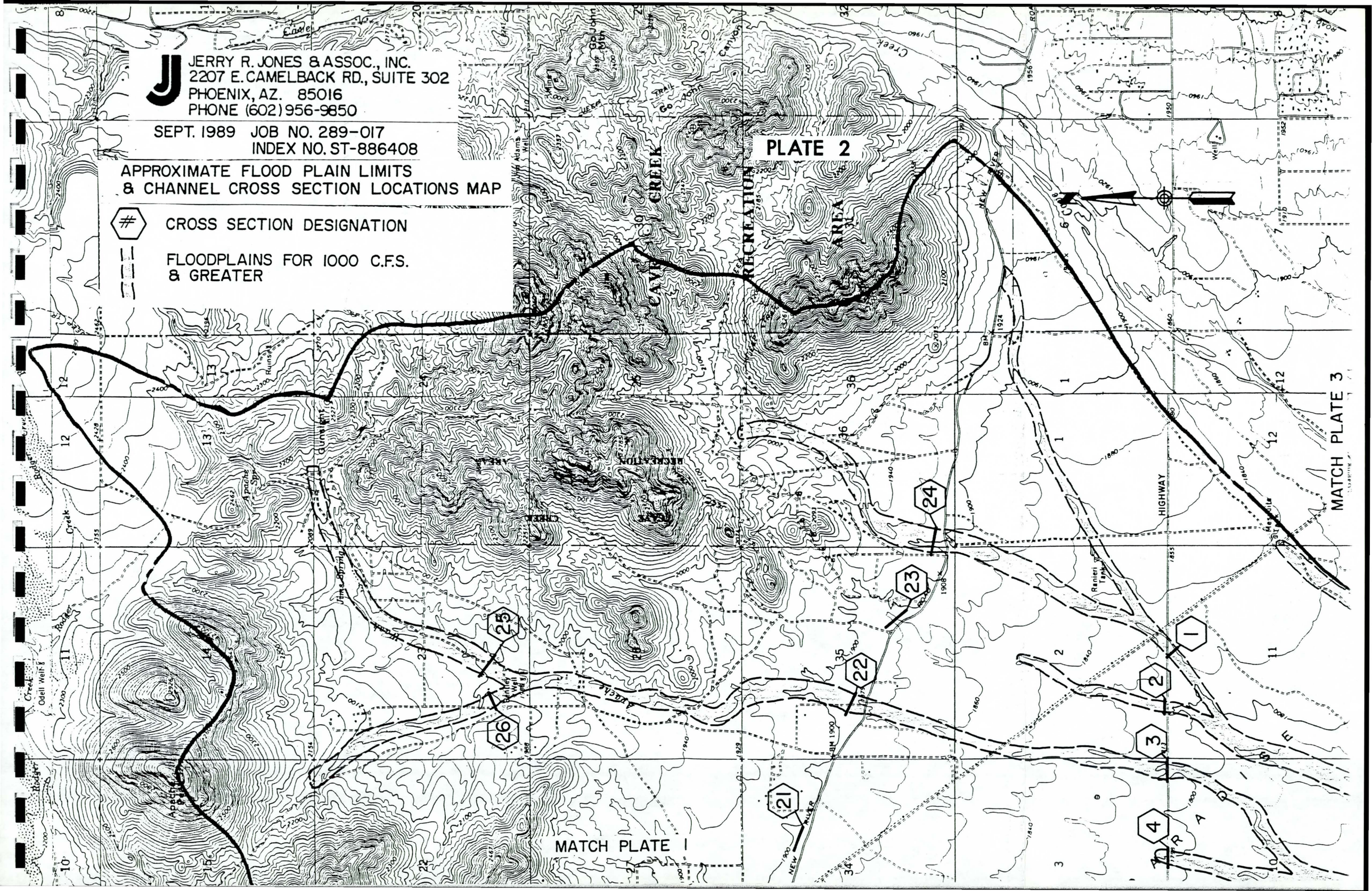
SEPT. 1989 JOB NO. 289-017
INDEX NO. ST-886408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APPROXIMATE FLOOD PLAIN LIMITS
& CHANNEL CROSS SECTION LOCATIONS MAP
CROSS SECTION DESIGNATION
FLOODPLAINS FOR 1000 C.F.S.
& GREATER
PLATE 2
MATCH PLATE 1
MATCH PLATE 3
CAVE CREEK RECREATION AREA
NEW RIVER
HIGHWAY
1
2
3
4
21
22
23
24
25
26

APPROXIMATE FLOOD PLAIN LIMITS
& CHANNEL CROSS SECTION LOCATIONS MAP
CROSS SECTION DESIGNATION
FLOODPLAINS FOR 1000 C.F.S.
& GREATER
* SEE F.E.M.A. MAPS
FOR FLOODPLAIN LOCATION
MATCH PLATE 2
MATCH PLATE 1
PLATE 3
CAVE BUTTES
RECREATION AREA
Apache
Wash
Cave
Black Tank
Circle Tank
Gravel Pit
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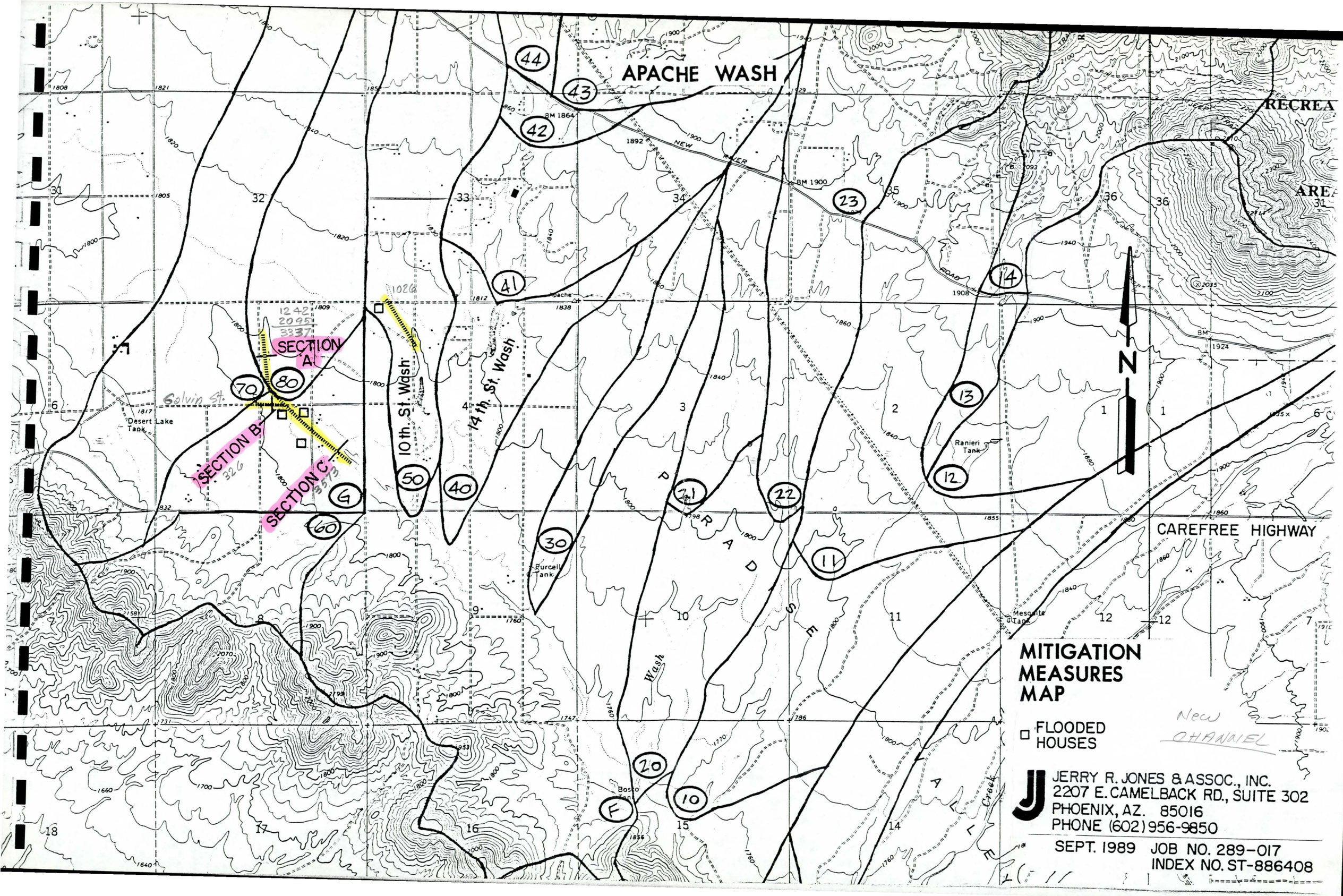
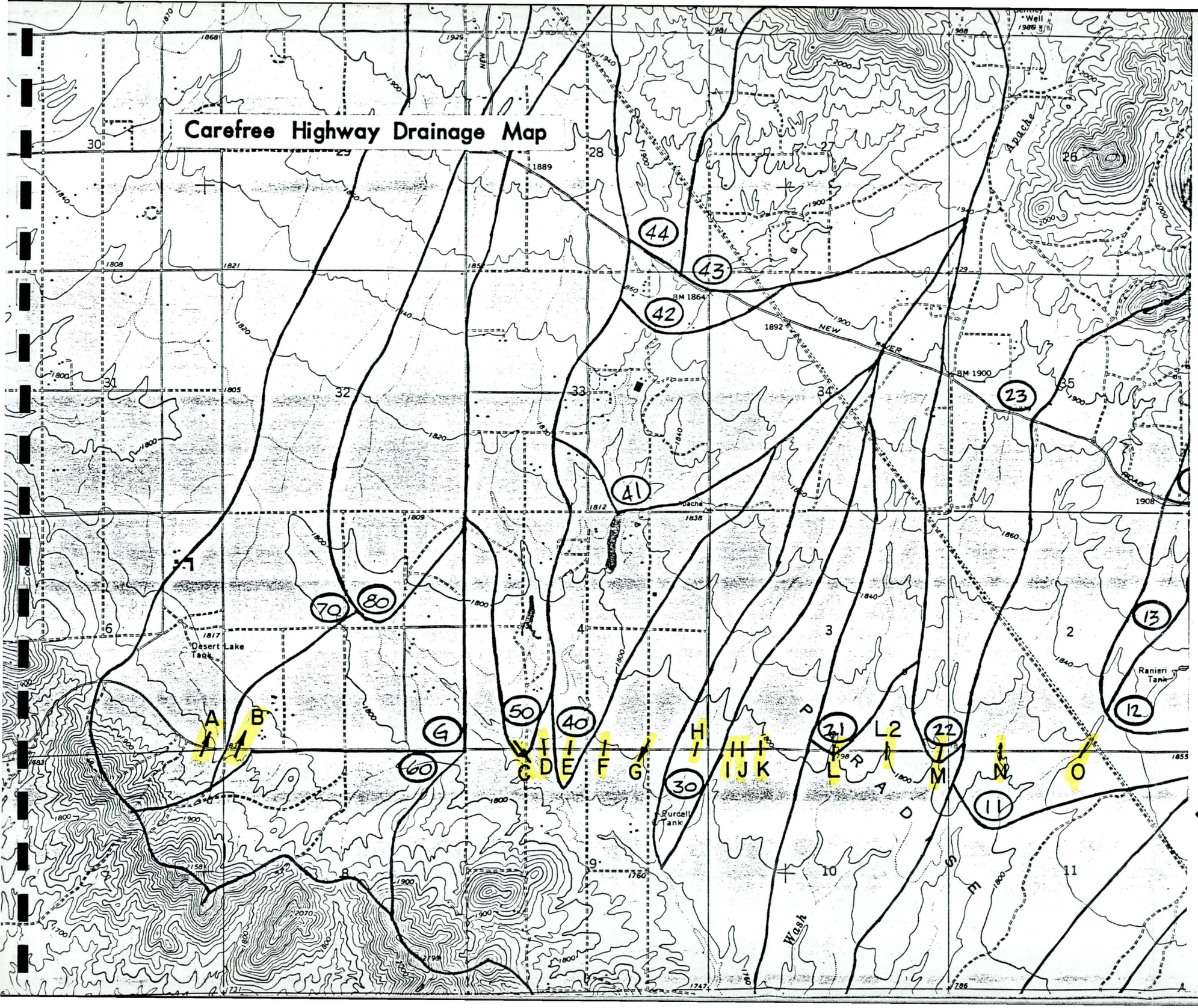
MITIGATION MEASURES MAP


APACHE WASH
NEW RIVER
ROAD
CAREFREE HIGHWAY
RECREA
AREA
10th. St. Wash
14th. St. Wash
DRAPER WASH
ALLEY CREEK
SECTION A
SECTION B
SECTION C
Desert Lake Tank
Ranieri Tank
Mesquite Tank
Purcell Tank
Bosco Tank
Apache
BM 1864
BM 1900
BM 1924
1892
1908
1838
1817
1809
1812
1855
1798
1786
1747
1760
1770
1856
1953
1581
1731
1660
1640
1700
2070
2991
2035
2093
2100
2200
2300
2500
2400
2000
2100
2200
2300
2400
2500
1900
1940
1860
1840
1820
1800
1780
1760
1740
1720
1700
1660
1640
1920
1935
1910
1902
1895
1885
1829
1821
1808
1805
1832
1581
1747
1786
1798
1855
1856
1953
1991
2070
2093
2035
2100
2200
2300
2400
2500
1860
1840
1820
1800
1780
1760
1770
1740
1720
1700
1660
1640
1900
1920

CAREFREE HIGHWAY DRAINAGE MAP

Carefree Highway Drainage Map



EXISTING CULVERT	REQUIRED STRUCTURE
A 1-30" CMP	1-8'x4' RCBC
B 2-36" CMPs	1-36" RCP
C 4-12x6"RCBC	Ext. Keep 70'
D 1-36" CMP	1-36" RCP
E 10x5' RCBC	100' Bridge
F 1-36" CMP	1-36" RCP
G 2-48" CMPs	2-10"x5" RCBC
H 2-48" CMPS	2-10"x5" RCBC
I 1-36" CMP	Combined with J
J 2-48" CMPs	1-8'x4' RCBC
K 30" EQ	1-48" RCP
L 2-36 CMPs	
4-48 CMPs	2-10'x5' RCBC
L 2-1-36 EQ	2-48" RCP
M 3-10"x5" RCBC	400' Bridge
N 4-48 COMP	100' Bridge
O 2-10x5"	200' Bridge

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STORM DRAIN/ROADWAY DRAINAGE MAP

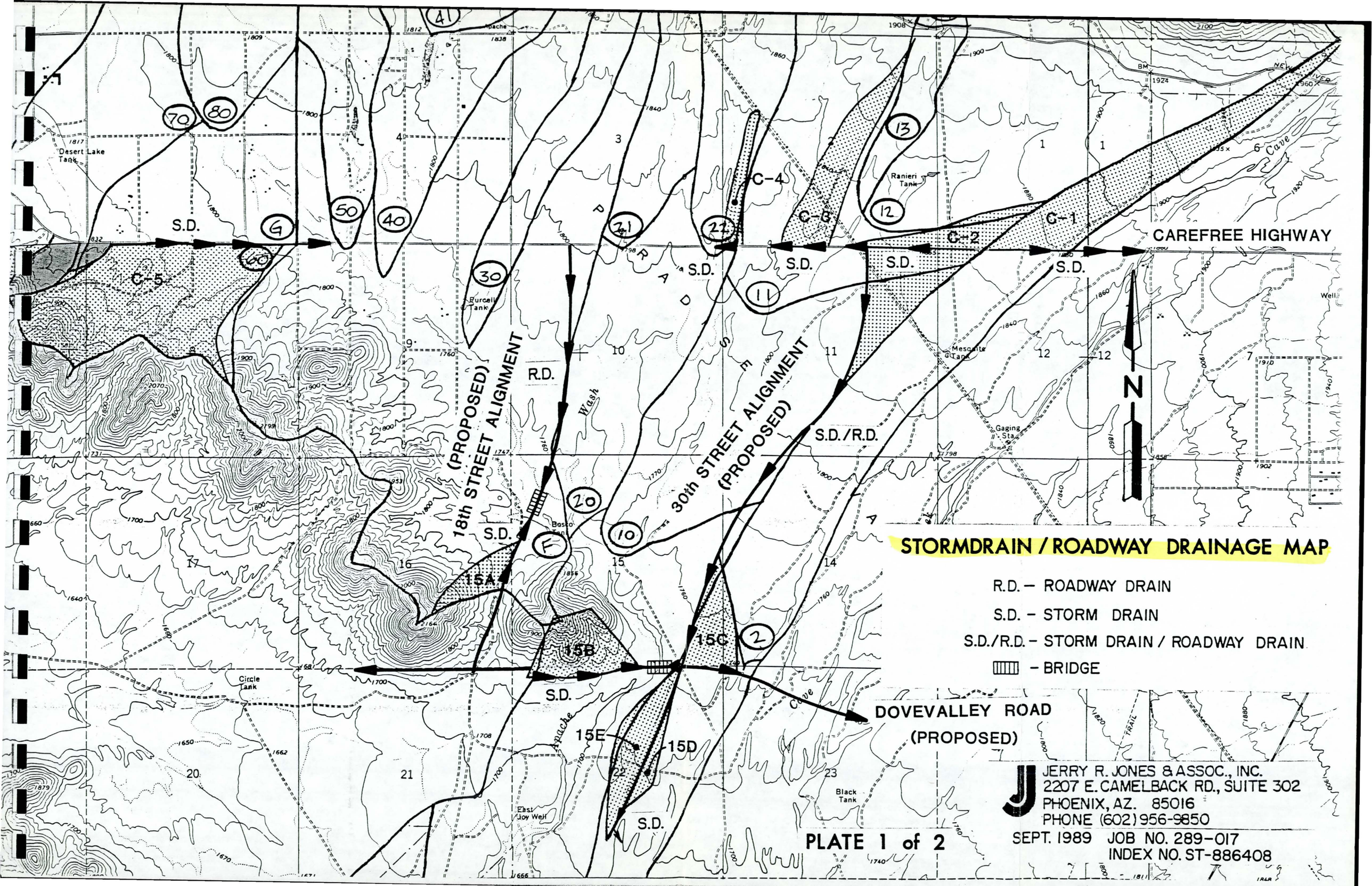
STORMDRAIN / ROADWAY DRAINAGE MAP
R.D. – ROADWAY DRAIN
S.D. – STORM DRAIN
S.D./R.D. – STORM DRAIN / ROADWAY DRAIN
– BRIDGE
CAREFREE HIGHWAY
DOVEVALLEY ROAD
(PROPOSED)
18th STREET ALIGNMENT
(PROPOSED)
30th STREET ALIGNMENT
(PROPOSED)
C-1
C-2
C-4
C-5
C-6
15A
15B
15C
15D
15E
S.D.
R.D.
S.D./R.D.
Desert Lake Tank
Apache
Purcell Tank
Ranieri Tank
Mesquite Tank
Gaging Sta.
Bosco Tank
Circle Tank
East Joy Well
Black Tank
Well
Cave
Wash
Apache
N
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PLATE 1 of 2

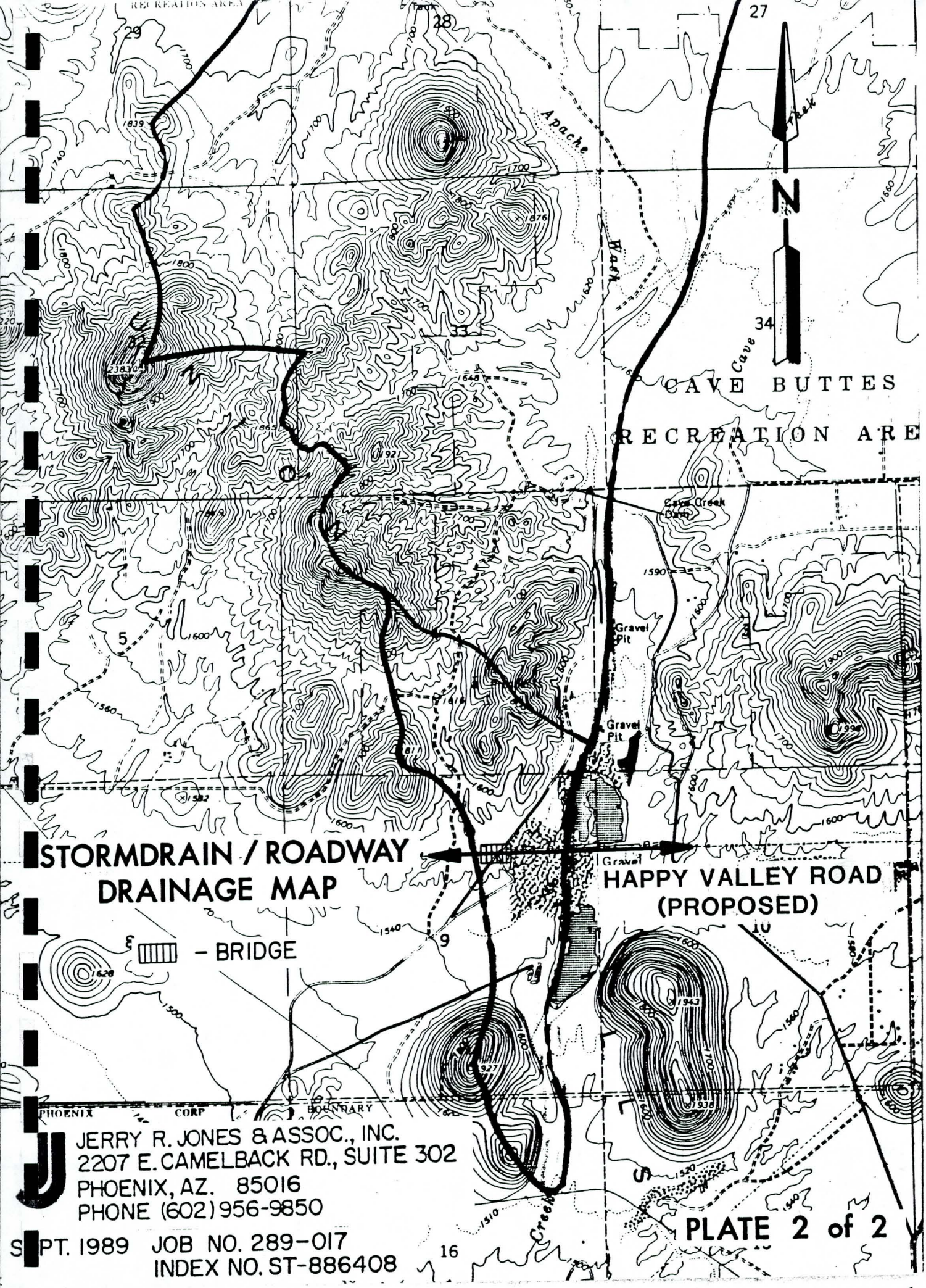

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PLATE 2 of 2

COST CALCULATIONS

COST ESTIMATE CALCULATIONS

Mitigation Area No. 1 Jonathan Wash

Channel along Galvin is sized using proportional amounts of the area contributing to total basin 70+80 0.27 Mi Sq.

Total is 2 Sq. Miles

Total Flow 2,331 .27/2=14%

2,331x.14=326 CFS 2,331-326=2,095 Remains

Section A = 3,337 CFS Length 3,000 Ft North of Galvin

Section B = 326 CFS Length 1,500 Ft Along Galvin

Section C = 3,573 CFS Length 4,000 Ft South of Galvin

Box culvert is required at Galvin and at 3rd Street

Culvert H.W. 7 Ft Use 5 Ft RCBC

Q/B=50 3,337 CFS/50 CFS/Ft=66.7 Ft

7-5x10 RCBCs Are Needed

$6.5xSq. Ftx50 Sq. Ftx7x30 Ft=$68,250x2=$136,500

Section A

Land: Length 3,000x(52 Ft+10 Ft)=4.3 Acresx$10,000/AC=$43,000

Excavation: 227.84 Sq. Ft/Ftx3,000 Ft=68,3520 Cu. Ft/27

25,315 Ydsx$4/Yds=$101,262

Channel Lining:

30' Bottom Width 2:1 Side Slopes 5.54' Deep =

12.38'x2+30'=54 Sq. Ft/9 Sy. Ft=6 SY/Ft

6 SY/Ftx3,000x$30/S.Y.=$540,000

Total Cost Section A $684,262

Section B

Land: 10' Easement +20.3 Ftx1,500 LFx$10,000/AC=1.04 ACx=$10,433
Excavation: 38.79 Sq. Ft/Ftx1,500 LF=58 185 Cu. Ft
58,185 Cu. Ft/27=2,155 YdsX$4/Yds=$8,620

Channel Lining:

10' Bottom Width 2:1 Side Slopes 2.56' Deep
(5.7x2)+10=21.5 Sq. Ft/Ft/9=2.4 SY/Ft
$30/SYx2.4 SY/Ftx1,500 LF=$108,000

Total Section B is $127,053.00

Section C

Land: (53+10)x4,000 Ft=5.8 ACx$10,000=$58,000
Excavation: 239.04 Sq. Ft/Ftx4,000 Ft=956,160 Cu. Ft=35,413 Cu. Yds
35,413 Cu. Ydx$4/Cu. YD=$141,653.00

Channel Lining:

30' Bottom Width 2:1 Side Slope 5.76' Deep
12.7'x2'+30'=55.5 Sq. Ft/Ft/9=6.2 SY/Ft
6.2 Sy/Ftx$30/Syx4,000=$744,000

Rip Rap:

30'x20'x3'=1,800 Cu. Ft/27=66 CY
66x$75/Cu. Yd=$4,950
Total Section C is $948,603

Total A, B, C=1,759,918

Total Plus Box Culverts=$1,896,418.00
Design, Construction Administration and Management (40%)=$758,567.20
Total Cost=$2,654,985.20

Mitigation Area No. 2 10th Street Wash

10th Street and Cloud Road
Basin No. 50 Below House=.19 Mi. Sq.
Total Area 1.15 S.M. .19/1.15=17%
Total Flow 1,229 CFSx.17=203 CFS
1,229-203 CFS=1,026 CFS Design Flow
Channel Length 1,500 Ft
Box Culvert Needed

Box Culvert:
Hw=5 Ft. q=30 CFS/Ft 1026 CFS/30 CFS/Ft=34 Ft
Use 6-6'x4' RCBCs
24 Ftx$6.5 Sq. Ft/Ftx6x30 Ft=$28,080 Box Culvert Cost at 10th Street

Land: 10 Ft Easement+30.3x1,500 Ftx$10,000/AC=$13,877

Excav. 87.18 Sq. Ft/Ftx1,500 Ft=130,770 Cu. Ft Ft/27=4,843 Cu. Yd.
4,843x$5/Cu. Yd.=$24,216

Channel Lining

Channel 15' Bottom Width 2:1 Side Slopes and 3.84 Ft Deep
(8.58'x2)+15'=32.17 Sq. Ft/Ftx1,500 Ft=48,259 Ft/9=5,362 Sq. Yds
5,362x$30/SY=$160,865

Rip-Rap

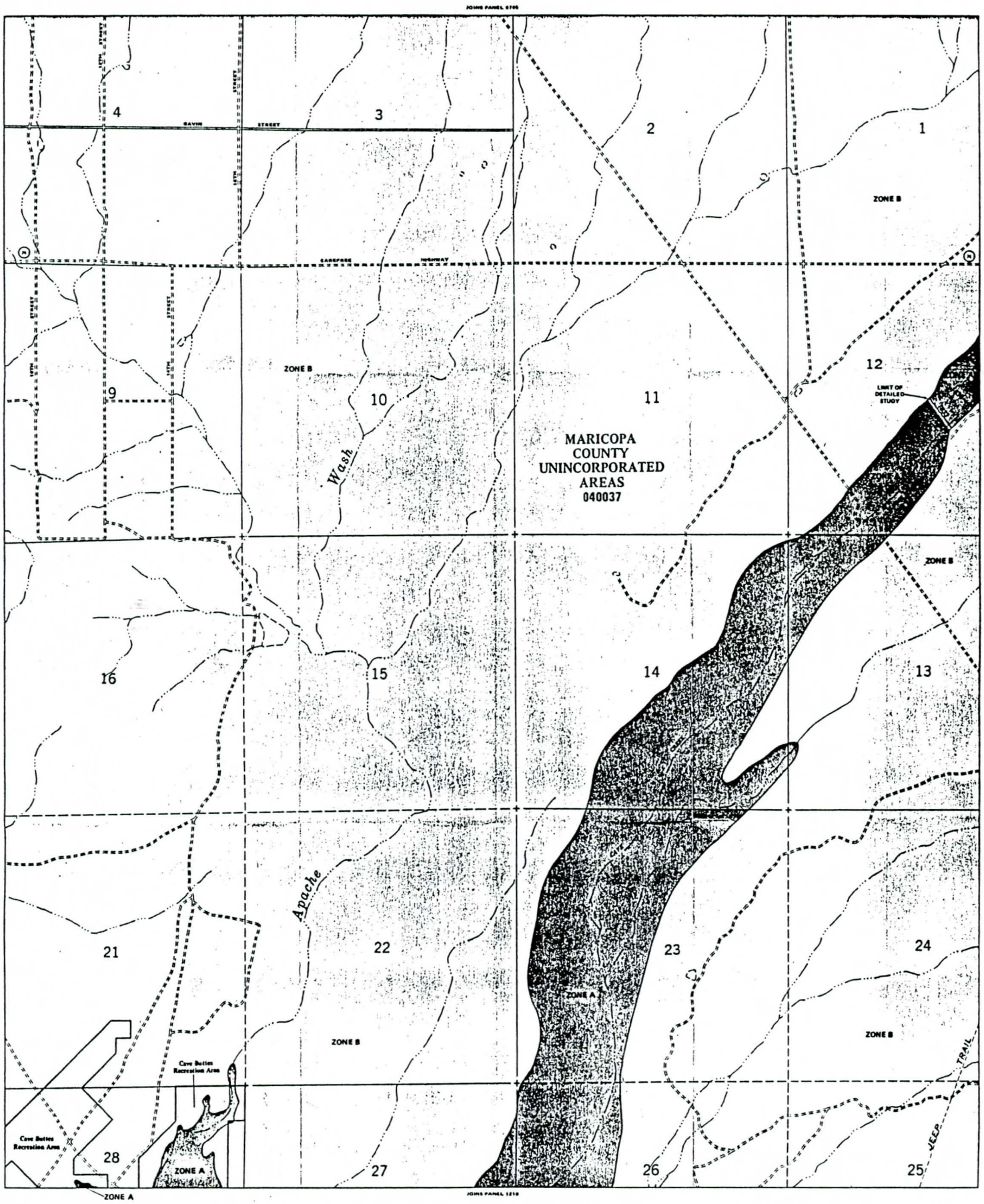
Use A Oulet Pad 20'x20'x3'=1,200 Cu. Ft/27=44 Cu. Yd
44 Cu. Ydx$75/Cu. Yd=$3,300

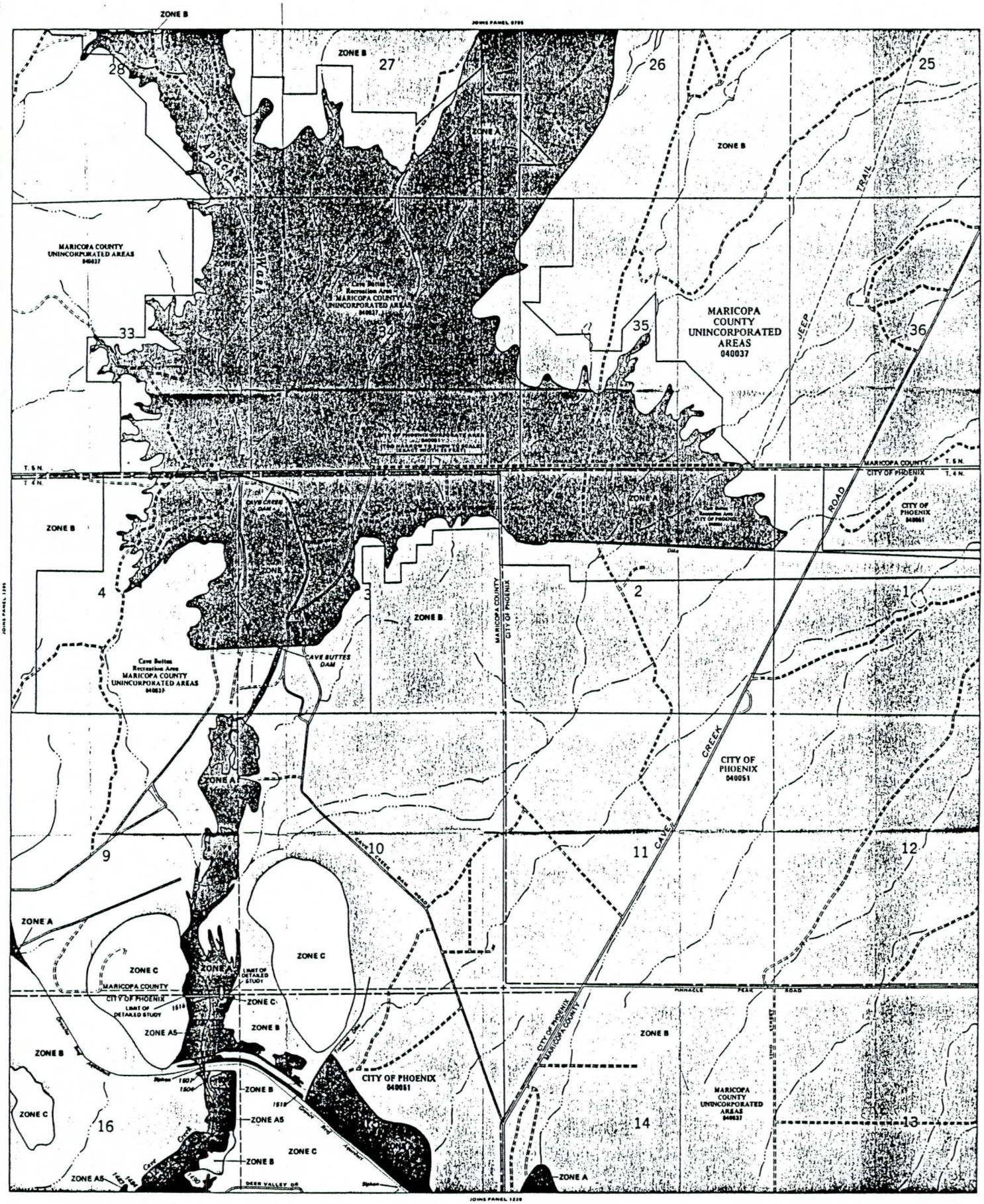
Subtotal $230,338

Design, Construction Administration and Management (40%)=$92,135.20

TOTAL=$322,473.20

FEMA MAPS


JOINS PANEL 0705
4
3
2
1
GAVIN
STREET
ZONE B
9
10
11
12
ZONE B
LIMIT OF DETAILED STUDY
Wash
MARICOPA
COUNTY
UNINCORPORATED
AREAS
040037
16
15
14
13
ZONE B
JOINS PANEL 0700
JOINS PANEL 0910
Apache
21
22
23
24
ZONE A
ZONE B
ZONE B
Cave Buttes Recreation Area
Cave Buttes Recreation Area
28
ZONE A
27
26
25
JEEP
TRAIL
ZONE A
JOINS PANEL 1210


ZONE B
ZONE A
ZONE C
ZONE A5
MARICOPA COUNTY UNINCORPORATED AREAS 040037
CITY OF PHOENIX 040051
Cave Buttes Recreation Area
CAVE BUTTES DAM
DAVE CREEK DAM
CAVE CREEK
JEEP TRAIL
ROAD
PINNACLE PEAK ROAD
DEER VALLEY DR
LIMIT OF DETAILED STUDY
T. 5 N.
T. 4 N.
JOINS PANEL 0750
JOINS PANEL 1250
25
26
27
28
33
34
35
36
1
2
3
4
9
10
11
12
13
14
16

HYDRAULIC DATA
CALCULATIONS
CHANNEL CROSS SECTIONS

TABLE VII
SOILS DATA

AREA	TOTAL AREA (A.C.)	SOILS GROUP B	C	D
A	268	92	0	176
B	293	27	0	266
C	751	101	69	581
D	766	51	122	593
E	907	241	153	513
F	1,697	315	600	782
G	612	37	443	132
10	614	128	0	486
11	868	276	124	468
12	1,204	25	546	633
13	95	79	0	16
14	802	39	193	570
20	437	179	15	243
21	323	66	68	189
22	329	69	19	241
23	1,095	209	159	727
24	1,865	151	486	1,228
25	730	103	194	433
30	317	104	12	201
40	355	147	145	63
41	569	221	9	339
42	70	48	0	22
43	891	119	382	390
44	394	81	131	182
50	481	123	143	215
60	258	85	119	54
70	201	130	28	43
80	647	178	287	182

TABLE VIII
TIME LAG CALCULATIONS

Basin Designation	CN	CN*	L	Lca	Cw	S/c*	K*	Tc	TL*
10	85.7	88.5	11500	5750	0.55	0.0081	57	0.93	0.55
11	85.6	88.4	14250	7125	0.55	0.0169	49	0.75	0.45
12	86.4	89.1	12500	8000	0.57	0.04	34	0.43	0.26
13	78.9	83.3	5000	2500	0.41	0.014	31	0.40	0.24
14	86.7	89.3	12000	9000	0.58	0.049	32	0.42	0.25
20	83.4	86.6	9750	4875	0.50	0.009	52	0.82	0.49
21	85.1	88.0	12500	6250	0.54	0.014	49	0.75	0.45
22	85.5	88.4	7875	3940	0.55	0.011	40	0.57	0.34
23	85.5	88.4	11500	5750	0.55	0.035	32	0.42	0.25
24	86.3	89.0	16000	5000	0.57	0.034	34	0.43	0.26
25	85.7	88.5	9880	4000	0.55	0.049	24	0.28	0.17
30	84.3	87.3	12250	6125	0.52	0.011	44	0.65	0.39
40	82.2	85.8	9000	5000	0.48	0.01	50	0.77	0.46
41	83.7	86.9	10500	4000	0.51	0.0126	43	0.63	0.38
42	80.5	84.5	1500	750	0.44	0.0133	15	0.17	0.10
43	85.2	88.1	14000	4000	0.54	0.0194	39	0.55	0.33
44	84.7	87.7	9000	4000	0.53	0.034	27	0.35	0.21
50	84.3	87.3	17500	8750	0.52	0.0123	64	1.10	0.66
60	83.0	86.4	7500	3000	0.49	0.020	30	0.4	0.24
70	84.9	87.8	23000	11500	0.53	0.022	59	0.98	0.59
80	83.6	86.8	21500	11000	0.51	0.017	64	1.10	0.66
G	85.1	88	8000	2500	0.54	0.019	29	0.37	0.22
F	84.9	87.8	14500	5000	0.53	0.004	79	1.5	0.90
E	84.6	87.6	15000	6500	0.53	0.01	60	1.0	0.60
D	86.8	89.3	12000	3000	0.58	0.019	33	0.43	0.26
C	86.3	89.0	8500	4250	0.57	0.03	28	0.35	0.21
B	87.0	89.5	7000	3000	0.58	0.04	21	0.25	0.15
A	84.7	87.7	8000	5000	0.53	0.026	31	0.40	0.24
1	85.5	88.4	17000	8500	0.55	0.008	73	1.33	0.80
2	87.7	90.1	21000	10500	0.60	0.012	68	1.13	0.68

* From Pima County Flood Control Hydrology Method

* TL=0.6 Tc From A Guide to Hydrologic Analysis Using SCS Method By McCuen

HYDROLOGIC DATA SHEET

Project Name and Location: APACHE WASH

Drainage Concentration Point: BASIN 50

Watershed Areas(A): 1.150 Square Miles

Length of Watercourse(Lc): 17500. ft Length to Center of Gravity(Lca): 9000. ft

Incremental Change in Length(Li) -ft. Incremental Change in Elevation(Hi) -ft.

Mean Slope (Sc): 0.0120 ft/ft Watershed Type(s): RURAL (future)

Basin Factor(nb): 0.0350 (future) Flood Frequency: 100.0 yrs.

P24 (24 hr):	4.60	in.	Areal Value:	in.
P6 (6 hr):	3.80	in.	Areal Value:	in.
P1 (1 hr):	2.39	in.	Areal Value:	in.
P2 (2 hr):	2.87	in.	Areal Value:	in.
P3 (3 hr):	3.19	in.	Areal Value:	in.

Soil Group(s): 0.0 %A 26.0 %B 30.0 %C 44.0 %D Cover Type(s): DESERT BRUSH (future)

Cover Density (pervious areas): 20.0% Impervious Cover: 1.0% (future)

Curve Number(s) - CN(s): 77. 85. 88. 99(pervious & impervious areas)

Adjusted Curve Number(s) - CN*(s): 81.7 88.0 90.4 99.0

Runoff to Rainfall Ratio(s),(C): 0.530 (pervious areas) 0.951 (impervious areas)

Runoff Supply Rate(q): 0.53 X i in/hr (function of i)

Time of Concentration (TC):1.5192 X i**-0.4 hrs. (function of i)

Iterative Solution of TC: 1.11 hrs. (K= 64.3)

Rainfall Intensity (i) at TC: 2.21 in./hr.

Runoff Supply Rate (q) at TC: 1.18 in./hr.

Peak Discharge:
645.33qA(sq. miles): 876. cfs

Discharge Location:

PSM 16-MAY-89

HYDROLOGIC DATA SHEET

Project Name and Location: APACHE WASH

Drainage Concentration Point: BASIN 30

Watershed Area (A): 317.00 Acres

Length of Watercourse(Lc): 12250. ft Length to Center of Gravity(Lca): 6125. ft

Incremental Change in Length(Li) -ft. Incremental Change in Elevation(Hi) -ft.

Mean Slope (Sc): 0.0237 ft/ft Watershed Type(s): RURAL (future)

Basin Factor(nb): 0.0350 (future) Flood Frequency: 100.0 yrs.

P24 (24 hr):	4.60	in.	Areal Value:	in.
P6 (6 hr):	3.80	in.	Areal Value:	in.
P1 (1 hr):	2.39	in.	Areal Value:	in.
P2 (2 hr):	2.87	in.	Areal Value:	in.
P3 (3 hr):	3.19	in.	Areal Value:	in.

Soil Group(s): 0.0 %A 33.0 %B 4.0 %C 63.0 %D Cover Type(s): DESERT BRUSH (future)

Cover Density (pervious areas): 20.0% Impervious Cover: 1.0% (future)

Curve Number(s) - CN(s): 77. 85. 88. 99(pervious & impervious areas)

Adjusted Curve Number(s) - CN*(s): 81.7 88.0 90.4 99.0

Runoff to Rainfall Ratio(s),(C): 0.532 (pervious areas) 0.951 (impervious areas)

Runoff Supply Rate(q): 0.54 X i in/hr (function of i)

Time of Concentration (TC):0.9247 X i**-0.4 hrs. (function of i)

Iterative Solution of TC: 33.6 mins. (K= 39.2)

Rainfall Intensity (i) at TC: 3.49 in./hr.

Runoff Supply Rate (q) at TC: 1.87 in./hr.

Peak Discharge:
1.008qA(acres): 598. cfs

Discharge Location:

PSM 16-MAY-89

HYDROLOGIC DATA SHEET

Project Name and Location: APACHE WASH

Drainage Concentration Point: BASIN 12

Watershed Areas(A): 1.890 Square Miles

Length of Watercourse(Lc): 12500. ft Length to Center of Gravity(Lca): 6250. ft

Incremental Change in Length(Li) -ft. Incremental Change in Elevation(Hi) -ft.

Mean Slope (Sc): 0.0168 ft/ft Watershed Type(s): RURAL (future)

Basin Factor(nb): 0.0350 (future) Flood Frequency: 100.0 yrs.

P24 (24 hr):	4.60	in.	Areal Value:	in.
P6 (6 hr):	3.80	in.	Areal Value:	in.
P1 (1 hr):	2.39	in.	Areal Value:	in.
P2 (2 hr):	2.87	in.	Areal Value:	in.
P3 (3 hr):	3.19	in.	Areal Value:	in.

Soil Group(s): 0.0 %A 32.0 %B 14.0 %C 54.0 %D Cover Type(s): DESERT BRUSH (future)

Cover Density (pervious areas): 20.0% Impervious Cover: 1.0% (future)

Curve Number(s) - CN(s): 77. 85. 88. 99(pervious & impervious areas)

Adjusted Curve Number(s) - CN*(s): 81.7 88.0 90.4 99.0

Runoff to Rainfall Ratio(s),(C): 0.527 (pervious areas) 0.951 (impervious areas)

Runoff Supply Rate(q): 0.53 X i in/hr (function of i)

Time of Concentration (TC):1.0780 X i**-0.4 hrs. (function of i)

Iterative Solution of TC: 41.4 mins. (K= 45.6)

Rainfall Intensity (i) at TC: 3.05 in./hr.

Runoff Supply Rate (q) at TC: 1.62 in./hr.

Peak Discharge:
645.33qA(sq. miles): 1977. cfs

Discharge Location:

PSM 17-MAY-89

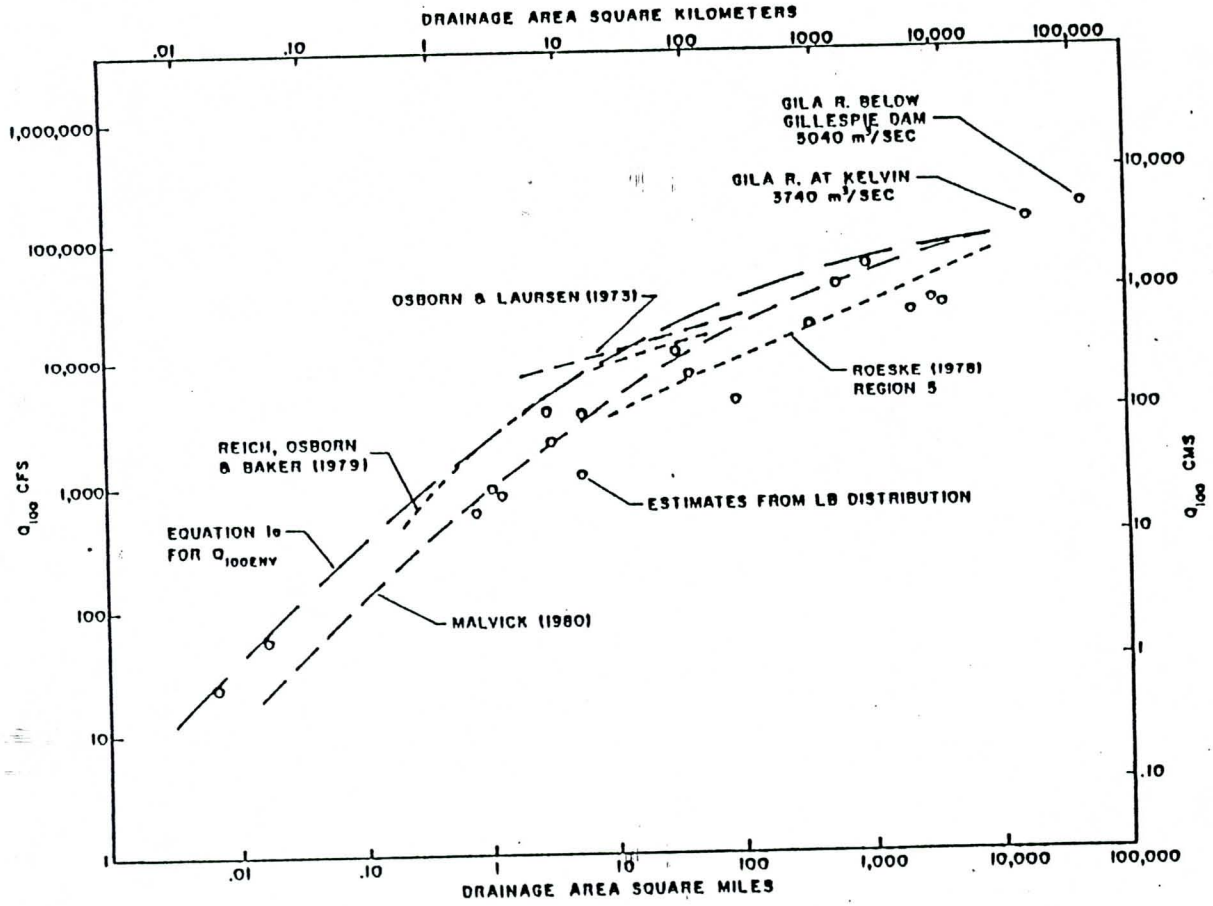


FIG. 1. Regional Flood Frequency Relationships for Peak Flow Estimation in Southeastern Arizona [Modified after Boughton and Renard (1984)]

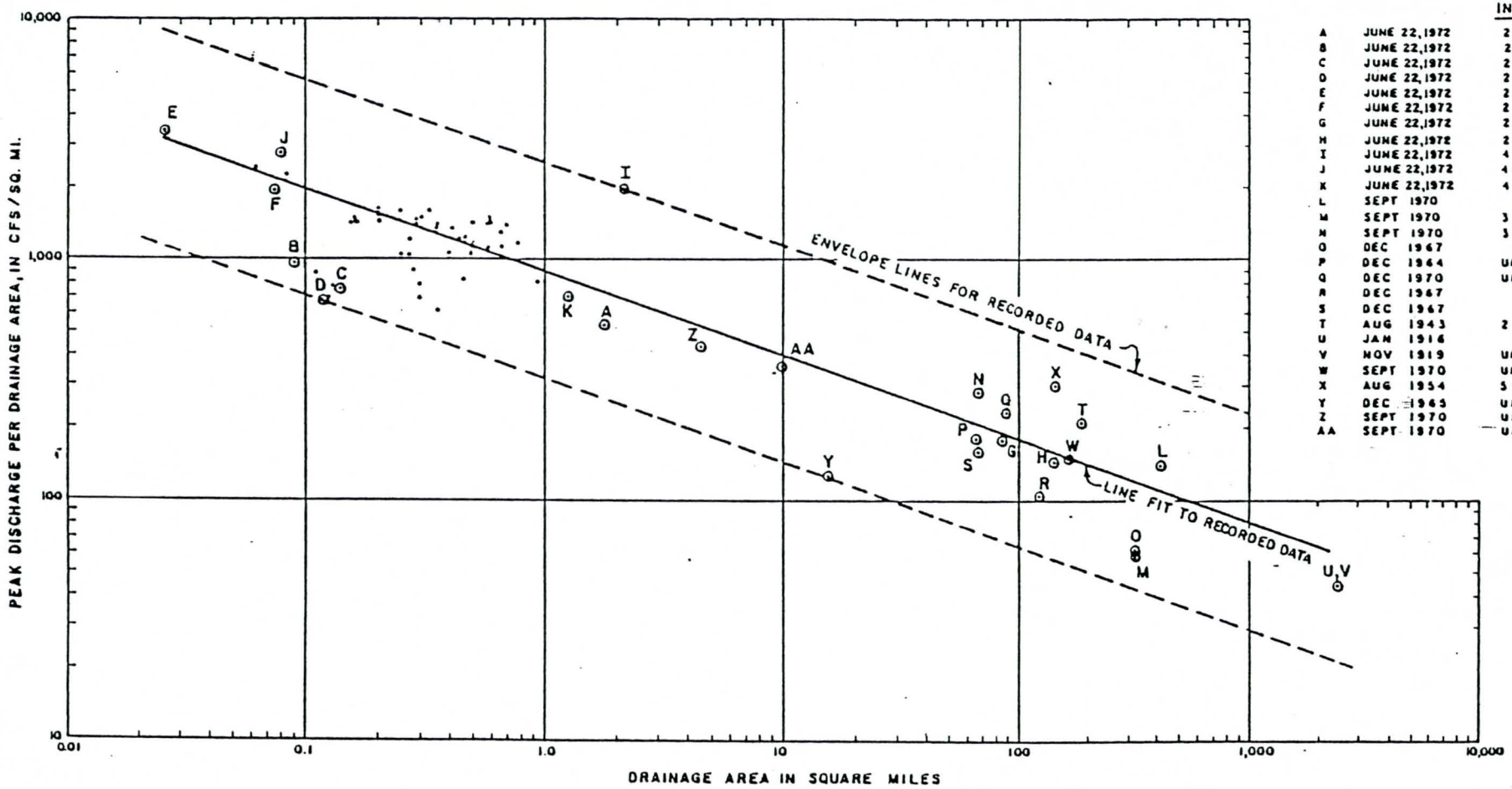
1980), Boughton and Renard (1984) produced the following equation to define the envelope shown in Fig. 1:

$$Q_{100ENV} = 2{,}200\ D^{(0.736 - 0.082 \log D)} \quad \text{(1a)}$$

where Q_{100ENV} = envelope value, in cfs; and D = drainage area in sq. miles. Eq. 1b shows the same equation converted to m^3/s and km^2 units:

$$Q_{100ENV} = 29.9\ D^{(0.803 - 0.082 \log D)} \quad \text{(1b)}$$

where Q_{100ENV} = envelope value, in m^3/s; and D = drainage area in km^2.



	STORM DATE	ESTIMATED RAINFALL-INCHES
A	JUNE 22, 1972	2 - 4
B	JUNE 22, 1972	2 - 4
C	JUNE 22, 1972	2 - 4
D	JUNE 22, 1972	2 - 4
E	JUNE 22, 1972	2 - 4
F	JUNE 22, 1972	2 - 4
G	JUNE 22, 1972	2 - 4
H	JUNE 22, 1972	2 - 4
I	JUNE 22, 1972	4 - 4 1/2
J	JUNE 22, 1972	4 - 4 1/2
K	JUNE 22, 1972	4 - 5
L	SEPT 1970	5
M	SEPT 1970	3 - 5
N	SEPT 1970	3 - 4
O	DEC 1967	4
P	DEC 1964	UNKNOWN
Q	DEC 1970	UNKNOWN
R	DEC 1967	4
S	DEC 1967	4
T	AUG 1943	2 - 3
U	JAN 1916	3
V	NOV 1919	UNKNOWN
W	SEPT 1970	UNKNOWN
X	AUG 1954	5 - 7
Y	DEC 1965	UNKNOWN
Z	SEPT 1970	UNKNOWN
AA	SEPT 1970	UNKNOWN

⊙ RECORDED PEAK DISCHARGES PER DRAINAGE AREA FOR MAJOR FLOODS IN PHOENIX AND VICINITY (GILA RIVER BASIN NEW RIVER AND PHOENIX CITY STREAMS ARIZONA DESIGN MEMORANDUM NO. 2 HYDROLOGY, PART I, TABLE 15 U.S. ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT OCTOBER 1974).

• ESTIMATED PEAK DISCHARGE PER DRAINAGE AREA FOR EACH SUB-BASIN FOR THE 100-YEAR EVENT AND EXISTING CONDITIONS.

COMPARISON OF ESTIMATED PEAK DISCHARGES FOR THE 100-YEAR RAINFALL WITH EXISTING WATERSHED CONDITIONS AND RECORDED PEAK DISCHARGES FOR RAINFALL FLOODS IN PHOENIX AND VICINITY

DRAINAGE CALCULATIONS FOR STORM DRAIN

Runoff Equation Q=0.8 (i-fc) Ap+0.9 (I-.2) Ai

C-1 D.A.=187.3 Acres L=10.000 ft. assume V=3 ft./sec.

Tc=L/V=56 minutes i=0.78 in/hr

Assume C-condition for fc=0.05 soil type

Total 187.3 acres use zoning RE-43 15% imp

187.3x.15=28.1=Ai, Ap=159.2

Q=0.8(0.78-.05)159.2+0.9(0.78-.2)28.1=107.6 CFS

C-2 DA=40.1 acres L=5000 ft. assume V=3 ft./sec.

Tc=L/V=28 minutes i=1.4 in/hr fc=0.05

40.1x.15=6.0 Ai, 34.1 AC=Ap

Q=0.8(1.4-0.5)34.1+0.9(1.4-.2)6=43.3 CFS

C-3 DA=92.1 acres L=6000 ft. assume V=3 ft./sec.

Tc=L/V=33 minutes i=1.3 fc=0.05

92.1x.15=13.8=Ai, Ap=78.3 AC

Q=0.8(1.3-.05)78.3+0.9(1.3-.2)13.8=92.0 CFS

C-4 DA=18.4 acres L=3000 ft. assume V=3 ft./sec.

Tc=L/V=17 minutes i=19 in/hr fc=0.05

18.4 ACx.15=2.8 AC Ai, 15.6 AC=Ap

Q=0.8(.19-.05)15.6+0.9(1.9-.2)x2.8=27.4 CFS

C-5 DA=281.6 AC L=7500 ft. assume V=4 ft./sec.

Tc=L/V=31 minutes i=1.4 in/hr fc=0.05

281.5x.15=42.2 Ai, 239.3=Ap

Q=0.8(1.4-0.05)x239+0.9(1.4-.2x42.2=304 CFS

C-6 DA=103.3 acres L=4000 ft. assume V=3 ft./sec

Tc=L/V=22 minutes i=1.7 in/hr fc=0.05

103.3 ACx.15=15.5=Ai, 87.8=Ap

Q=0.8(1.4-.05)x87.8+0.9(1.7-.2)x15.5=115 CFS

15-A DA=30.1 AC L=2500 ft. assume V=4 ft./sec.
Tc=L/V=10.4 minutes i=2.3 in/hr fc=0.05
30.1 ACx.15=4.5 Ai, Ap=25.6 AC
Q=0.8(2.3-.05)25.6+0.9(2.3-.2)x4.5=54.6 CFS

15-B DA=62.4 AC L=2500 ft. assume V=4 ft./sec.
Tc=L/V=10.4 minutes i=2.3 in/hr fc=0.05
62.4x.15=9.4=Ai, 53=Ap
Q=0.8(2.3-.05)x0.9(2.3-.2)x9.4=113.2 CFS

15-C DA=57.7 AC L=2400 ft. assume v=3 ft./sec.
Tc=L/V=13.3 minutes i=2.1 in/hr fc=0.05
57.7 ACx.15=8.7=Ai, Ap=49.0 AC
Q=0.8(2.1-.05)49+0.9(2.1-.2)8.7=99.2 CFS

15-D DA=18.4 AC L=2700 ft. assume V=3 ft./sec.
Tc=L/V=15 minutes i=2.0 in/hr fc=0.05
18.4 ACx.15=2.8=Ai, 15.6=Ap
Q=0.8(2.0-.05)15.6+0.9(2.0-.2)x2.8=28.9 CFS

15-E DA=57.4 AC L=4500 ft. assume V=3 ft/sec/
Tc=L/V=25 minutes i=1.5 in/hr fc=0.05
57.4 ACx.15=8.16 Ai 49.24=Ap
Q=0.8(1.5-.05)49.24+0.9(1.5-.2)8.16=66.7 CFS

One storm drain system will serve area 15-D and 15-E
Design flow is 95.6 CFS

Storm Drain, 18th Street L=6000 ft. W=80 ft. R/W=11'
Ac=Ai Q=0.9 (I-.2) Ai
Assume V=3 ft/sec Tc=L/v 33 min i=1.3 in/hr
Q=0.9(1.3-.2)x11=10.89 CFS

****
CLOUD ROAD CHANNEL
****

NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
15.00	3.84	30.37	87.18	2.0:1	2.0:1	32.19

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
1.22	11.77	0.00800	1026.00	0.02200	4.31	10.08

****
SECTION A BASIN 70-80
****

NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
30.00	5.54	52.18	227.84	2.0:1	2.0:1	54.80

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
1.24	14.65	0.00700	3337.00	0.02200	6.28	12.49

****
SECTION B BASIN 70-80
****

NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
10.00	2.56	20.26	38.79	2.0:1	2.0:1	21.47

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
1.07	8.40	0.00700	326.00	0.02200	2.66	7.98

****
SECTION C BASIN 70-80
****

SECTION # 1 STATION 1.00

NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
30.00	5.76	53.03	239.04	2.0:1	2.0:1	55.75

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
1.24	14.95	0.00700	3573.00	0.02200	6.53	12.70

****
2 9-017 SECTION # 1
B SIN # 12, 13 & 14
****

IRREGULAR CROSS SECTION

S A.	0.00	200.00	212.00	282.00	303.00	503.00
ELEV.	8.40	4.00	0.00	0.00	7.00	11.00
N	0.040	0.040	0.035	0.035	0.040	0.040

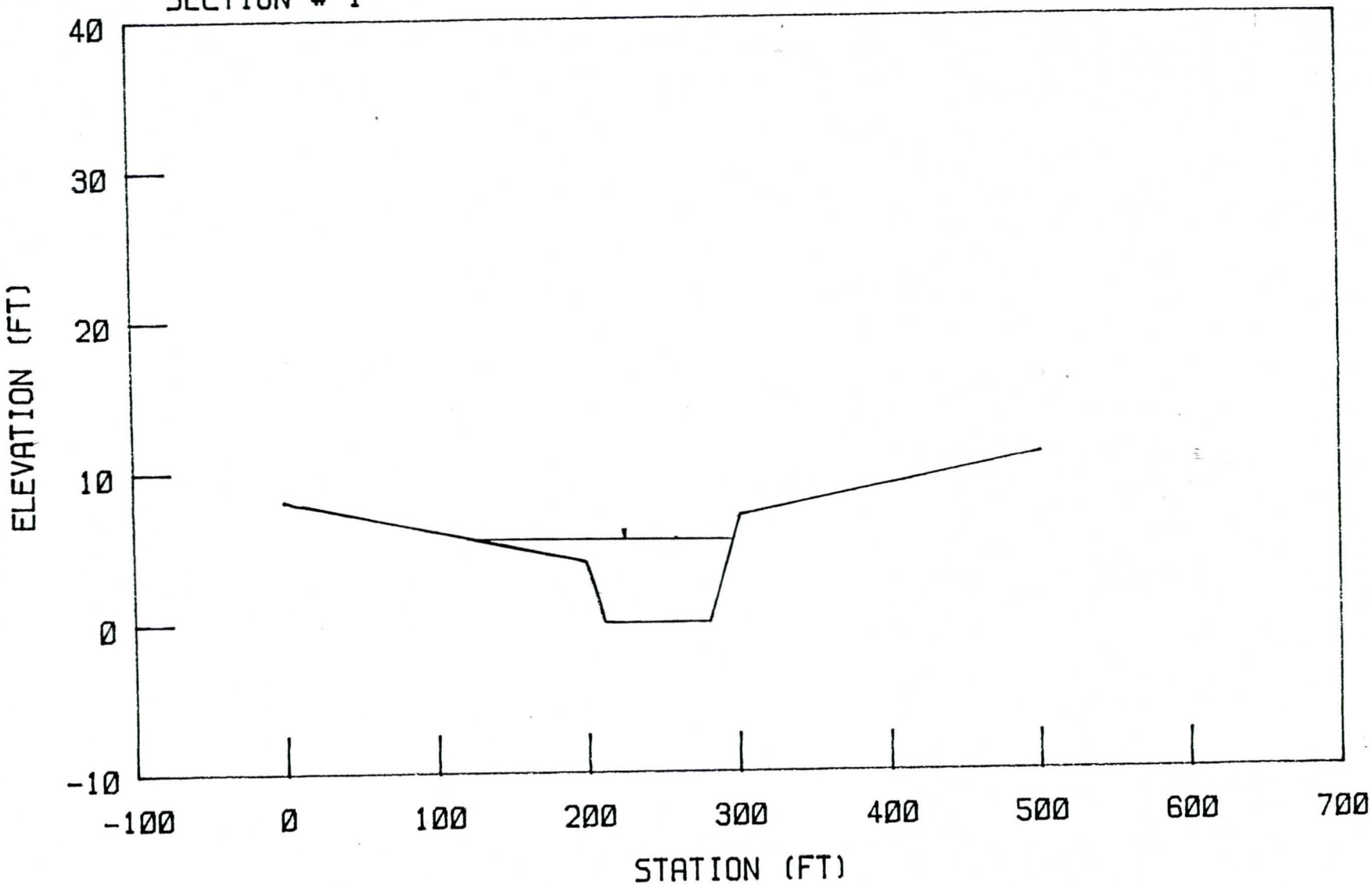
NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	5.57	170.09	535.35	0.0:1	0.0:1	171.66

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
1.13	11.39	0.01800	6096.00	0.03766	5.93	10.15

JOB NO. 289-017
18-APR-89

SECTION # 1



****
9-017 SECTION # 2
IN # 11
****

IRREGULAR CROSS SECTION

S.	0.00	200.00	207.50	223.50	231.00	431.00
ELEV.	12.50	2.50	0.00	0.00	2.50	12.50
N	0.040	0.040	0.030	0.030	0.040	0.040

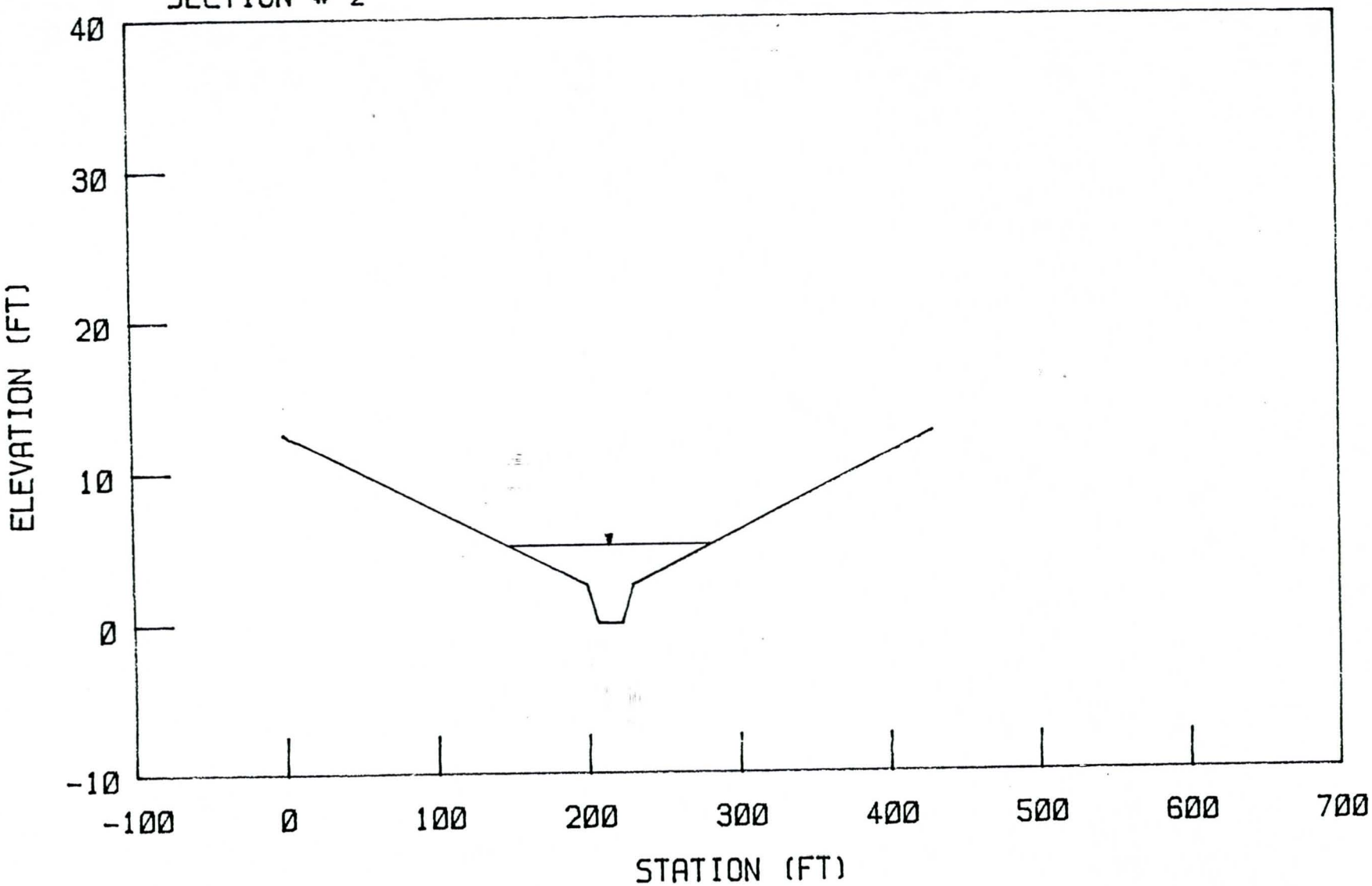
NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	5.74	160.47	368.60	0.0:1	0.0:1	161.44

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.60	5.20	0.00600	1915.00	0.03810	4.85	7.90

JOB NO. 289-017
18-APR-89

SECTION # 2



****
2 -017 SECTION # 3
B IN # 22
****

IRREGULAR CROSS SECTION

S A.	0.00	200.00	206.60	238.60	245.20	445.20
E EV.	13.30	3.30	0.00	0.00	3.30	13.30
N	0.040	0.040	0.030	0.030	0.040	0.040

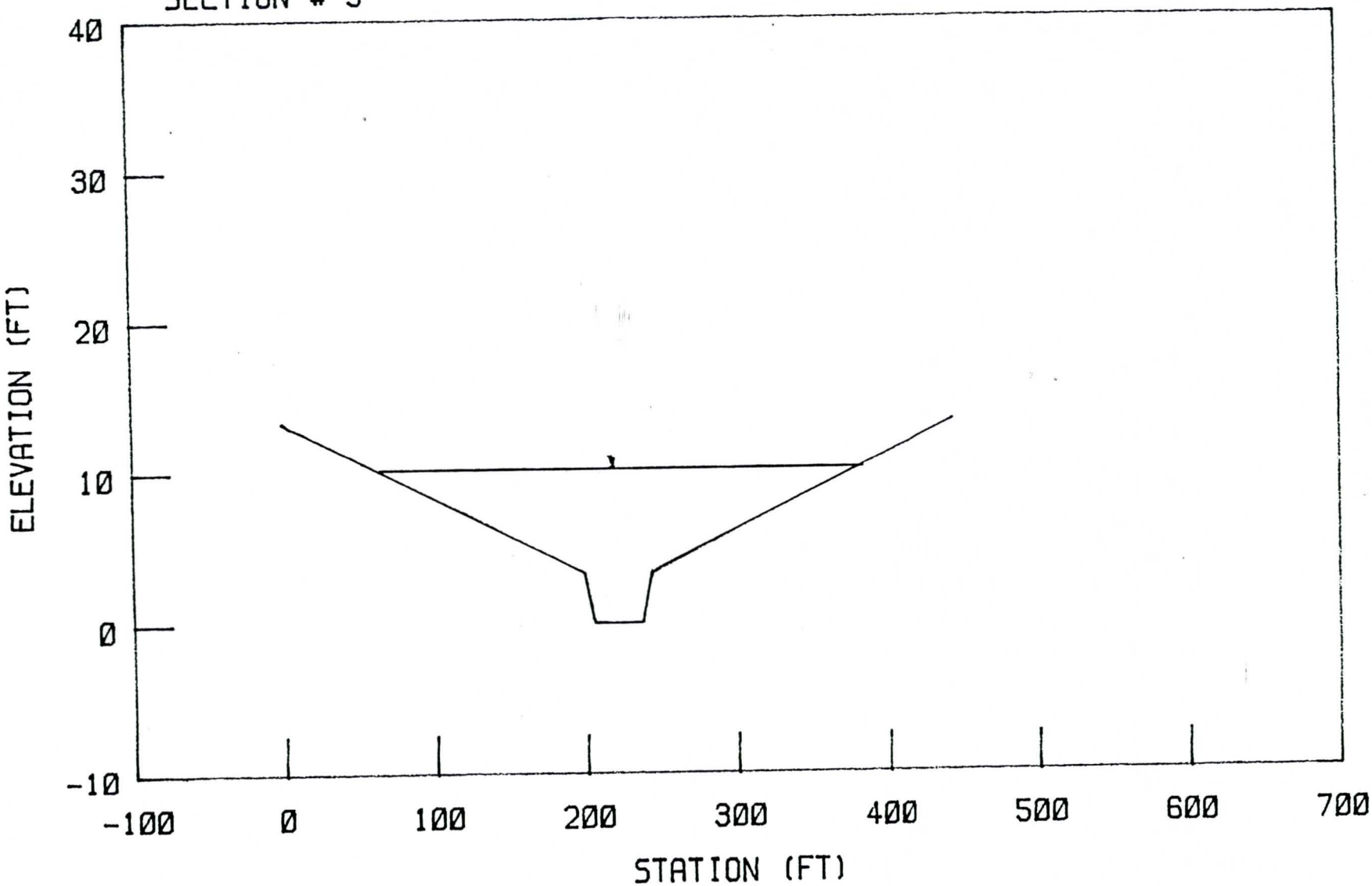
N RMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	10.28	324.46	1417.79	0.0:1	0.0:1	326.37

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.67	7.92	0.00600	11230.00	0.03856	8.95	11.01

JOB NO. 289-017
18-APR-89

SECTION # 3



****
2 9-017 SECTION # 4
I SIN # 21
****

IRREGULAR CROSS SECTION

S A.	0.00	300.00	306.00	313.00	319.00	619.00
ELEV.	5.00	2.00	0.00	0.00	2.00	5.00
N	0.040	0.040	0.030	0.030	0.040	0.040

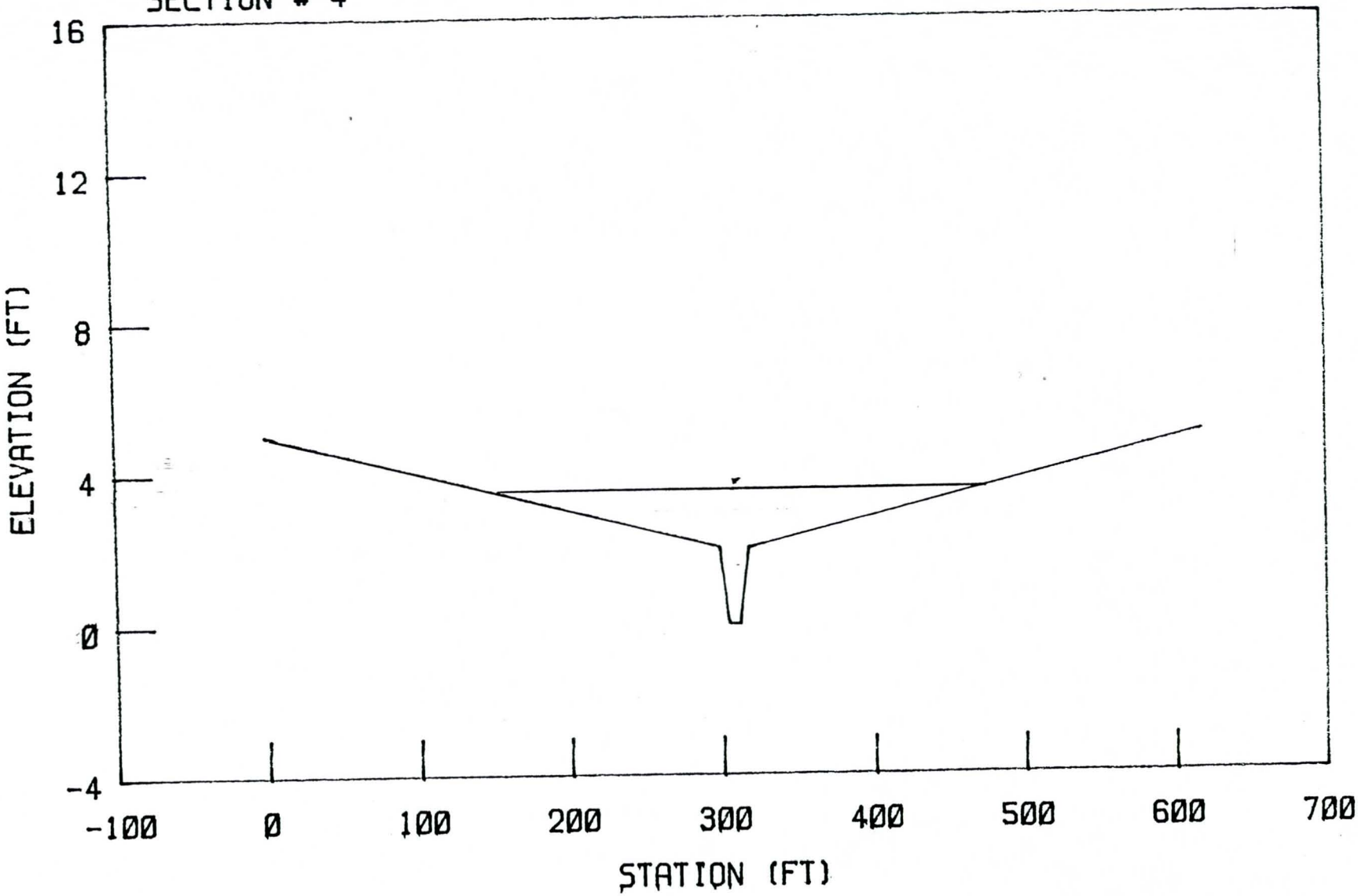
NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	3.61	340.84	315.52	0.0:1	0.0:1	341.50

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.41	2.26	0.00400	712.00	0.03941	3.03	4.67

JOB NO. 289-017
18-APR-89

SECTION # 4



****
2 [illegible]-017 SECTION # 5
E [illegible]IN # 30
****

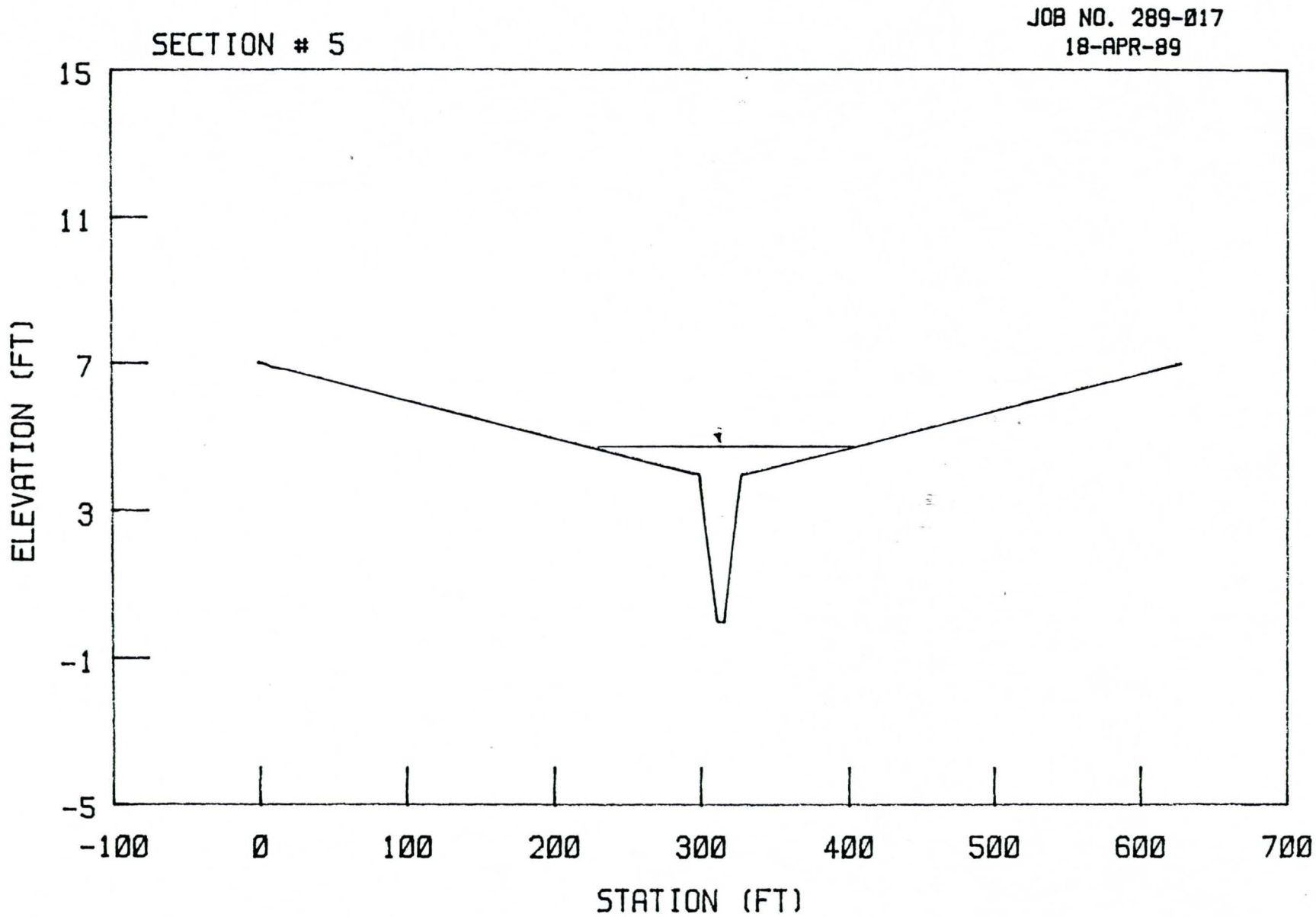
IRREGULAR CROSS SECTION

S[illegible].	0.00	300.00	312.00	317.00	329.00	629.00
[illegible] EV.	7.00	4.00	0.00	0.00	4.00	7.00
[illegible]N	0.030	0.030	0.030	0.030	0.030	0.030

[illegible]ORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	4.72	173.23	140.92	0.0:1	0.0:1	174.54

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
1.00	5.09	0.01400	718.00	0.03000	4.72	5.12


SECTION # 5
JOB NO. 289-017
18-APR-89
15
11
7
3
-1
-5
ELEVATION (FT)
-100
0
100
200
300
400
500
600
700
STATION (FT)

****
279-017 SECTION # 6
BETWEEN 40 & 30
****

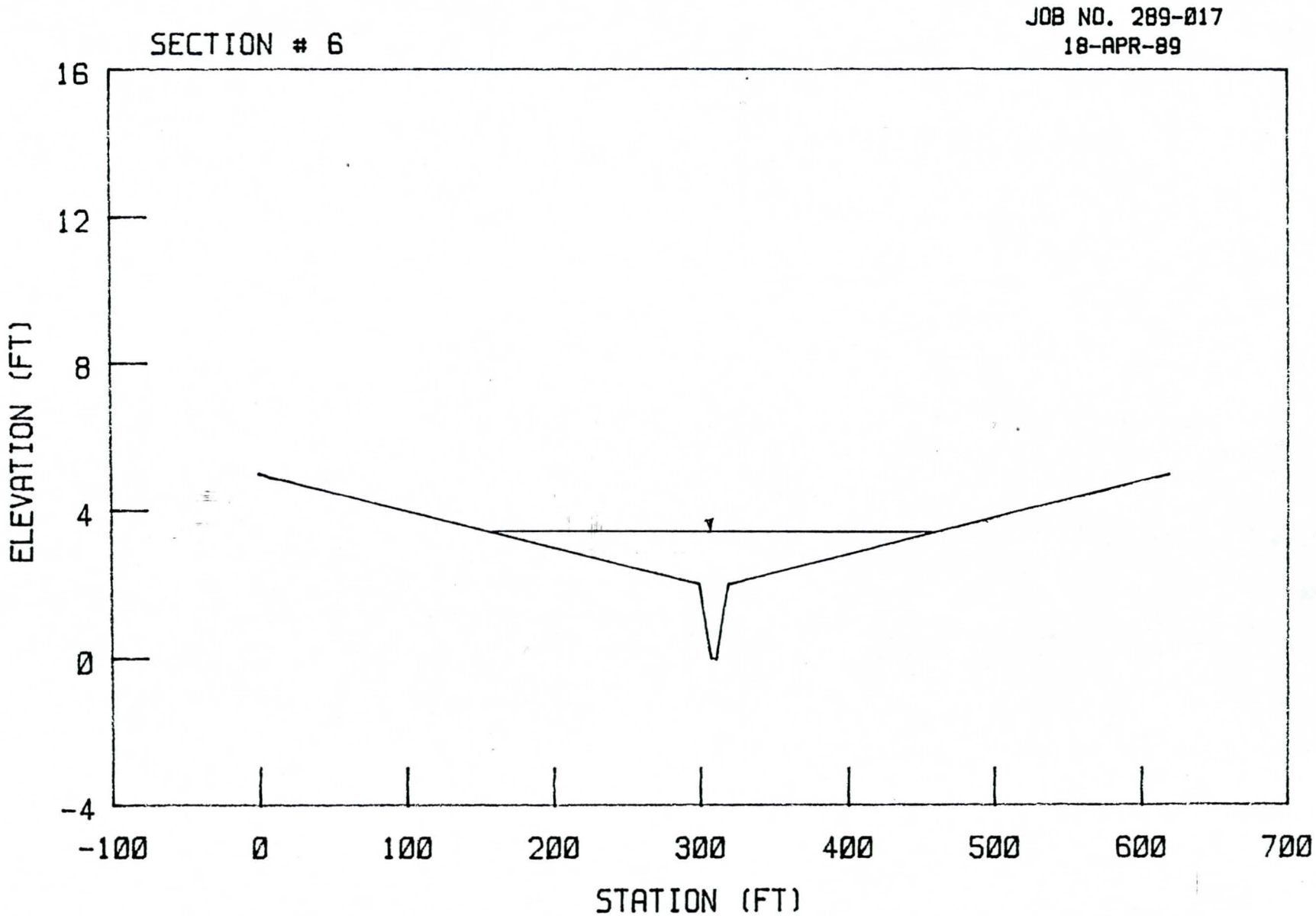
IRREGULAR CROSS SECTION

STA.	0.00	300.00	308.00	312.00	320.00	620.00
ELEV.	5.00	2.00	0.00	0.00	2.00	5.00
N	0.030	0.030	0.030	0.030	0.030	0.030

NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	3.40	300.47	248.70	0.0:1	0.0:1	300.98

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.54	2.76	0.00400	687.50	0.03000	3.02	4.62


JOB NO. 289-017
18-APR-89
SECTION # 6
16
12
8
4
0
-4
ELEVATION (FT)
-100
0
100
200
300
400
500
600
700
STATION (FT)

****
19-017 SECTION # 7
BSIN # 43 EAST TRIBUTARY
****

IRREGULAR CROSS SECTION

DA.	0.00	300.00	300.10	308.10	308.20	608.20
ELEV.	7.00	4.00	0.00	0.00	4.00	7.00
N	0.030	0.030	0.030	0.030	0.030	0.030

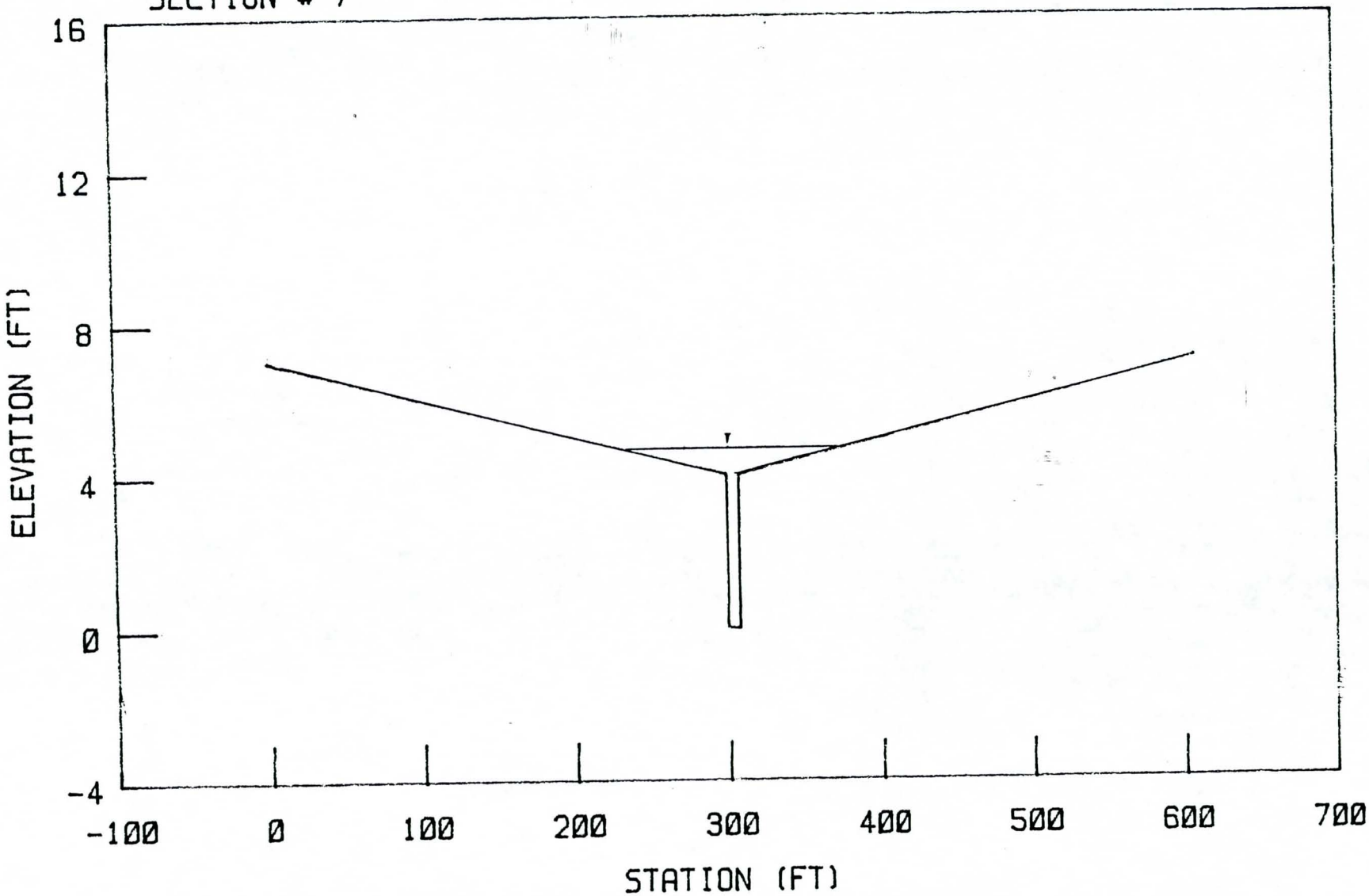
NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	4.79	167.04	101.99	0.0:1	0.0:1	174.85

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
1.11	4.90	0.02000	500.00	0.03000	4.85	4.49

JOB NO. 289-017
18-APR-89

SECTION # 7



****
39-017 SECTION # 8
SIN # 43 MAIN CHANNEL
****

IRREGULAR CROSS SECTION

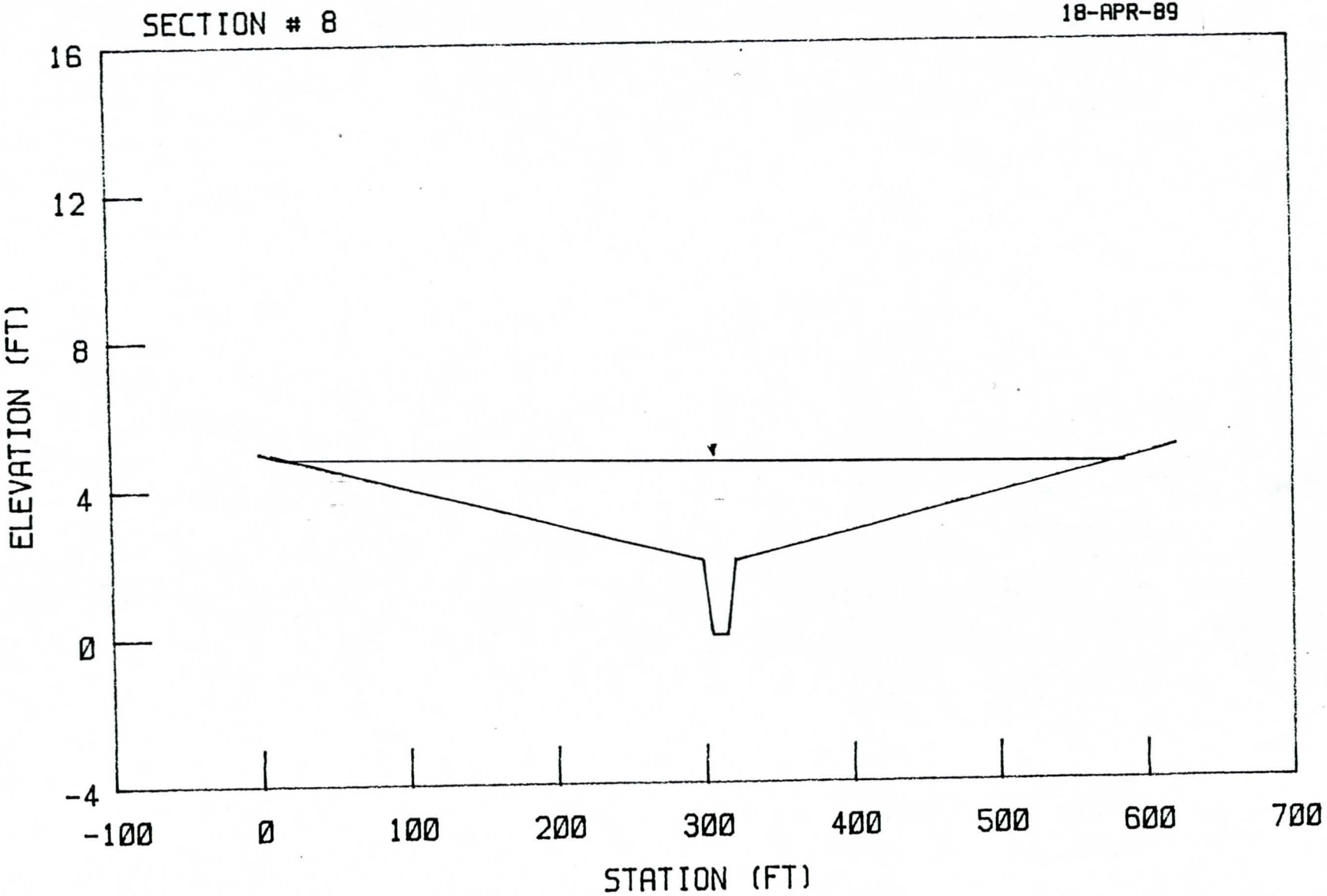
A.	0.00	300.00	306.00	316.00	322.00	622.00
LEV.	5.00	2.00	0.00	0.00	2.00	5.00
N	0.040	0.040	0.035	0.035	0.040	0.040

ORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	4.63	547.29	779.61	0.0:1	0.0:1	547.97

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.44	2.99	0.00400	2332.00	0.03979	3.82	5.80

JOB NO. 289-017
18-APR-89



****
39-017 SECTION # 9
SIN # 50 UPPER PORTION
****

IRREGULAR CROSS SECTION

A.	0.00	300.00	303.00	307.00	310.00	610.00
EV.	6.00	3.00	0.00	0.00	3.00	6.00
N	0.030	0.030	0.030	0.030	0.030	0.030

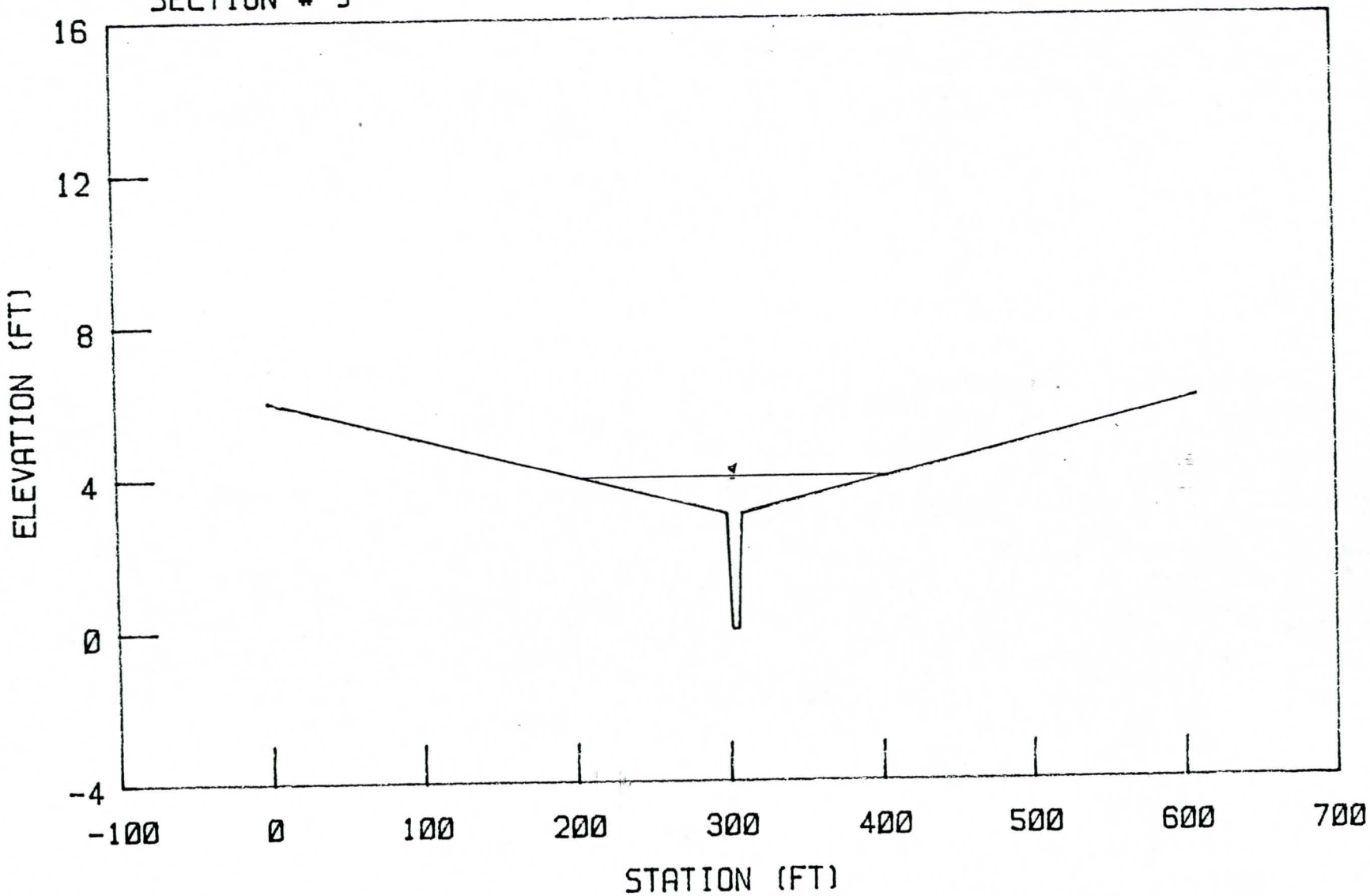
ORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	3.97	204.93	125.74	0.0:1	0.0:1	207.42

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.72	3.18	0.00800	400.00	0.03000	3.81	4.21

JOB NO. 289-017
18-APR-89

SECTION # 9



****
9-01/ SECTION # 10
SIN # 70 MID. POINT
****

IRREGULAR CROSS SECTION

A.	0.00	300.00	308.00	312.00	320.00	620.00
EV.	5.00	2.00	0.00	0.00	2.00	5.00
N	0.030	0.030	0.025	0.025	0.030	0.030

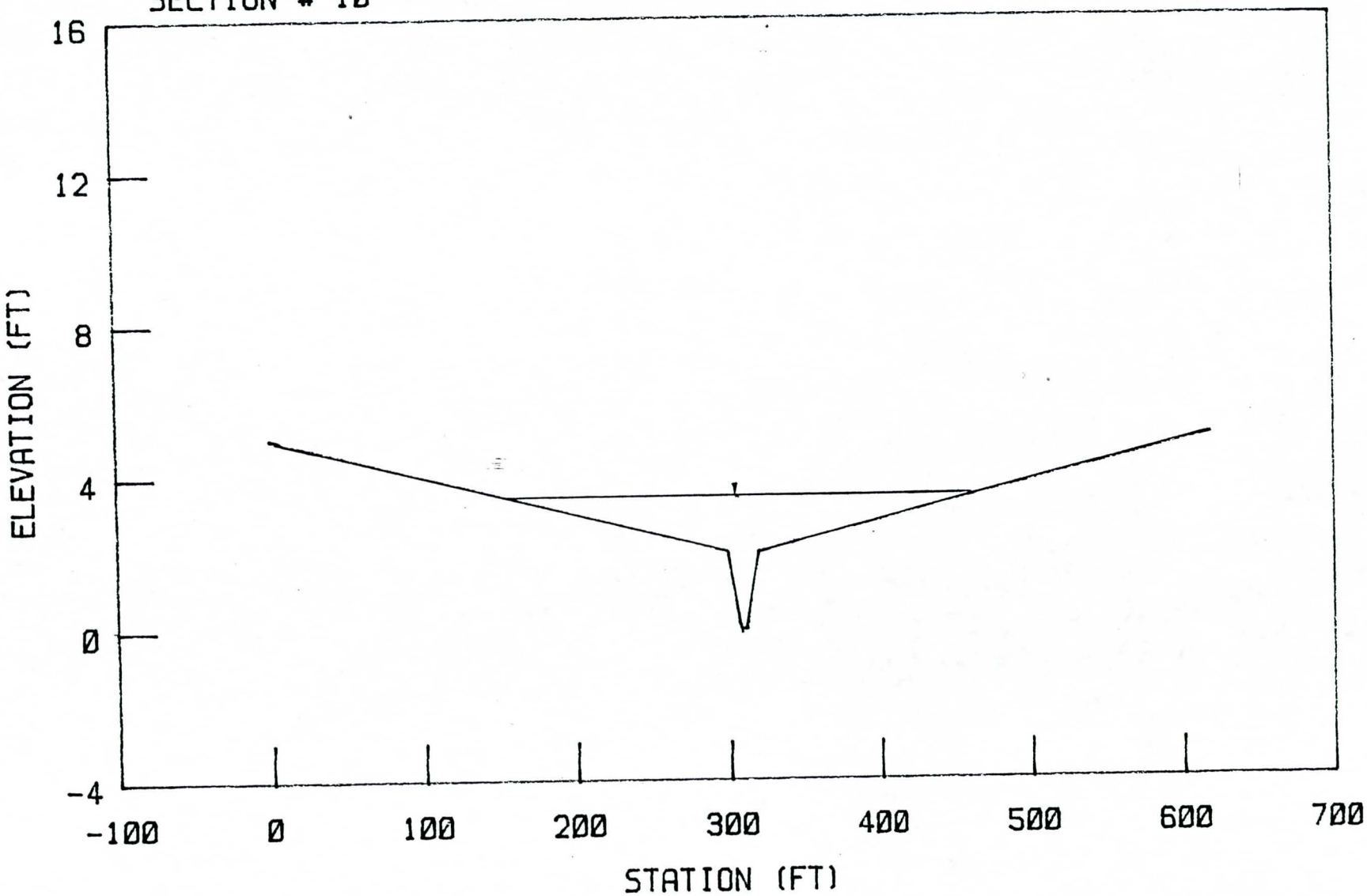
NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	3.52	323.35	284.38	0.0:1	0.0:1	323.85

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.77	4.10	0.00800	1165.50	0.02979	3.34	5.08

JOB NO. 289-017
18-APR-89

SECTION # 10



****
39-01/ SECTION # 11
SIN # 80
****

IRREGULAR CROSS SECTION

A.	0.00	300.00	316.00	318.00	332.00	632.00
LEV.	7.00	4.00	0.00	0.00	4.00	7.00
N	0.025	0.025	0.025	0.025	0.025	0.025

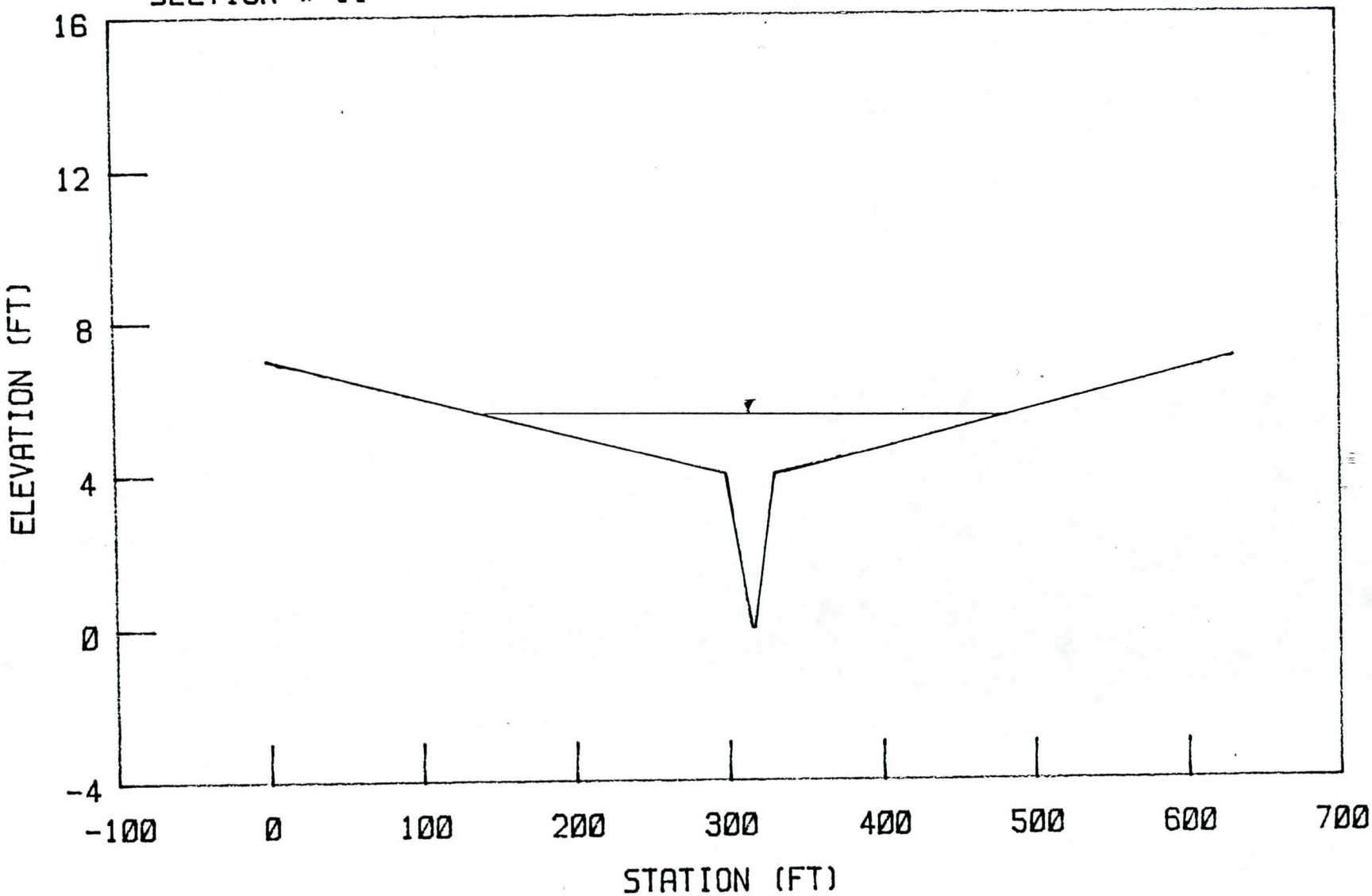
ORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	5.46	323.93	327.76	0.0:1	0.0:1	325.00

ROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.66	3.79	0.00400	1242.00	0.02500	5.13	5.38

JOB NO. 289-017
18-APR-89

SECTION # 11



****
19-017 SECTION # 12
BASIN # 50 LOWER 1/3
****

IRREGULAR CROSS SECTION

STA.	0.00	300.00	310.50	320.50	331.00	631.00
ELEV.	6.50	3.50	0.00	0.00	3.50	6.50
N	0.030	0.030	0.030	0.030	0.030	0.030

SECTION # 1 STATION 1.00

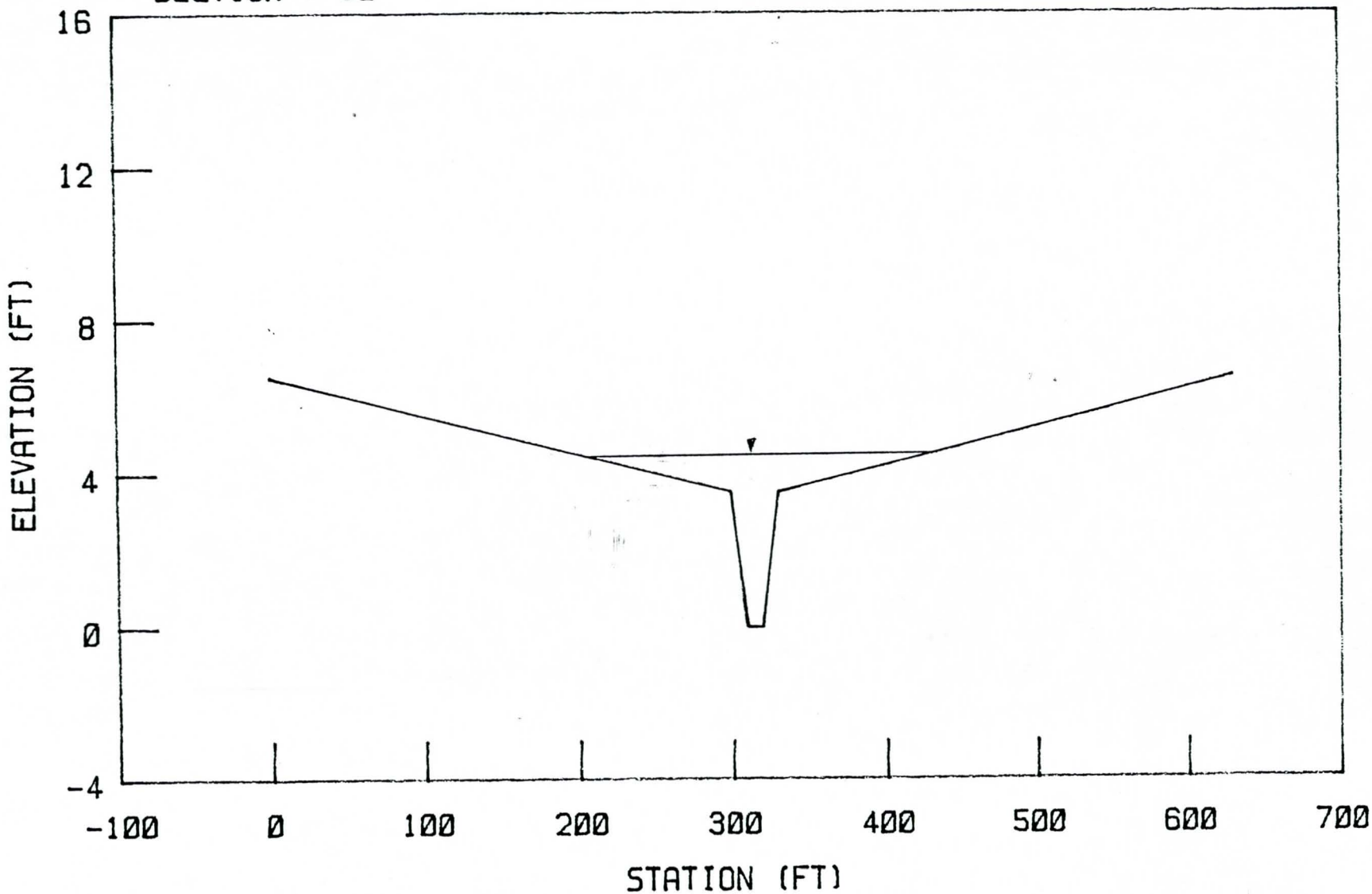
NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	4.67	264.53	244.29	0.0:1	0.0:1	265.68

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.77	4.20	0.00800	1026.00	0.03000	4.46	5.29

JOB NO. 289-017
18-APR-89

SECTION # 12



****
79-017 SECTION # 13
BASIN # 41
****

IRREGULAR CROSS SECTION

STA.	0.00	300.00	312.00	328.00	340.00	640.00
ELEV.	6.00	3.00	0.00	0.00	3.00	6.00
N	0.040	0.040	0.030	0.030	0.040	0.040

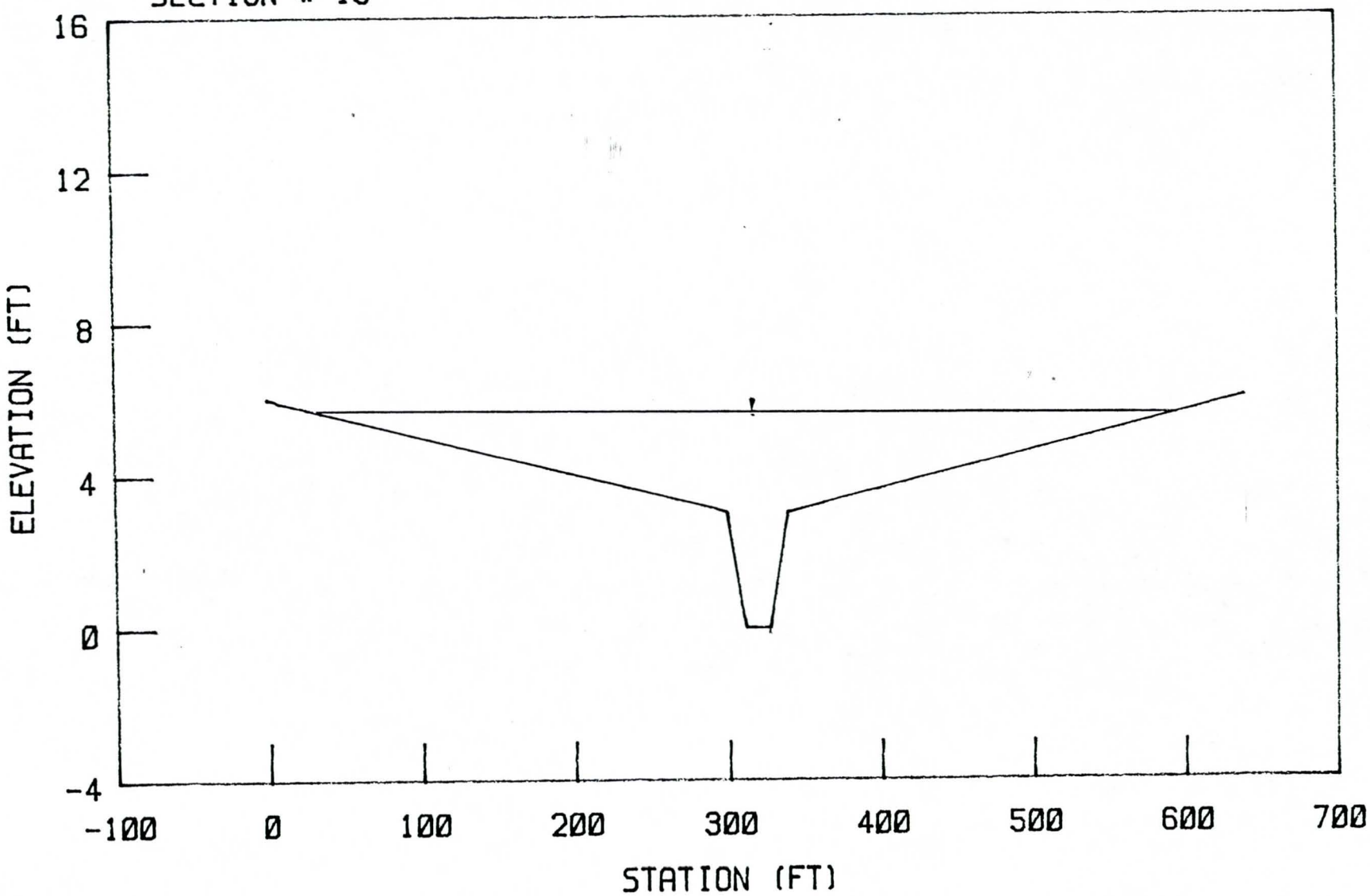
NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	5.63	566.12	881.23	0.0:1	0.0:1	566.88

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.71	5.06	0.01000	4460.00	0.03942	5.23	6.67

JOB NO. 289-017
18-APR-89

SECTION # 13



****
39-017 SECTION # 14
SIN # 40
****

IRREGULAR CROSS SECTION

A.	0.00	300.00	308.00	318.00	326.00	626.00
LEV.	7.00	4.00	0.00	0.00	4.00	7.00
N	0.035	0.035	0.030	0.030	0.035	0.035

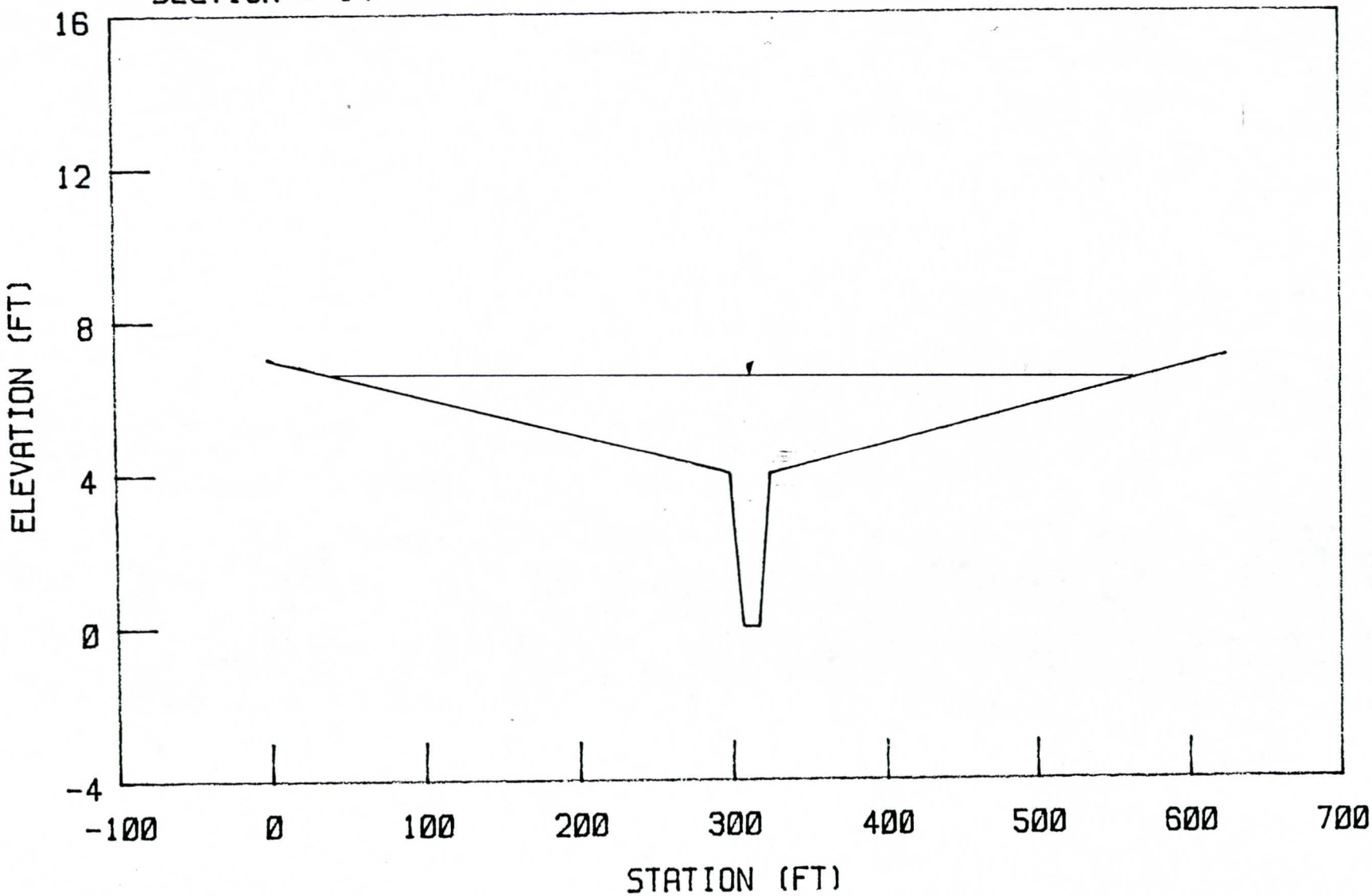
NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	6.53	531.24	775.86	0.0:1	0.0:1	533.16

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.80	5.49	0.01000	4263.00	0.03480	6.27	6.59

JOB NO. 289-017
18-APR-89

SECTION # 14



****
2[illegible]0-017 SECTION #15 BASINS 50,60,70,80,G
****

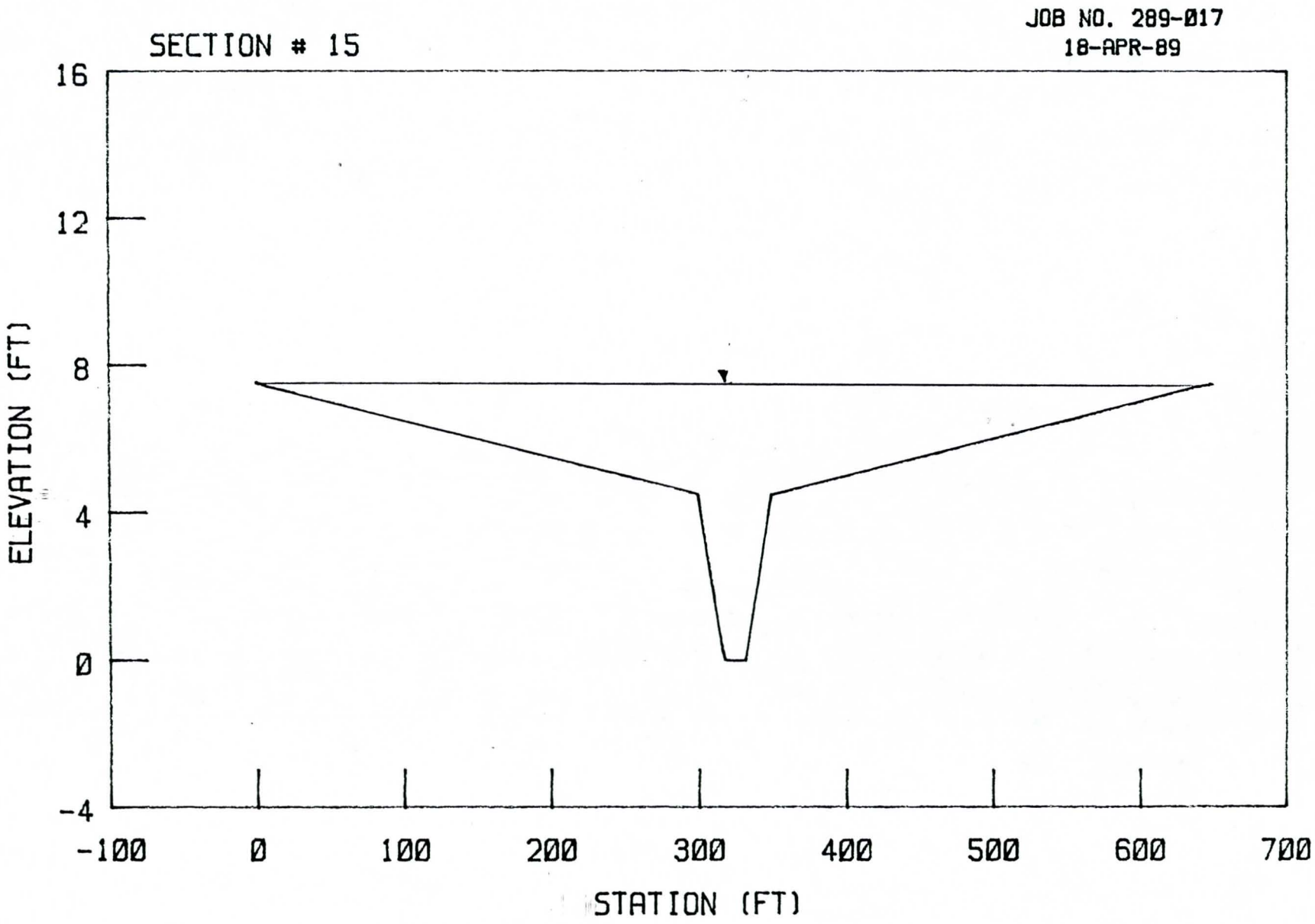
IRREGULAR CROSS SECTION

S[illegible]A.	0.00	300.00	318.00	332.00	350.00	650.00
I[illegible]EV.	7.50	4.50	0.00	0.00	4.50	7.50
N	0.040	0.040	0.035	0.035	0.040	0.040

NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	7.58	650.00	1245.37	0.0:1	0.0:1	651.30

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.57	4.47	0.00600	5570.00	0.03968	6.80	7.06


SECTION # 15
JOB NO. 289-017
18-APR-89
16
12
8
4
0
-4
ELEVATION (FT)
-100
0
100
200
300
400
500
600
700
STATION (FT)

****
2 9-017 SECTION # 16
I S BASIN 70 + 80
****

IRREGULAR CROSS SECTION

A.	0.00	300.00	312.00	320.00	332.00	632.00
LEV.	6.00	3.00	0.00	0.00	3.00	6.00
N	0.035	0.035	0.035	0.035	0.035	0.035

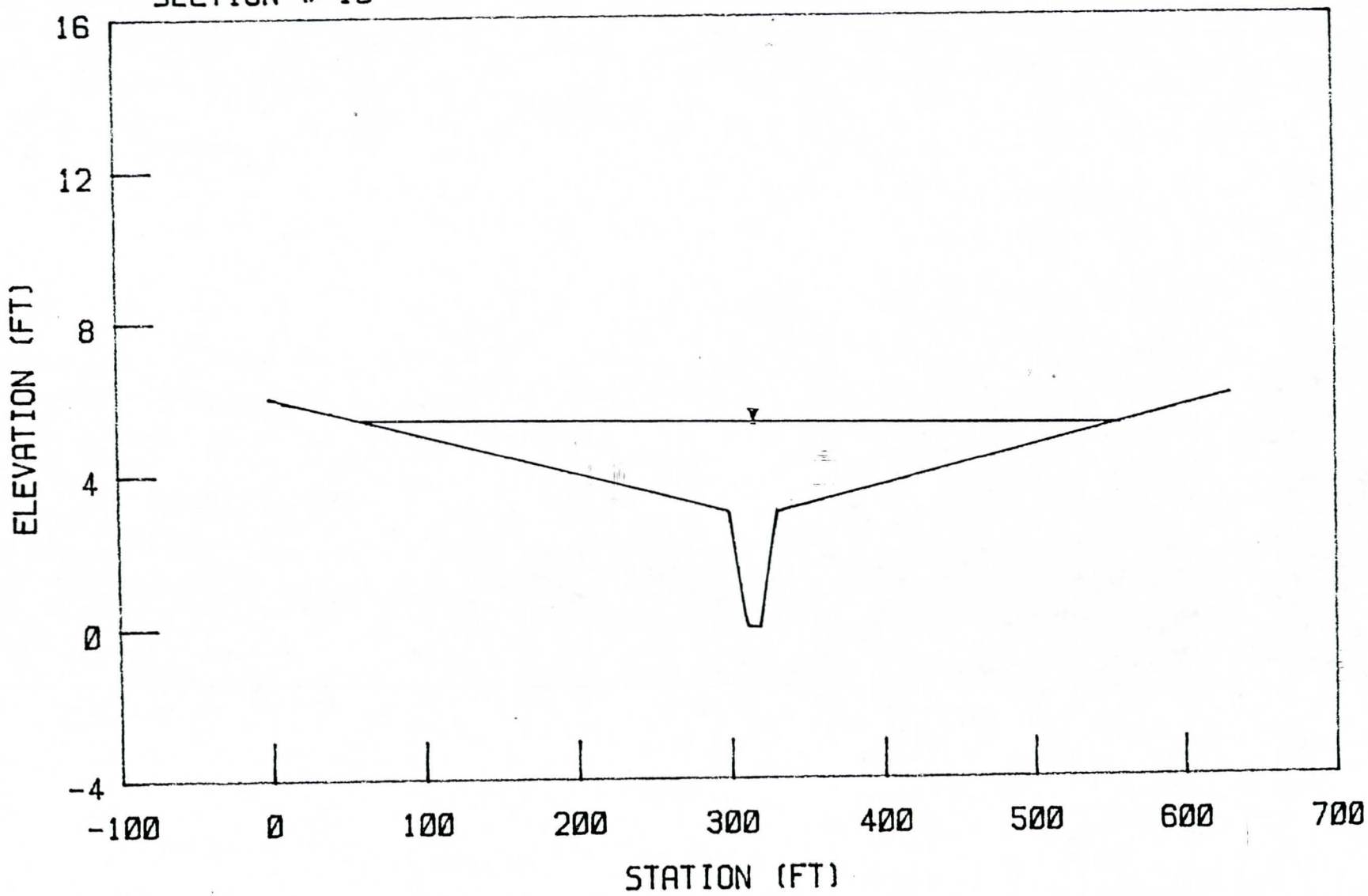
NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	5.34	500.30	683.20	0.0:1	0.0:1	501.07

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.79	5.23	0.01000	3573.00	0.03500	5.09	6.35

JOB NO. 289-017
18-APR-89

SECTION # 16



****
39-017 SECTION # 17
WNSTREAM BASIN 30
****

IRREGULAR CROSS SECTION

A.	0.00	300.00	312.00	322.00	334.00	634.00
LEV.	9.00	6.00	0.00	0.00	6.00	9.00
N	0.040	0.040	0.035	0.035	0.040	0.040

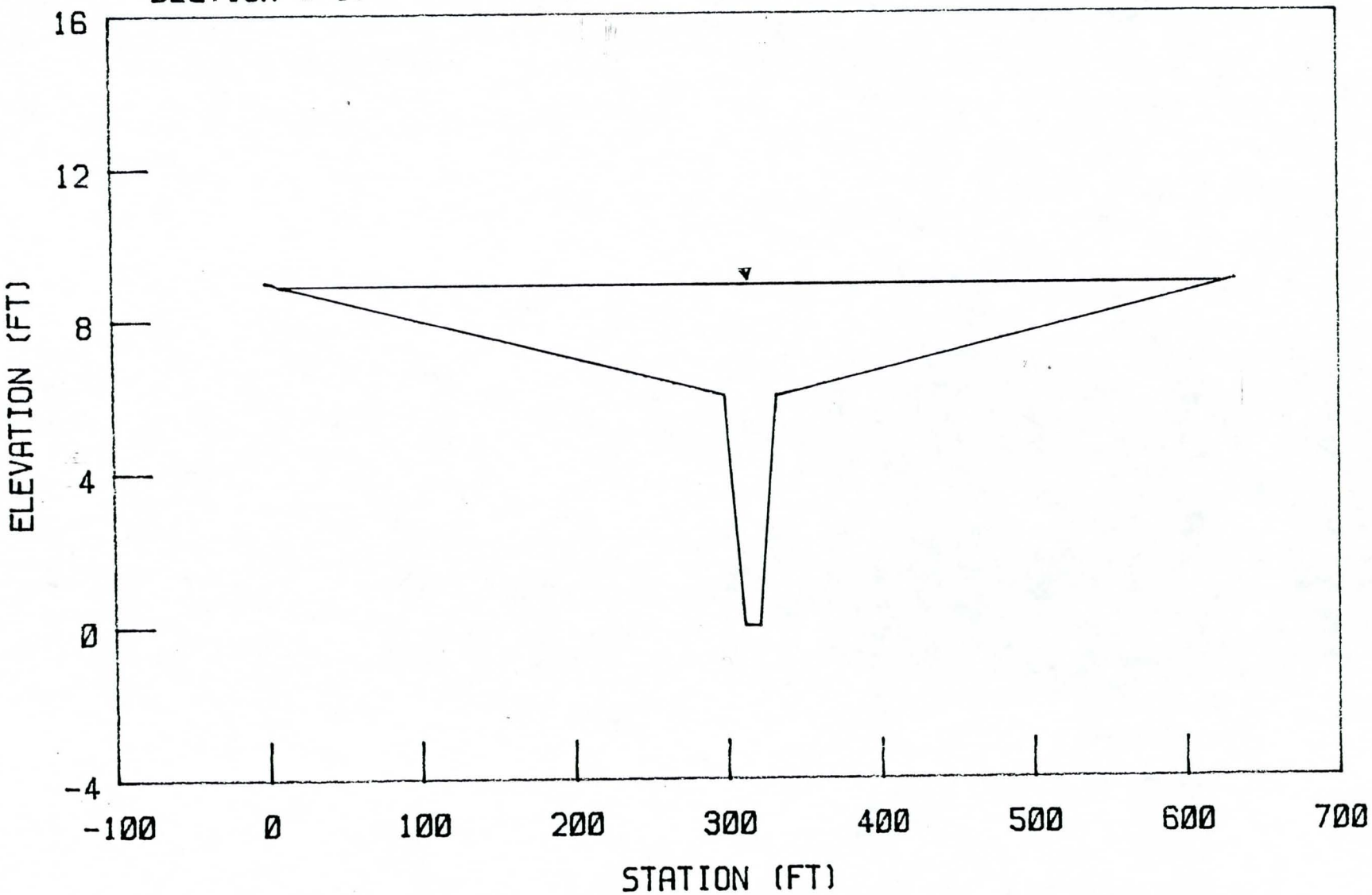
ORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	9.43	634.00	1408.67	0.0:1	0.0:1	637.73

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.89	7.51	0.01400	10580.00	0.03982	9.26	8.13

JOB NO. 289-017
18-APR-89

SECTION # 17



****
39-027 SECTION # 18
BIN F
****

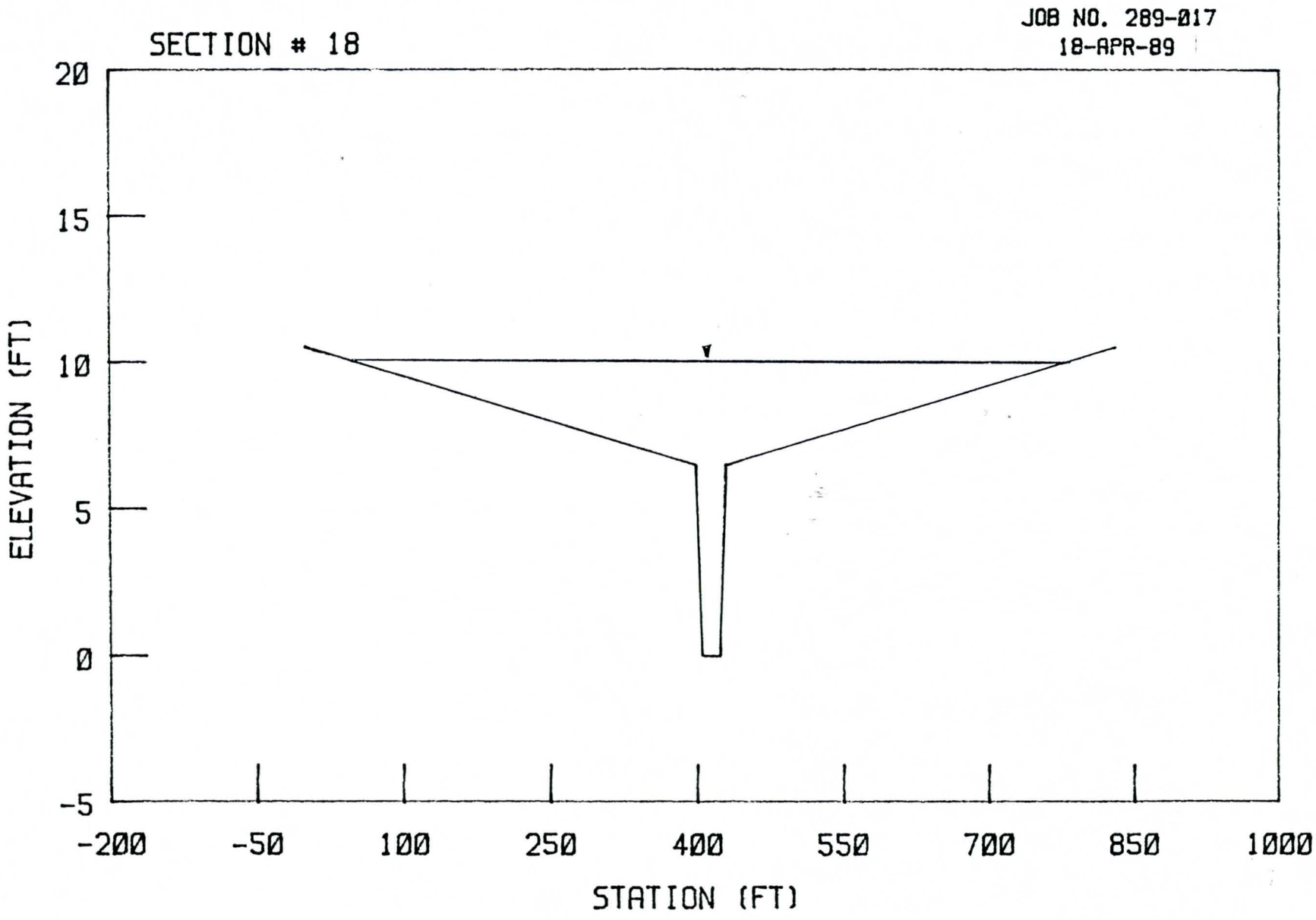
IRREGULAR CROSS SECTION

A.	0.00	400.00	406.50	424.50	431.00	831.00
ELEV.	10.50	6.50	0.00	0.00	6.50	10.50
N	0.035	0.035	0.030	0.030	0.035	0.035

NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	10.11	753.46	1576.09	0.0:1	0.0:1	768.99

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.93	7.66	0.01200	12078.00	0.03435	10.00	8.11


SECTION # 18
JOB NO. 289-017
18-APR-89
20
15
10
5
0
-5
ELEVATION (FT)
-200
-50
100
250
400
550
700
850
1000
STATION (FT)

****
39-017 SECTION # 19
SIN # 20
****

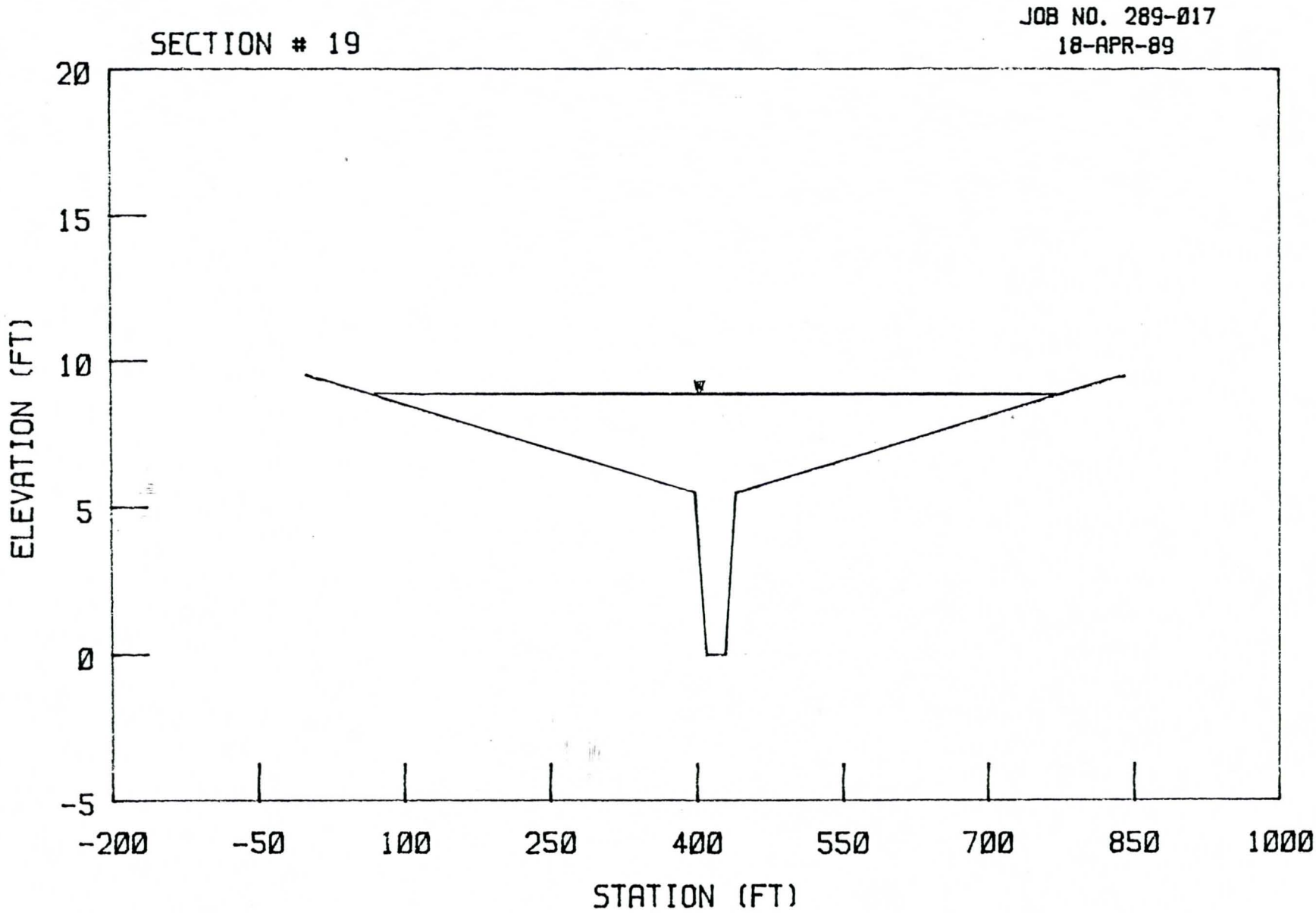
IRREGULAR CROSS SECTION

A.	0.00	400.00	411.00	431.00	442.00	842.00
LEV.	9.50	5.50	0.00	0.00	5.50	9.50
N	0.035	0.035	0.030	0.030	0.035	0.035

NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	9.05	752.06	1580.06	0.0:1	0.0:1	754.69

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.93	7.68	0.01200	12134.00	0.03478	8.93	8.12


JOB NO. 289-017
18-APR-89
SECTION # 19
20
15
10
5
0
-5
ELEVATION (FT)
-200
-50
100
250
400
550
700
850
1000
STATION (FT)

****
289-017 SECTION # 20
ASIN # 10
****

IRREGULAR CROSS SECTION

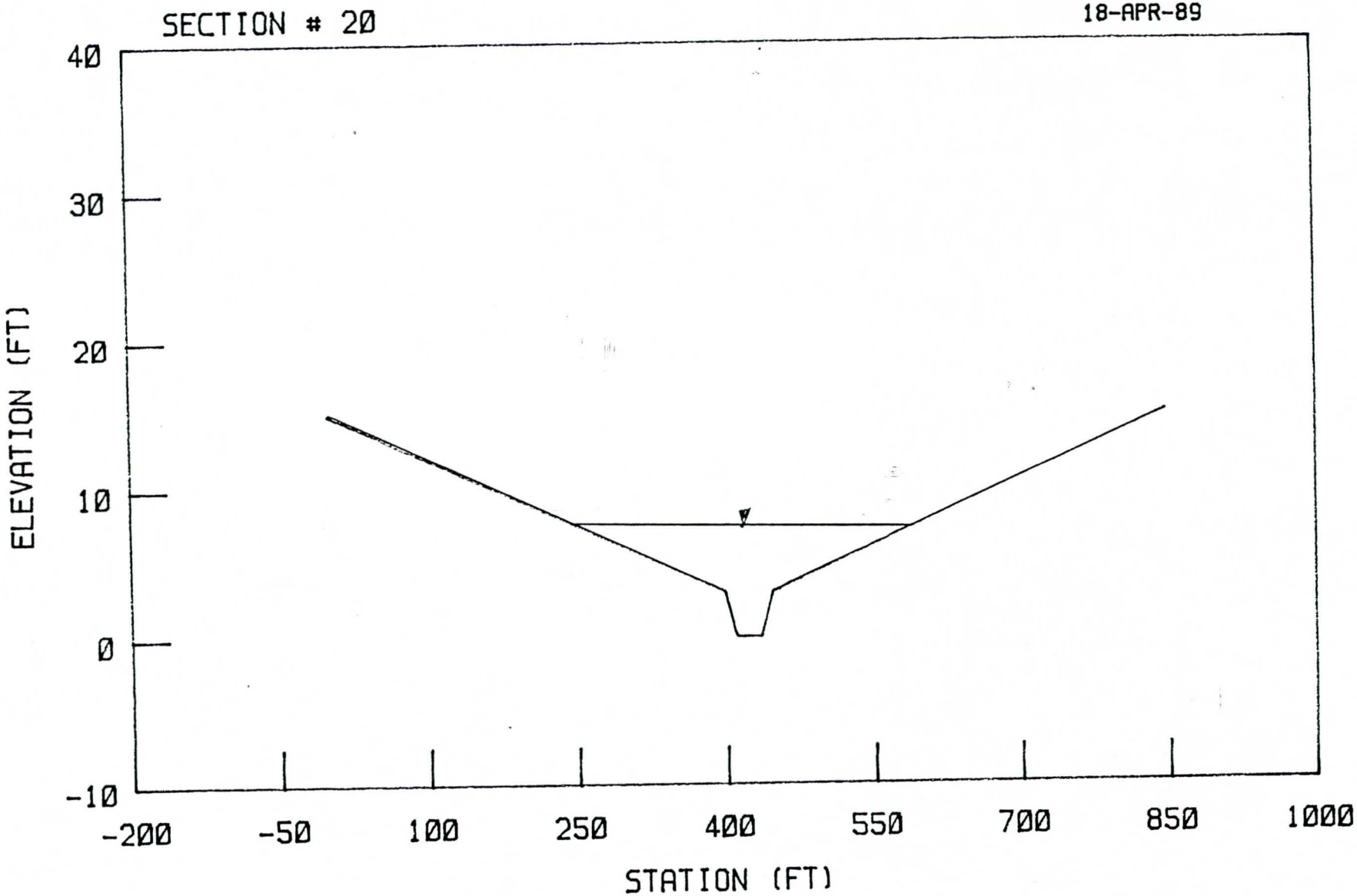
IA.	0.00	400.00	412.00	437.00	449.00	849.00
ELEV.	15.00	3.00	0.00	0.00	3.00	15.00
N	0.040	0.040	0.035	0.035	0.040	0.040

RMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	7.52	350.30	1013.33	0.0:1	0.0:1	351.18

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.87	8.38	0.01200	8493.00	0.03943	7.19	9.41

JOB NO. 289-017
18-APR-89



****
89-017 SECTION # 21
S BASIN # 41
****

IRREGULAR CROSS SECTION

A.	0.00	100.00	106.00	109.00	115.00	215.00
LEV.	7.00	2.00	0.00	0.00	2.00	7.00
N	0.040	0.040	0.040	0.040	0.040	0.040

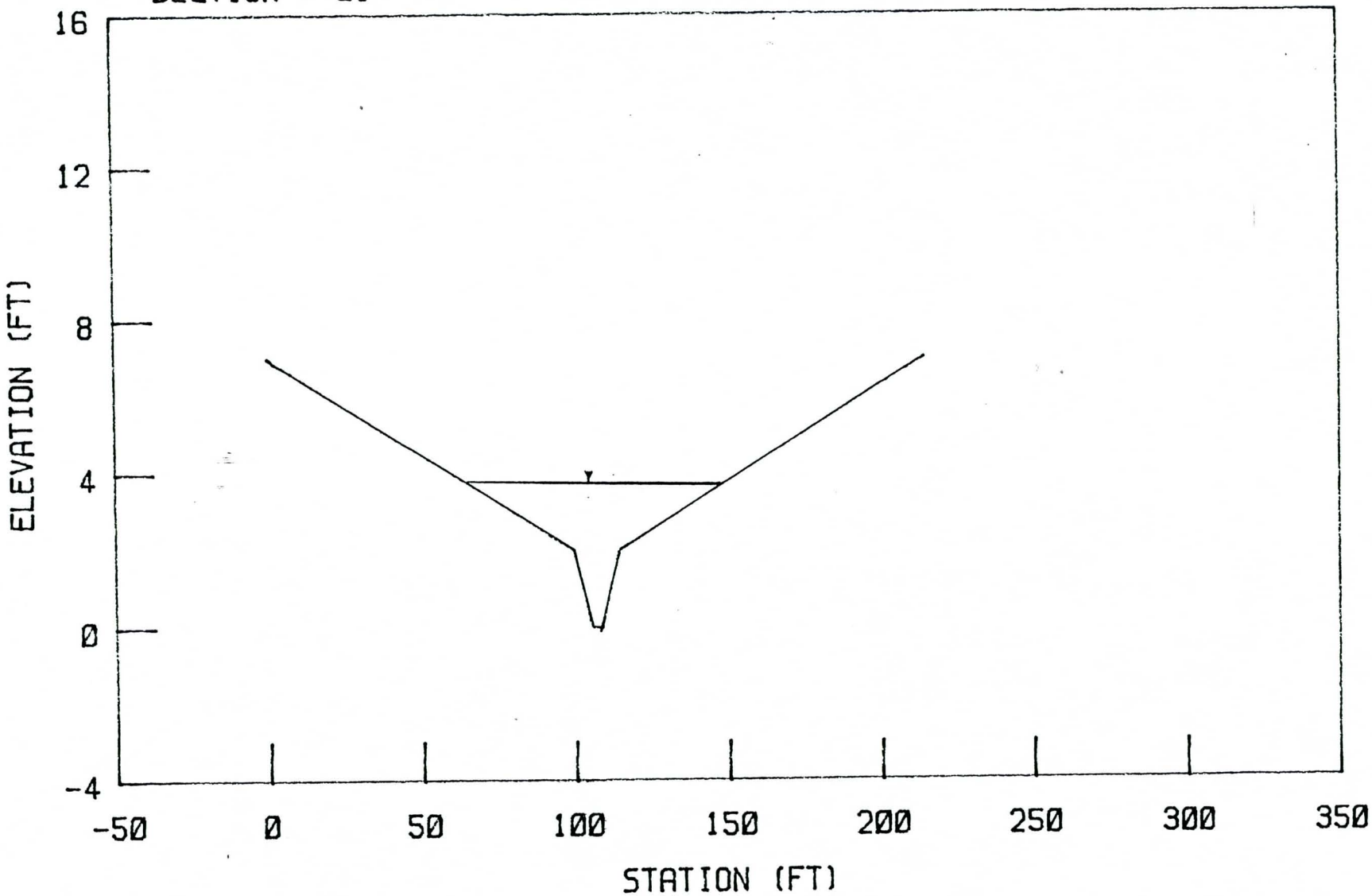
NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	3.64	80.40	96.00	0.0:1	0.0:1	81.14

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.67	4.17	0.01000	400.00	0.04000	3.26	5.82

JOB NO. 289-017
18-APR-89

SECTION # 21



****
39-027 SECTION # 22
SIN # 23
****

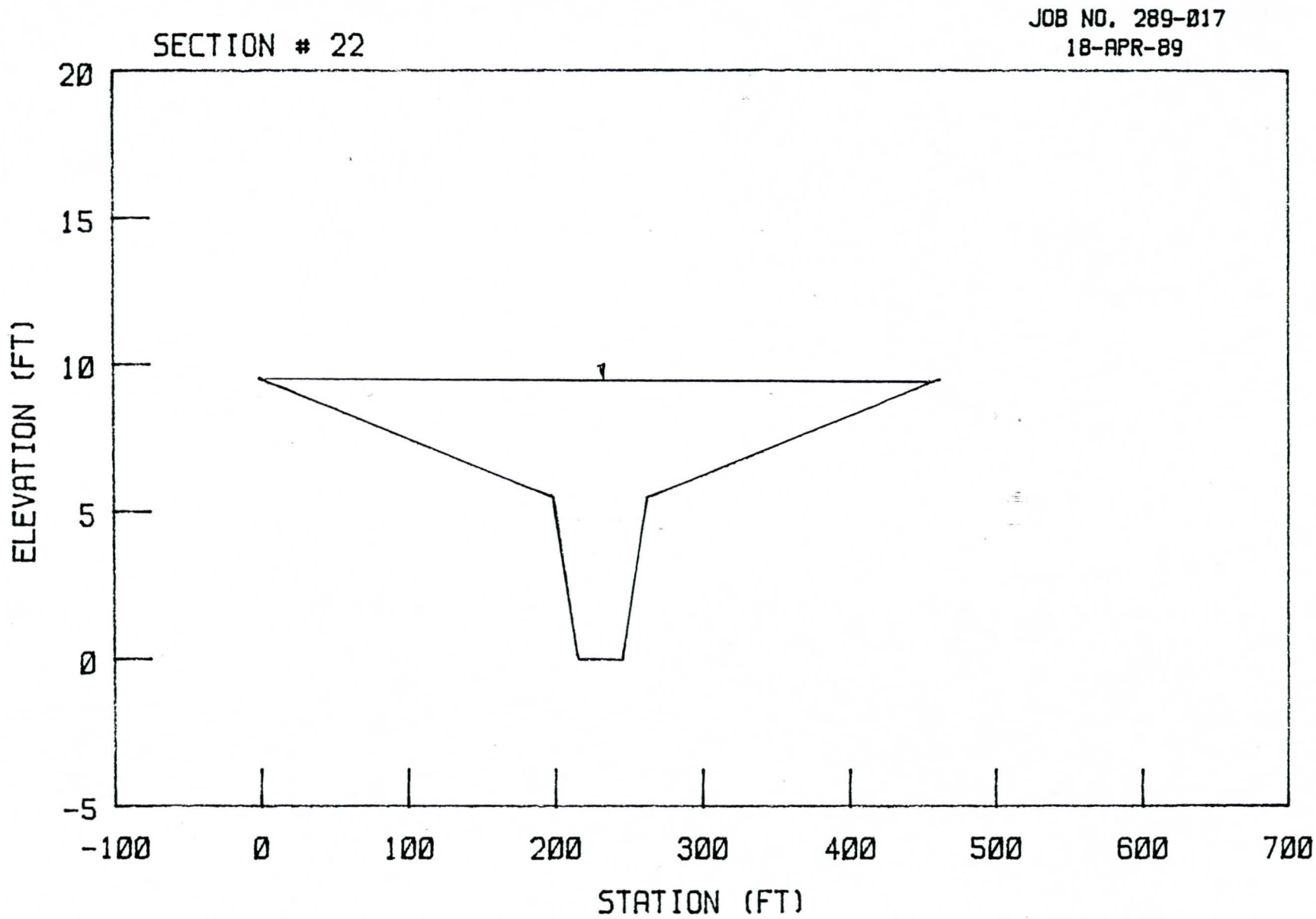
IRREGULAR CROSS SECTION

A.	0.00	200.00	216.50	246.50	263.00	463.00
LEV.	9.50	5.50	0.00	0.00	5.50	9.50
N	0.040	0.040	0.035	0.035	0.040	0.040

NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	9.92	463.00	1504.09	0.0:1	0.0:1	465.71

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.72	7.37	0.00800	11091.00	0.03946	9.23	9.37


JOB NO. 289-017
18-APR-89
SECTION # 22
20
15
10
5
0
-5
ELEVATION (FT)
-100
0
100
200
300
400
500
600
700
STATION (FT)

****
29-017 SECTION # 23
SIN # 11 UPS
****

IRREGULAR CROSS SECTION

A.	0.00	200.00	210.00	220.00	230.00	430.00
EV.	4.00	2.00	0.00	0.00	2.00	4.00
N	0.035	0.035	0.030	0.030	0.035	0.035

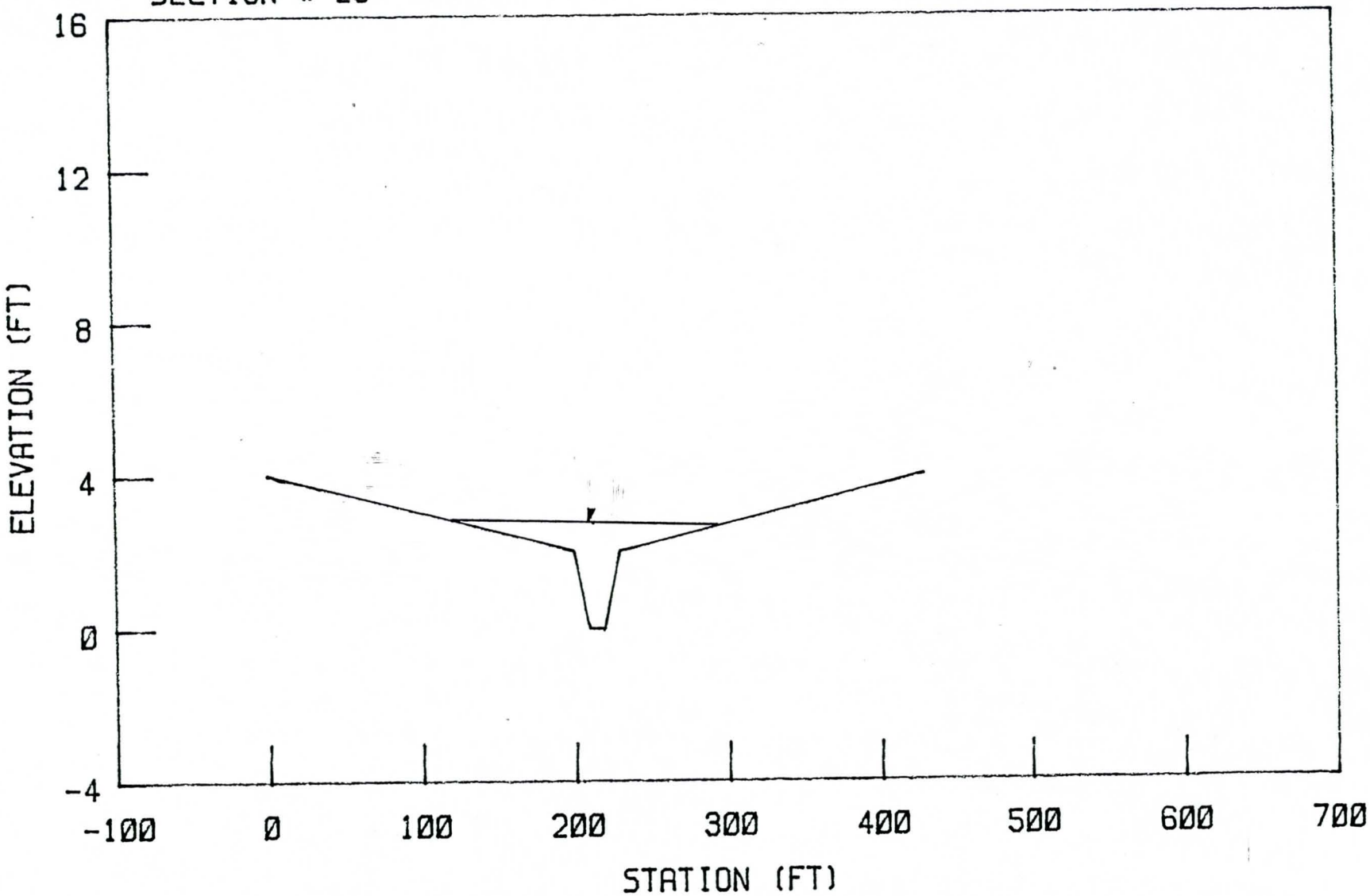
NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	2.77	183.28	121.72	0.0:1	0.0:1	183.68

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.71	3.29	0.01000	400.00	0.03430	2.57	4.48

JOB NO. 289-017
18-APR-89

SECTION # 23



****
39-017 SECTION # 24
1N # 14
****

IRREGULAR CROSS SECTION

A.	0.00	300.00	309.00	329.00	338.00	638.00
LEV.	6.00	3.00	0.00	0.00	3.00	6.00
N	0.035	0.035	0.030	0.030	0.035	0.035

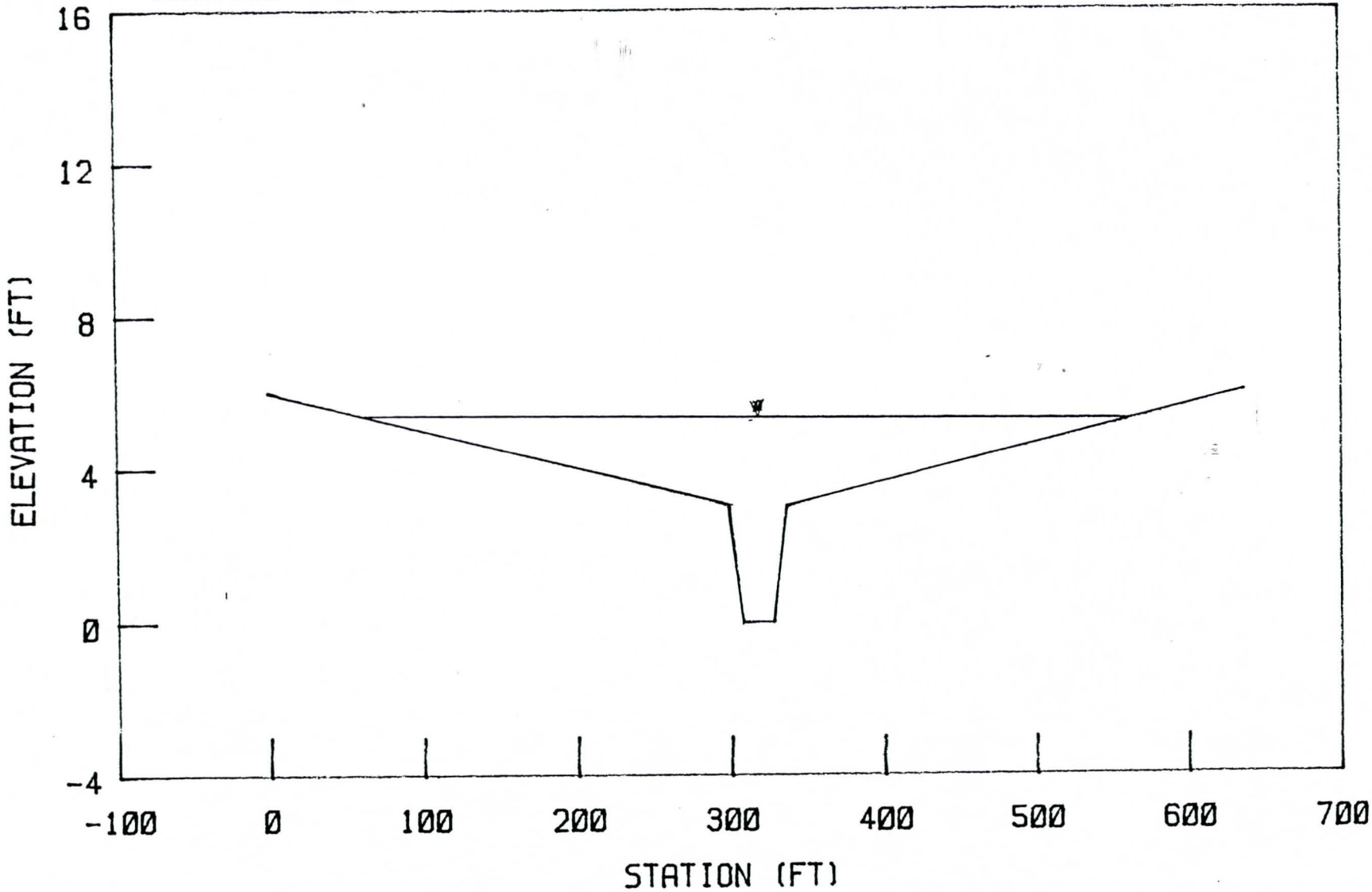
NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	5.29	496.69	700.15	0.0:1	0.0:1	497.69

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.51	3.41	0.00400	2387.00	0.03458	4.58	6.01

JOB NO. 289-017
18-APR-89

SECTION # 24



****
B9-017 SECTION # 25
SIN # 24
****

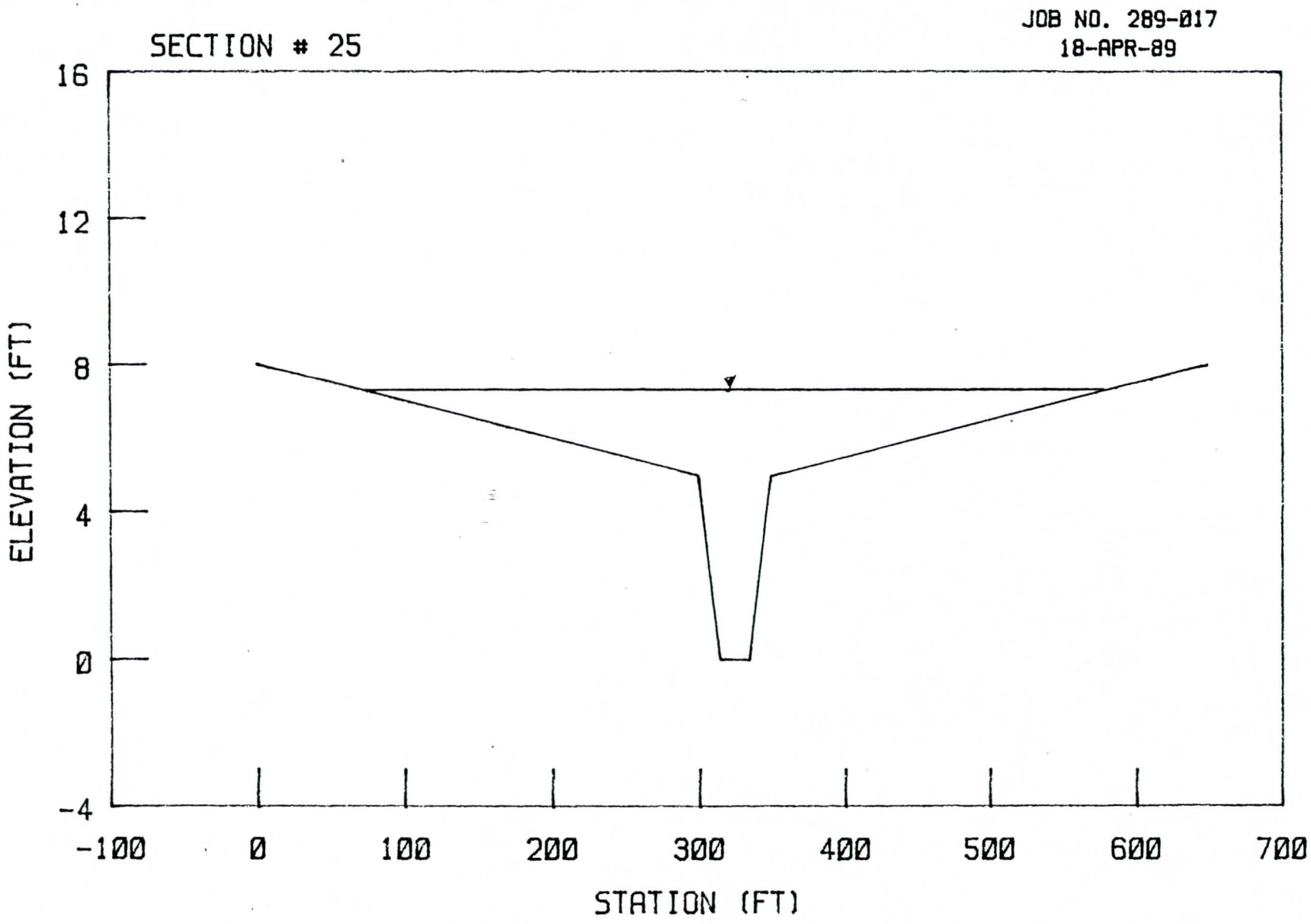
IRREGULAR CROSS SECTION

TA.	0.00	300.00	315.00	335.00	350.00	650.00
ELEV.	8.00	5.00	0.00	0.00	5.00	8.00
N	0.035	0.035	0.030	0.030	0.035	0.035

NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	7.35	519.79	844.21	0.0:1	0.0:1	521.44

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.90	6.49	0.01200	5481.00	0.03464	7.20	7.12


SECTION # 25
JOB NO. 289-017
18-APR-89
16
12
8
4
0
-4
ELEVATION (FT)
-100
0
100
200
300
400
500
600
700
STATION (FT)

****
29-017 SECTION # 26
BASIN # 25
****

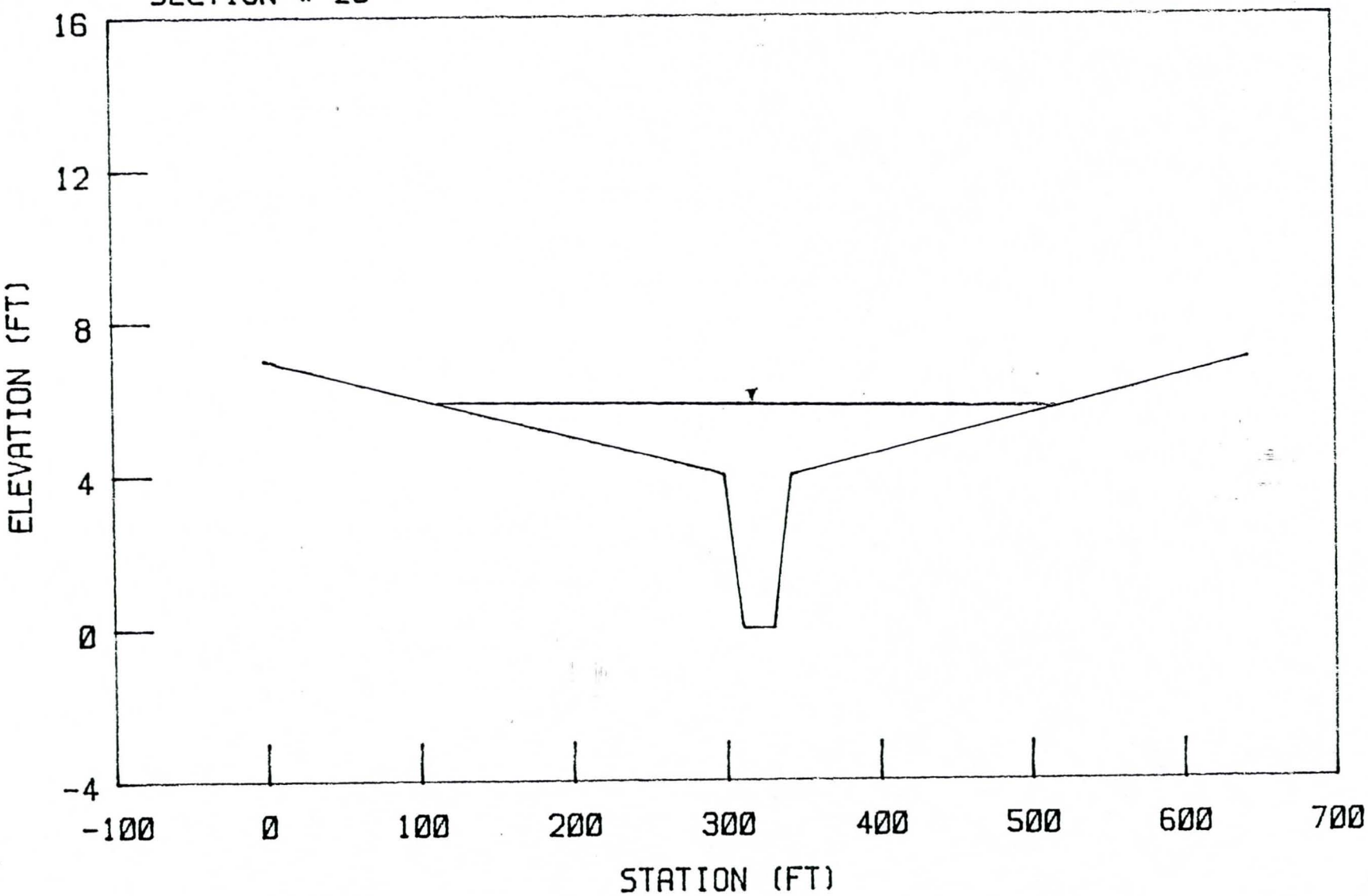
IRREGULAR CROSS SECTION

STA.	0.00	300.00	312.00	332.00	344.00	644.00
ELEV.	7.00	4.00	0.00	0.00	4.00	7.00
N	0.035	0.035	0.030	0.030	0.035	0.035

NORMAL FLOW COMPUTATION

BW	YN	TOP WIDTH	AREA	L.B. SLOPE	R.B. SLOPE	PERIMETER
0.00	5.82	408.66	540.66	0.0:1	0.0:1	409.97

FROUDE #	VELOCITY	SLOPE	DISCHARGE	N VALUE	YC	VC
0.87	5.67	0.01200	3067.00	0.03457	5.67	6.40

JOB NO. 289-017
18-APR-89

SECTION # 26