Civil Branch

Casandro Wash Detention Dam Concept Design Report

for the

Flood Control District of Maricopa County

CH2M HILL

June 1994

Civil Branch

FLOOD CONTROL DISTRICT
of
Maricopa County

Interoffice Memorandum

DATE: June 10, 1994

TO: SS, WFR, ODP, & AWB(CW)3.2

FROM: MAL

SUBJECT: Design Concept Report - Casandro Wash Dam

CH2M Hill have submitted their Design Concept Report for the above mentioned project. Please review the report and submit your comments to me no later than **Tuesday, June 28** so that I will have time to review and compile them. I would like to schedule an in-house comment review meeting for Thursday, June 30 at 9:00 am to review the comments with you before they are condensed and sent to the consultant. Please let me know if this time works for you. Along with a hardcopy of the comments, please send me a copy of your comments by E-mail.

If you have any questions, please give me a call at X-8742.

Thanks.

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File Folder: Casandro\io-drfsb.nwp

ORDER OF MAGNITUDE
COST ESTIMATE

PROJECT: CASANDRO WASH
MARICOPA COUNTY FLOOD CONTROL DISCTRICT
PROJECT NO. SWW35441.CV

	DESCRIPTION	QTY	UNIT	INSTALLED UNIT COST	TOTAL
	A. RESERVOIR CONSTRUCTION				
1.	CLEAR BRUSH, DOZER & BRUSH RAKE, LIGHT	18	Acre	$1,600.00	$28,800
2.	DEVELOP WATER SUPPLY	1	L.S.	$6,000.00	$6,000
	PRE-WET BORROW AREAS	1	L.S.	$1,500.00	$1,500
3.	GRADING RESERVOIR W/ SCRAPERS				
a.	SCRPR HAUL TO DAM SITE	70,000	C.Y.	$3.07	$214,900
4.	FINISH GRADING	12,000	S.Y.	$0.12	$1,440
	B. DAM CONSTRUCTION				
1.	PRE-WET BORROW AREAS	1	L.S.	$1,500.00	$1,500
2.	FOUNDATION EXC - SCRAPERS - 600' HAUL	13,000	C.Y.	$2.50	$32,500
3.	CHIMENY DRAIN CONSTRUCTION:				
a.	TRENCH EXCAVATE	1,700	C.Y.	$4.00	$6,800
b.	PLACE DRAIN MATERIAL	1,700	C.Y.	$12.00	$20,400
c.	DRAIN PIPE - 6" PVC	300	L.F.	$5.00	$1,500
4.	SPREAD EARTH BACKFILL - DOZER	70,000	C.Y.	$1.34	$93,800
5.	COMPACTION, SHEEPSFOOT, 6" LIFT, 4 PASS	70,000	C.Y.	$0.53	$37,100
6.	FINISHING GRADING SLOPES	6,100	S.Y.	$0.12	$732
	C. STRUCTURES				
1.	SPILLWAY CONSTRUCTION				
a.	EXCAVATE SPILLWAY CHANNEL	8,000	C.Y.	$5.00	$40,000
b.	CAST IN-PLACE CONC SLAB W/ REINF	870	C.Y.	$200.00	$174,000
c.	CAST IN-PLACE CONC WALLS W/ REINF	230	C.Y.	$350.00	$80,500
d.	CAST IN-PLACE CONC FOOTINGS W/ REINF	50	C.Y.	$170.00	$8,500
2.	STILLING BASINS				
a.	EXCAVATE STILLING BASIN	200	C.Y.	$5.00	$1,000
b.	DISIPATORS: CAST IN-PLACE CONC W/ REINF	10	C.Y.	$350.00	$3,500
c.	CAST IN-PLACE CONC SLAB W/ REINF	138	C.Y.	$200.00	$27,600
d.	CAST IN-PLACE CONC WALLS W/ REINF	52	C.Y.	$350.00	$18,200
e.	CAST IN-PLACE CONC FOOTINGS W/ REINF	15	C.Y.	$170.00	$2,550
3.	DRAIN STRUCTUES & PIPELINE				
a.	DRAIN INLET - CONC W/ REINF	10	C.Y.	$350.00	$3,500
b.	DRAIN OUTLET - CONC W/ REINF	5	C.Y.	$350.00	$1,750
c.	PIPELINE - 36" RCP	220	L.F.	$73.00	$16,060
d.	TRENCH EXC & BCKFL W/ CONC SLURRY	200	L.F.	$30.00	$6,000
e.	DRAIN OUTLET - MISC METALS	1	L.S.	$500.00	$500

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ORDER OF MAGNITUDE
COST ESTIMATE

PROJECT: CASANDRO WASH
MARICOPA COUNTY FLOOD CONTROL DISCTRICT
PROJECT NO. SWW35441.CV

	DESCRIPTION	QTY	UNIT	INSTALLED UNIT COST	TOTAL
	D. SEWER RE-ALIGNEMENT				
1.	LOCATE & CUT EXISTING SEWER LINE	2	Ea.	$500.00	$1,000
a.	REMOVE EXSITING 10" VCP & MANHOLE	430	L.F.	$8.00	$3,440
2.	NEW MANHOLES	3	Ea.	$7,000.00	$21,000
3.	NEW 12" DIA VCP SEWER LINE	440	L.F.	$12.00	$5,280
4.	TRENCH EXCAVATION	1,900	C.Y.	$2.36	$4,484
a.	TRENCH BACKFILL	1,500	C.Y.	$5.00	$7,500
b.	BCKFL W/ CONC UNDER DAM AREA	630	C.Y.	$25.00	$15,750
	E. SITE DEVELOPMENT				
1.	ACCESS ROAD (APPROX 400 LF X 12' WIDE)				
a.	GRADING ROADWAY	1,250	S.Y.	$2.74	$3,425
b.	BASE, PREPARE&ROLL SUBBASE	1,250	S.Y.	$1.11	$1,388
c.	BASE COURSE, GRAVEL, 6"DEEP	1,250	S.Y.	$2.32	$2,900
2.	LANDSCAPING				
	SEEDING	4.00	Acre	$1,800.00	$7,200
3.	FENCING				
a.	CHAINLINK FENCE - 72"	1,500	L.F.	$8.50	$12,750
b.	DOUBLE WIDE GATE - 12'	2	EA	$1,500.00	$3,000
4.	SIGNING	1	L.S.	$1,000.00	$1,000
	F. DOWN STREAM IMPROVEMENTS				
1.	GRADING				
a.	SCRPR HAUL TO STOCKPILE - 1500' HAUL	500	C.Y.	$2.00	$1,000
2.	RIPRAP - DUMPED 12"	1,400	C.Y.	$40.66	$56,924
3.	FINISH GRADING	19,000	S.Y.	$0.12	$2,280
	CONTRACTOR SURVEYS	5	Mths	$2,000.00	$10,000

SUBTOTAL CONSTRUCTION COST		$991,000
MARK-UPS:		
MOB/BOND/INSURANCE	5%	$50,000
CONTINGENCY	20%	$208,000
TOTAL CONSTRUCTION COST		$1,249,000
FIELD / LAB TESTING	2%	$25,000
CONSTRUCTION MGNT & ADMIN	5%	$64,000
TOTAL CONSTRUCTION COST W/ TESTING, CM & ADMIN		$1,338,000

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Engineers
Planners
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Scientists

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June 10, 1994

SWW35441.PS

Michael Lopez, P.E.
Planning Engineer
Flood Control District of Maricopa County
2801 West Durango
Phoenix , AZ 85009

Subject: Casandro Wash Concept Design Report

Dear Mr. Lopez:

Enclosed are six copies of the Concept Design Report for Casandro Wash in Wickenburg, Arizona.

If you have any questions about the information included in this submittal, please feel free to call me.

Sincerely,

CH2M HILL

Thomas Wolf for

Steven R. Walker, P.E.
Project Manager
phx\sww35441.ps\cdrltr.doc

Phoenix Office 1620 W. Fountainhead Parkway, Suite 550, Tempe, AZ 85282-1843 602 966-8188
P.O. Box 28440, Tempe, AZ 85285-8440 Fax No. 602 966-9450

Casandro Wash Detention Dam
Concept Design Report

for the

Flood Control District of Maricopa County

Registered Professional Engineer (Civil)
CERTIFICATE NO.
19444
THOMAS J.
WOLF
Date Signed 6-9-94
ARIZONA

CH2M HILL

June 1994

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List of Acronyms

AASHTO	American Association of State Highway Transportation Officials
ABC	Aggregate Base Course
ACI	American Concrete Institute
ADMS	Area Drainage Master Study
ADWR	Arizona Department of Water Resources
AISC	American Institute of Steel Construction
BUREC	U.S. Bureau of Reclamation
cfs	Cubic feet per second
COE	U.S. Army Corps of Engineers
CY	Cubic yards
FCDMC	Flood Control District of Maricopa County
MAG	Maricopa Association of Governments
MCE	Maximum credible earthquake
MUSLE	Modified Uniform Soil Loss Equation
OD	Outside diameter
PMF	Probable maximum flood
PSIAC	Pacific Southwest InterAgency Committee
RCC	Roller compacted concrete
RCP	Reinforced concrete pipe
SCS	Soil Conservation Service
SPT	Standard penetration test
TP	Test pit
UBC	Uniform Building Code
VE	Value engineering
WSEL	Water surface elevation

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Executive Summary

In January 1994, the Flood Control District of Maricopa County (FCDMC) contracted with CH2M HILL to provide preliminary and final design services for the proposed Casandro Wash Detention Dam project. Casandro Wash is an ephemeral stream draining approximately a 3-square-mile watershed west of the town of Wickenburg in Maricopa County, Arizona. Flooding has occurred in Casandro Wash on several occasions. Some of the more significant recent events occurred in 1976, 1983, and 1993. In each of these floods, residents reported property damage from inundation and sediment deposition.

The Casandro Wash Detention Dam is classified by the Arizona Department of Water Resources as a high hazard, small dam. The half probable maximum flood (5,404 cfs) is recommended for spillway design purposes. However, based on the results of the Value Engineering Meeting of April 12, 1994, the spillway should also pass the full PMF without freeboard. Freeboard will be controlled by residual freeboard requirement of 3 feet above the maximum routed 0.5_PMF water surface elevation.

A sedimentation investigation was conducted to estimate potential sediment supply to the reservoir site. Sediment deposited in the Casandro Dam reservoir area reduces the available storage volume for floodwater. For the purposes of sizing the reservoir, approximately 2 acre-feet should be allowed for sediment storage during the 100-year event. Monitoring of sediment accumulation should be included in the reservoir maintenance plan. According to FCDMC staff, a regular maintenance schedule of about 5 years may be expected if no large floods occur on Casandro Wash. If maintenance occurs every five years, about 2 acre-feet of sediment will be removed on average.

Hydraulic structures associated with the Casandro Wash Detention Dam include the low-flow outlet, spillway, spillway chute, energy dissipator at the end of the spillway chute, and a sedimentation reservoir within the reservoir. Outflow from the reservoir includes a low flow orifice, and the emergency spillway. As currently planned, the emergency spillway will consist of an ogee crest, with the crest apex at elevation 2153.0 feet. The proposed spillway chute has slope of 4:1, which is sufficient to maintain supercritical flow. The sedimentation reservoir, located near the reservoir inlet, will be designed according to guidelines presented in the FCDMC Hydraulic Design Manual, following approval of the site grading plan.

The geotechnical investigation was performed to obtain subsurface information at the proposed damsite and reservoir area for development of geotechnical recommendations for design and construction. The field exploration included 13 soil borings and 21 test pits. Laboratory tests were performed to characterize the onsite materials and determine their engineering properties. A CH2M HILL engineer specified test pit and boring locations, determined sampling intervals, and provided general oversight during all exploration operations. Laboratory testing included Atterberg limits, sieve analysis, specific gravity, bulk density, and moisture content to establish index properties and verify field classifications. The data for all laboratory results is included in the previously submitted Geotechnical Data Report.

Several dam alignments were evaluated during concept design. All proposed alignments extended off the same high point on the right abutment to varying points on the left abutment. The foundation soils are similar for all proposed alignments. The foundation material encountered consisted of recent alluvial deposits comprised of loose to medium dense sand overlying dense to very dense cemented sand. The depth to the partially cemented material varied greatly. The overlying loose soil in the reservoir should be removed and the dam founded on the cemented or very dense sand. The abutment conditions were similar to the foundation except for an increase in the amount of fines present to approximately 12 percent. The right abutment is thin in cross section and should be buttressed with fill. Because geotechnical conditions are similar at the proposed alignments, the final alignment should be determined based on other conditions such as spillway size and orientation, reservoir storage, and minimizing earthwork.

The proposed dam should be a homogenous earthfill dam constructed of materials excavated from the reservoir. Field exploration and laboratory test results did not reveal suitable low permeable material for use as a core for a zoned earth dam. Therefore, a homogenous dam with a chimney drain is preferred over importing clay soil for a core. The material in the reservoir may be suitable for use in construction of a RCC dam, but cost and potentially compressible foundation conditions eliminated RCC from further consideration.

CH2M HILL recommends that the top crest width of the dam be increased to 20 feet to allow for a wider access road and to increase stability of the dam. Based on the above investigation, a design peak rock acceleration of 0.1g is recommended for final design. (Details of the seismic investigation will be included in the Geotechnical Design Report.)

Field surveys of the project area were performed from January through mid-April 1994. The only known utility within the project area is a 10-inch vitrified clay sewerline. A 6-inch waterline is located north of the detention reservoir which serves the adjacent residential properties. It generally parallels the wash alignment and is approximately 200 feet north of the wash centerline.

Residents on the north side of the reservoir have sewer, water, and electrical services that extend along their private access drives. The service connections for the residents and commercial buildings along the south side of the reservoir extend to the south (toward U.S. 60), and away from the project area. Service connections do not appear to be in conflict with the dam\detention basin. However, the south access road alignment will likely be located over the sewer and water service connections to the Ryan property on the right abutment of the proposed dam. Also, the overhead power pole for service to the residents is located within the dike prism and may need to be relocated.

The 10-inch sewerline has an easement of varying width through the project area. Partial relocation of the sewer will require an amendment to the easement description and resubmittal to the Town of Wickenburg for their approval.

The Grading Plan shown in the plan submittal depicts the property parcels in the project area. Consideration was given during development of the plan to minimize right-of-way needed for the facility. It is anticipated that in lieu of purchasing right-of-way, fill slope easements could be obtained for certain (as yet undefined) areas that require grading.

Access easements will be required for the north and south maintenance roads.

Construction of the Casandro Wash Detention Dam requires the acquisition of two permits: the Dam Safety Permit issued by Arizona Department of Water Resources (ADWR) Dam Safety Division; and the U.S. Army Corps of Engineers (COE) Section 404 Fill and Dredge permit. FCDMC is primarily responsible for obtaining these permits, however, CH2M HILL is assisting in preparing applications and in coordinating the permitting efforts. Prior to construction, a U.S. EPA Stormwater NPDES permit for construction activities will also be required.

As part of the concept design analysis, two dam alignments were identified and staked in the field during the initial field and geotechnical investigations. They were based on the geotechnical setting (for instance, the location of abutments) as well as the storage capacity needed to impound the 100-year storm.

The concept design alternative analysis consisted of developing preliminary earthwork quantities and order-of-magnitude construction cost estimates to determine the preferred layout. The results of this analysis showed that the Alignment II alternative was more cost effective than Alignment I. Alignment II is shorter, requires less earthwork, and provides better hydraulics for the spillway.

Two options were reviewed for the spillway construction: structural concrete and RCC. Structural reinforced concrete appears to be the most cost-effective option for constructing the spillway and energy dissipator.

The concept design plan and dam location were the two primary factors in determining the extent of sanitary sewer relocation. A profile of the existing sewer was prepared from as-built drawings. The digital terrain model, proposed grading plan, and dam alignment were superimposed on the profile to determine the extent of required sewer relocation. Two alignments were investigated for the relocated sewer. The second alignment consisted of routing the sewer under the dam, which became the preferred alternative.

Access to the dam will use portions of existing private drives off the public streets. Roads for maintenance access will spur off the private drives and extend to the top of the dam on both the north and south side of the spillway, as well as to the upstream and downstream toes.

The preliminary construction cost estimate for the detention basin and dam project is $1,338,000. Estimates were developed for the major elements in the concept design submittal. A 20-percent contingency was applied for minor items not specifically identified or shown.

The recommended design features are summarized below:

- Dam location: see plans submittal; Appendix A.
- Dam height: 32 feet to the top of the dam. 22 feet to the crest.
- Dam length : 350± feet, dam top width: 20 feet.
- Embankment slopes, upstream 3:1, downstream 3:1.
- Dam configuration: homogenous earthfill with chimney drain.
- Spillway type: structural concrete, 80-foot width.
- The spillway configuration: Ogee crest.
- Impoundment area : 14 acres.
- 100-year water surface elevation: 2153.9 feet.
- Design capacity: 0.5_Probable Maximum Flood (PMF) with 3 feet of freeboard. Full PMF contained within the principal spillway
- Low flow outlet.

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Section 1.
Introduction

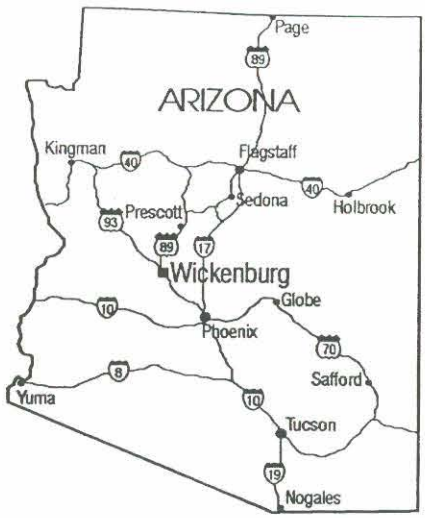
In January 1994, the Flood Control District of Maricopa County (FCDMC) contracted with CH2M HILL to provide preliminary and final design services for the proposed Casandro Wash Detention Dam project. This Concept Design Report summarizes the data collected, and presents the results and recommendations of the preliminary analyses for the proposed dam. It documents the design considerations and the decisions made which led to the concept design plan submittal. The work described includes a review of the hydrologic analysis prepared in support of the area drainage master study (by others); an analysis of the maximum probable flood for the Casandro Wash watershed; a summary of the geotechnical investigations of the dam site, detention basin and borrow areas; and the proposed modifications to conflicting utilities.

Casandro Wash is an ephemeral stream draining approximately a 3-square-mile watershed west of the town of Wickenburg in Maricopa County, Arizona (see Figure 1-1). The watershed generates approximately 1,770 cfs in the 100-year storm event. The storm runoff in the watershed is conveyed through Wickenburg in generally a south to north direction, crossing U.S. Highway 60, where runoff is discharged into Sols Wash.

Downstream of the crossing at U.S. 60, Casandro Wash is characterized by a poorly defined alluvial channel within a broad, deep valley. The downstream reaches of Casandro Wash are conveyed primarily through undersized drainage channels and inverted crown roadway sections. Immediately upstream of the confluence with Sols Wash, a railroad drainage crossing structure limits the conveyance capacity of Casandro Wash into Sols Wash, resulting in localized flooding of the urban areas between Mariposa Drive and the Southern Pacific Transportation Company railroad crossing.

Flooding has occurred in Casandro Wash on several occasions. Some of the more significant recent events occurred in 1976, 1983, and 1993. In each of these floods, residents reported property damage from inundation and sediment deposition.

An Area Drainage Master Study (ADMS) prepared for FCDMC in 1991 recommended the construction of a detention dam to reduce the flood impacts from discharges in Casandro Wash. In addition, the plan recommended construction of an outfall stormdrain conveyance system downstream of the proposed dam location to the outfall at Sols Wash.



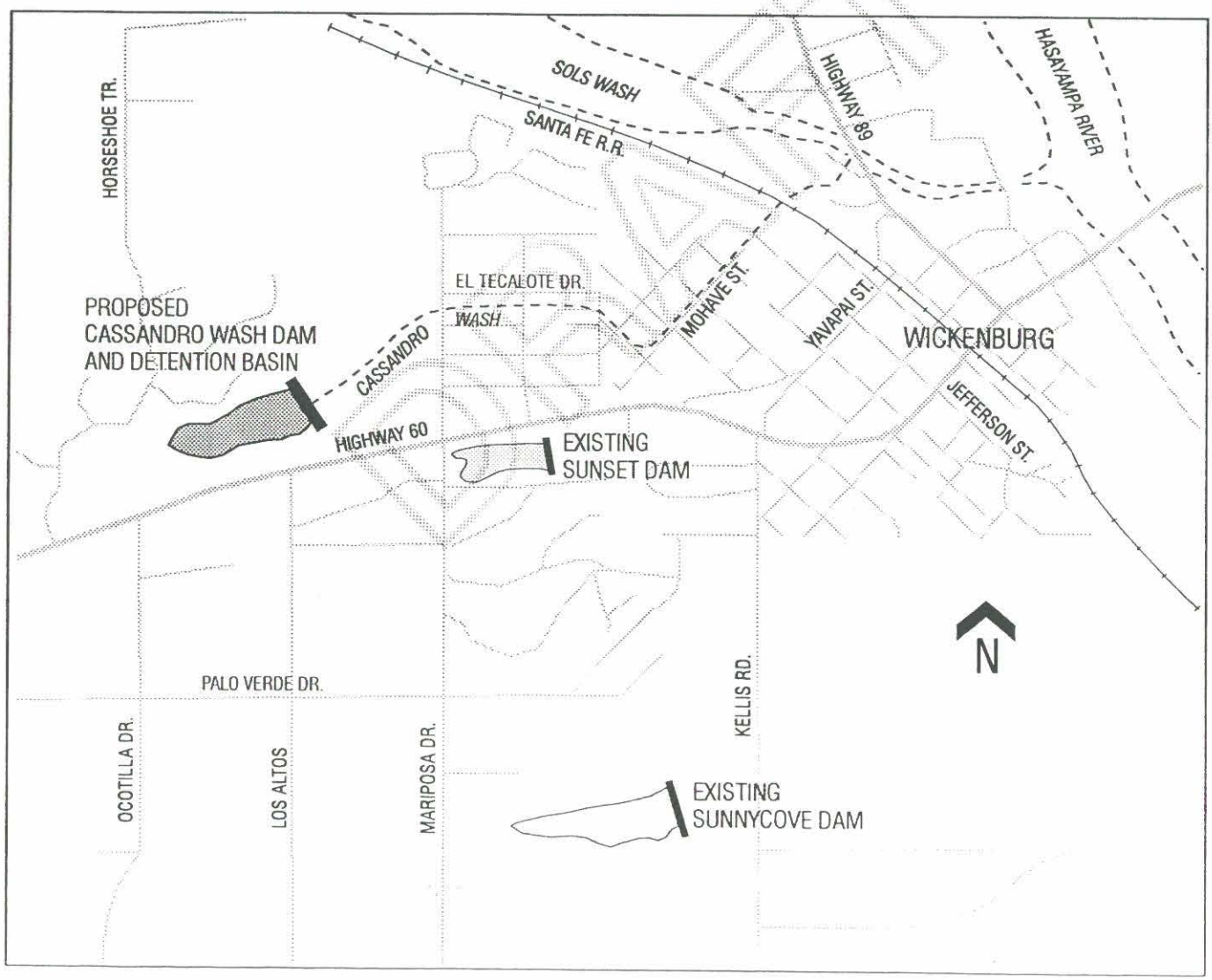


FIGURE 1-1

LOCATION AND VICINITY MAP

CASSANDRO WASH DETENTION BASIN
WICKENBURG, AZ

CH2M HILL

Objectives

The objectives of this report are to:

1. Describe the hydrologic, geologic, and geotechnical settings for the proposed dam.

2. Identify design- and permitting-related constraints for the structure.

3. Present the proposed criteria for the final design.

4. Describe alternative dam locations, sizes, configurations, and construction materials, and the evaluation process used to select from among them.

5. Present the recommended concepts at approximately a 25% design level for review and approval by the FCDMC.

6. Present preliminary budget-level opinions of probable cost for use in evaluating and budgeting the proposed project.

Information used in this design was derived from a number of sources and previous studies. Some of the sources included:

- Topographic mapping dated June 18, 1993 prepared for the FCDMC by Aerial Mapping Company, Inc.

- Design plans and analyses for the Sunset and Sunnycove Dam prepared by the SCS and dated June 1975.

  Hydrologic modeling prepared for the Wickenburg ADMS dated 1990

- Utilities maps prepared by the Town of Wickenburg

- Right-of-way maps and land ownership information provided by the FCDMC

Value Engineering Meeting

On April 12, 1994, a Value Engineering meeting was held at the fire station in Wickenburg. Hydrology, hydraulics, geotechnical, and unit cost data were presented. Several alternative dam alignments, configurations, construction methods, and outlet configurations were also presented and evaluated. A summary of those discussions along with the meeting's agenda, attendees list, handouts, and minutes are presented in Appendix E. As a result of the meeting,

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refinements were made to the concept plans which led to the current designs shown in the concept designs accompanying this report. Those refinements resulting in significant improvement to the initial concept plan are listed below:

- Review of the hydraulics resulted in raising the top of dam to an elevation of 2163.5, and spillway crest to elevation 2153.0.

- The north (left) dam abutment was rotated eastward, which better aligned the dam with the natural drainage channel and made the dam length shorter.

- With the revised dam location and higher dam, the spillway width was revised to 80 feet. This requires less structural concrete.

The concept design submittal presents the refinements to the detention basin and dam concept grading plan as well as major design elements including the spillway, energy dissipater, access roads, and relocated sewer.

Existing property and right-of-way information was provided by the Town of Wickenburg and modified with updated information provided by FCDMC. The grading plan was reviewed to minimize the affect on adjacent properties and the purchase of unnecessary land. Existing property lines and proposed right-of-way are shown in the concept design submittal.

Acknowledgments

CH2M HILL would like to acknowledge the efforts and assistance of the staff of the Town of Wickenburg, specifically Mayor Dallas Gant, Town Manager Ben Navdelli, and Building Inspector, Skip Blunt. We would also like to thank the Wickenburg Volunteer Fire Department for the generous use of their meeting room facilities.

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Section 2.
Hydrology and Hydraulics

This section of the Concept Design Report describes hydrologic modeling, sedimentation engineering, and hydraulic design of outlet structures for the Casandro Wash Detention Dam.

Hydrologic Analysis

Hydrologic modeling of Casandro Wash was performed using HEC-1, and the modeling guidelines adopted in the FCDMC Hydrologic Design Manual for the design of the proposed detention dam. The 100-year discharge was estimated using procedures outlined in the FCDMC publication *"Drainage Design Manual for Maricopa County, Arizona, Volume I Hydrology"* (1992). Preliminary design criteria for the detention dam require that the 100-year event be substantially detained below the spillway elevation and/or the maximum outflow be less than or equal to the hydraulic capacity of the proposed storm drain to be constructed downstream of the dam. Preliminary design of the storm drain is described in the FCDMC report *"Casandro Wash Outfall for Casandro Wash Dam"* (1993). Design of the storm drain is not part of this project. According to the FCDMC report, the capacity of the storm drain is 339 cfs.

Hydrology

Hydrologic data for the Casandro Wash watershed were directly obtained or were modified from the Wickenburg ADMS, except as described below. Future watershed conditions assume 100 percent build-out according to the existing zoning in the watershed to account for potential changes in runoff rates over the long design life of the detention dam. Recently, development in the Casandro Wash watershed has been rapid.

Rainfall. Rainfall was estimated for the 6-hour local storm (drainage areas less than 100 square miles). Rainfall depths were determined using the PREFRE program provided with the FCDMC Hydrology Manual. Rainfall depths were input into the HEC-1 model after adjustment for areal reduction using Table 2.2 (p. 220 of the FCDMC Manual). A depth-area reduction factor of 0.985 was used. The adjusted 6-hour rainfall depths for Casandro Wash are:

- P_2 = 1.39 inch (2-year)
- P_{10} = 2.20 inches (10-year)
- P_{100} = 3.35 inches (100-year)

FCDMC design storm pattern number 1.5 was used as shown on Figure 2.17 and interpolated from Table 2.3 of the FCDMC manual.

Rainfall Losses. Rainfall losses were determined using FCDMC Manual Tables and Green-Ampt soil loss parameters. Surface retention was estimated at 0.10. This estimate was based on a theoretical maximum for the area for natural conditions, hill slopes, and desert of 0.15 inch and a theoretical minimum for paved urban areas of 0.05 inch. Development of the area typically has been residential and commercial with residential development of up to four residences per acre. The surface retention or initial abstraction of 0.10 represents a future conditions detention basin average.

Green-Ampt parameters were based on soil characteristics described in the Aguila-Carefree Soil Conservation Service (SCS) Soil Survey Report. Soil units in the watershed included clay loams, sandy clay loams, and sandy loams. Soil unit coverages were areally weighted using equations and methodologies described in the FCDMC manual. Percent imperviousness for the watershed was estimated based on full build out under existing zoning for the Town of Wickenburg. For areas within unincorporated Maricopa County without ordinanced zoning, the zoning for the Town of Wickenburg nearest the Maricopa County portion of the watershed was used. Future condition percent imperviousness averaged about 35 percent for the entire watershed.

Unit Hydrograph. Clark unit hydrograph procedures were used to develop runoff peaks and volumes. Time of concentration equation #5.5, for desert and mountain areas, in the FCDMC manual was used. Detention basin area was planimetered on USGS topographic mapping. Watershed length was similarly measured on USGS topographic mapping. The detention basin factor Kb for the time of concentration equation was determined by areally weighting between the categories of commercial, residential areas, Type A, and desert range lands Type B using Figure 5.5 of the FCDMC manual. Measured watercourse slopes were adjusted, as required, using Figure 5.4 of the FCDMC manual. Unit hydrograph parameters input into HEC-1 were determined using the software program MCUHP1 provided with the FCDMC Manual.

Channel Routing. Channel routing parameters were based on typical average cross section from the dam to an upstream confluence of the two subwatersheds. Only one routing reach was needed for the watershed upstream of the proposed dam site. Modified Puls storage routing techniques were used, according to guidelines given in the FCDMC Manual. Due to the short length of the routing reach, minimal hydrograph attenuation occurs in the model output.

Detention basin Routing. Detention basin routing was computed using elevation-storage information estimated by planimetering 2-foot contour interval mapping provided by the FCDMC and the proposed grading plan and dam alignment provided by CH2M HILL. Detention basin outflow was estimated as described in the Hydraulic Structures Design section of this report, and included both the low flow orifice discharge and discharge over the spillway. The detention basin stage-elevation-area-volume relationship was adjusted to account for 2 acre-feet sediment storage during the 100-year event, as described later in this report.

Modeling Results. Peak discharge estimates for the Casandro Wash detention dam project are shown in Table 2-1. The 100-year design peak was estimated at 1,769 cfs with a total volume of 156 acre-feet. The 2- 10- and 50-year discharge estimates are 506 cfs, 1,028 cfs, and 1,544 cfs, respectively, with volumes of 43, 86, and 129 acre-feet. The calculation of synthetic skew for the 2-, 10- and 100-year discharge using procedures outlined in Bulletin 17B of the Water Resource Council indicate the synthetic skew is -0.11, well within the regional skew of -0.1 computed by the Water Resource Council in Bulletin 17B. Computation sheets and sample output from HEC-1, 100-year modeling are provided in the appendix.

Table 2-1.
Casandro Wash
Hydrology

Recurrence Interval (years)	Peak (cfs)	Volume (acre-feet)
100	1,769	156
50	1,544	129
2	506	43

Probable Maximum Flood

The probable maximum flood and emergency spillway design criteria for the Casandro Wash Detention Dam were determined as specified in ADWR's report *"Guidelines for the Determination of Spillway Capacity Requirements"* dated May 1991 (hereafter, "the ADWR Manual").

The half-probable maximum flood (0.5_PMF) and full PMF were estimated using procedures outlined in Hydrometerological Report 49 (HMR 49; *Probable Maximum Precipitation Estimates, Colorado River and Great Detention basin Drainages*, U.S. Army Corps of Engineers, September 1977). The HEC-1 hydrologic model was used to estimate the PMF and 0.5_PMF. The 100-year HEC-1 model described in the previous section of this report was modified by substituting 0.5_PMF and full PMF rainfall distributions.

Probable maximum precipitation (PMP) for a "local" storm was determined from HMR 49, as documented in computation sheets provided in the appendix. The PMP analysis included the following:

- 1-hour PMP of 11.5 inches
- No elevation adjustment (site < 5,000 feet)
- 6-hour to 1-hour ratio of 1.32
- Areal reduction of 0.25-, 0.5-, 0.75-hour PMP values (area = 1.24)
- No areal reduction adjustment for 1-hour to 6-hour durations
- COE alternative incremental PMP distribution (EM#1110-2-1411)
- No areal distribution of the PMP storm

Application of the PMP depth and distribution to the HEC-1 watershed model for Casandro Wash resulted in a PMF estimate of 10,941 cfs (HEC-1 file "CASFPMFE.HC1"). The 0.5_PMF was determined by ratioing the full PMF hydrograph ordinates from the HEC-1 model using a JR record, resulting in a 0.5_PMF estimate of 5,404 cfs (HEC-1 file "CASHPMFE.HC1"). Computation sheets for determination of PMF and 0.5_PMF are included in the appendix.

Dam and Detention Basin Criteria

In Arizona, spillway design criteria, as outlined in the ADWR Manual, are a function of the hazard classification of the dam. Hazard classification is based on factors such as the height of the dam, storage capacity, existing and probable future downstream development, uses of the detention basin, operational procedures, type of dam, type of spillway, site and foundation geology, the size, slope and material composition and configuration of the downstream channel, and the distance of the dam from the nearest downstream development. The Casandro Wash Detention Dam will have a spillway crest height of about 22 feet (total dam height of about 30 feet), a maximum storage capacity of about 150 acre feet (below the spillway), will have increased future residential development downstream, will be used for flood control purposes only, will be uncontrolled, and will probably be earthen with an overflow emergency spillway.

The Casandro Wash Detention Dam will be classified as a small, significant-to-high-hazard dam by ADWR due to the presence of more than a small number of habitable structures downstream and the potential for appreciable economic losses downstream, according to criteria outlined in the ADWR Manual. Table 1 of the ADWR Manual (see appendix) classifies these characteristics as high hazard. The dam is classified as high hazard for urban development, and significant hazard for economic loss. Dam size is a function of its height and capacity. The proposed dam's height is less than 25 feet, and its proposed capacity is

Top or crest ?
See pg. iv

between 15 and 499 acre feet. These characteristics give the proposed structure a cumulative rating factor of 0. According to Table 2 of the ADWR Manual, "small" dams have a cumulative rating between 0 and 2.

Spillway Design Criteria

The spillway design flood recommended in the ADWR Manual for the proposed Casandro Wash Detention Dam configuration is the half probable maximum flood (0.5_PMF), given the hazard and size classification. Small dams in the high hazard class are to have a spillway that passes the 0.5_PMF. By comparison, small dams in the significant hazard class are to have a spillway that passes the 100-year to 0.5_PMF, as indicated on Table 3 of the ADWR Manual.

Total freeboard, or the distance between the top of the dam and the spillway crest, is determined by the type of dam, the maximum water surface during discharge of the design flow (0.5_PMF), wave height and runup, and economic factors. The minimum permissible total freeboard for the spillway will be 4 feet, according to the ADWR Manual.

Residual freeboard, or the distance between the maximum water surface during passage of the inflow design flood and the top of the dam, must be a minimum of three feet, except when the inflow design flood is the 0.5_PMF or greater. For cases when the inflow design flood is 0.5_PMF or greater, the residual freeboard may be reduced. Freeboard will be applied to the routed 0.5_PMF maximum water surface elevation. Table 2-2 summarizes the spillway design criteria for the dam.

Table 2-2.
Casandro Wash
Spillway Design Criteria

Spillway Capacity	0.5_PMF
Freeboard	4 ft (spillway to top of dam) or 3 ft above 0.5_PMF WSEL
0.5_PMF	5,404 cfs

Summary

For the Casandro Wash Detention Dam project, the 0.5_PMF of 5,404 cfs is recommended for spillway design purposes. However, based on the results of the Value Engineering Meeting of April 12, 1994, the spillway should also pass the full PMF without freeboard. Freeboard will be controlled by residual freeboard requirement of 3 feet above the maximum

routed 0.5_PMF water surface elevation (WSEL). The Casandro Wash Detention Dam is a high hazard, small dam.

Detention Basin Design

The Casandro Wash Detention Basin and Dam were sized to store the 100-year flood. HEC-1 detention basin routings were performed to estimate flood water storage requirements, maximum water surface ponding elevations, and to optimize spillway and low-flow outlet characteristics. Design of the spillway and outlet will be described later in this report.

Stage-Storage Capacity Curve. A detention basin grading plan was developed to meet site geotechnical and civil requirements (described elsewhere), as well as flood water storage needs. A 2-foot contour interval digital terrain model of the detention basin was developed using AutoCAD-based software. Level-pool surface areas were determined for each contour interval and were checked by planimetering plotted maps of the grading plan. Elevations and surface area were used by the HEC-1 model to estimate storage volume. Figure 2-1 shows storage capacity and area curves.

Stage-Discharge Rating Curve. Detention basin outflow will be through a low-flow orifice outlet as well as over the spillway (only for floods greater than Q50). The spillway elevation and orifice opening were varied to achieve the maximum outflow without exceeding the 339 cfs capacity of the proposed FCDMC storm drain downstream. The capacity of the downstream storm drain was estimated from a HEC-1 model provided by the FCDMC. Both the timing and magnitude of detention basin outflow was compared to the FCDMC HEC-1 to test if the capacity was exceeded. After optimization, a spillway elevation of 2153 ft. and an orifice opening of 1.4 ft^2 were selected. The spillway rating curve was developed using procedures described elsewhere in this report. Figure 2-2 shows the stage discharge curve.

Drain Time. The estimated time to drain the detention basin is approximately 76 hours. This drain time applies to all flows in excess of the 100-year, including the full PMF, since flood volumes in excess of the 100-year flow exit through the spillway. Shorter drain times can be achieved by removing or enlarging the orifice.

Maximum Ponding Elevation. The maximum ponding elevations after routing for various design events are summarized in Table 2-3 (not including freeboard requirements, if any). Maximum ponding elevations were estimated using HEC-1. The proposed top of dam elevation is 2163.0 feet.

Figure 2-1: Storage capacity and area curves.

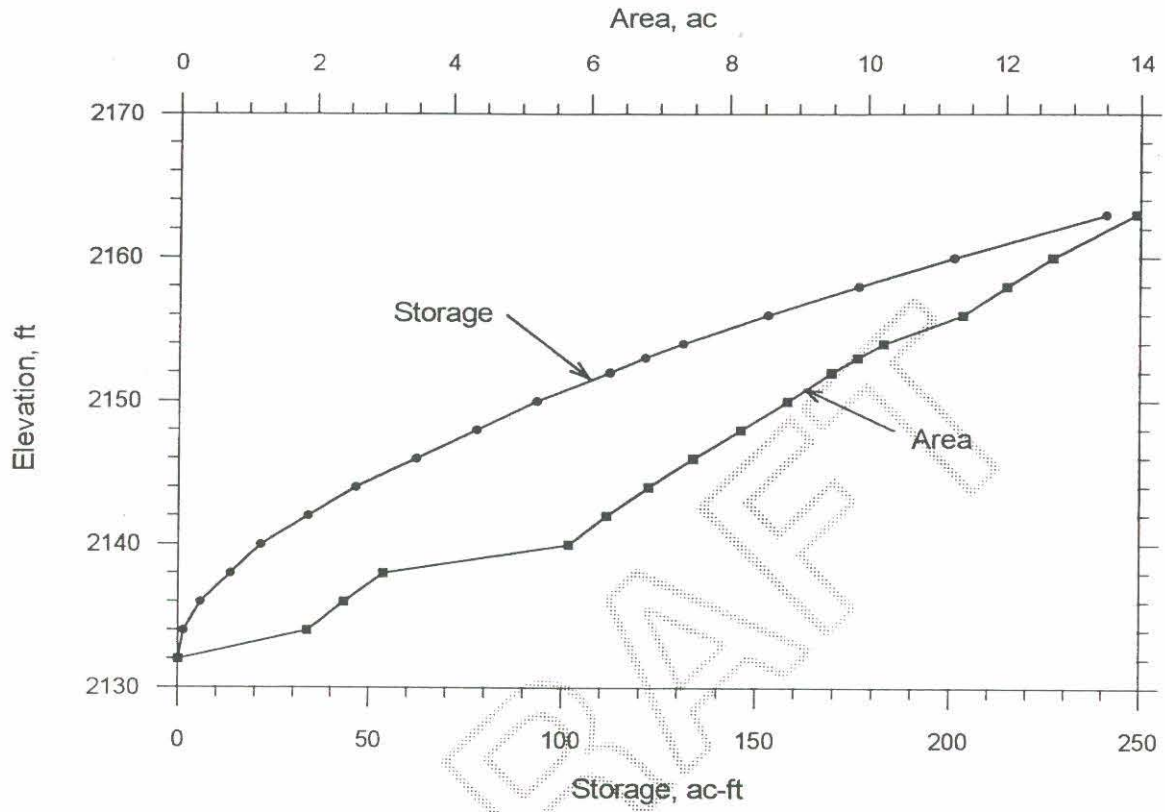

Figure 2-2: Stage discharge curve

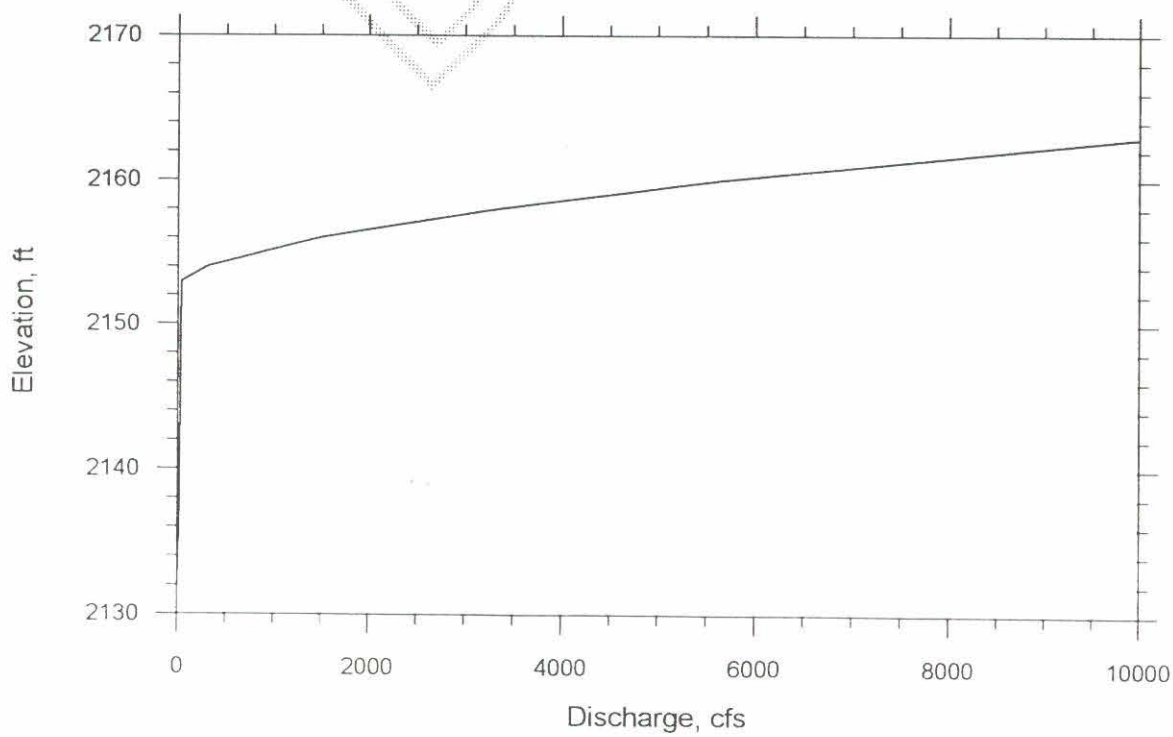

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Table 2-3. Casandro Wash Maximum Ponding Elevation	
Flood Recurrence Interval	**Elevation**
Q100	2153.9
0.5_PMF	2158.8
PMF	2162.8

Sedimentation Engineering

A sedimentation investigation was conducted to estimate potential sediment supply to the detention basin. Sediment yield estimates will be used to predict sediment maintenance requirements and estimate sediment storage requirements during the design storm. Criteria for design of sedimentation reservoir within the detention basin will be addressed separately.

Sediment Supply

Sediment deposited in the Casandro Dam detention basin area reduces the available storage volume for floodwater. The estimate of sediment supply will be used to evaluate the additional storage volume needed to meet the requirements for floodwater storage and conveyance through the dam.

Data Requirements. Technical data required for estimating sediment supply was obtained from existing studies, regional geologic, land use and watershed mapping, HEC-1 hydrologic modeling of the watershed prepared for this project, and a sieve analysis of Casandro Wash bed sediments.

Methodology. Sediment supply was estimated using the following methodologies:

- PSIAC Method (Pacific Southwest InterAgency Committee). This procedure was developed for planning-level analyses of sedimentation in the southwestern United States, and uses generalized watershed characteristics to predict sedimentation rates. The methodology is described in "*Design Manual for Engineering Analysis of Fluvial Systems*," Arizona Department of Water Resources, 1985.

- MUSLE (Modified Uniform Soil Loss Equation). MUSLE was developed by the U.S. Soil Conservation Service to predict rates of soil erosion, and is also commonly used to predict sediment yield in the arid southwest. MUSLE can be used to estimate

sediment supplied from individual design storms, as well as average annual sediment production. MUSLE is described in "*Design Manual for Engineering Analysis of Fluvial Systems*," Arizona Department of Water Resources, 1985, with supplemental information available in "*Predicting Rainfall Erosion Loss - A Guide to Conservation Planning*," USDA Agricultural Handbook 537, 1978.

- C.T. Yang's Bedload Sediment Transport Function. C.T. Yang developed a sediment transport function which is commonly used to predict sediment movement rates in sand/gravel-bedded streams. Casandro Wash sediment load is mostly sand and gravel as indicated by sieve analysis of channel bed sediments from the project site. Yang's sediment equation is described in "*Unit Stream Power Equation for Gravel*," ASCE Journal of Hydraulic Engineering, Vol. 110, No. 12, December, 1984.

- SCS Modeling for Sunset and Sunnycove Dams. The SCS prepared a sedimentation investigation for two dams on watersheds similar to Casandro Wash, that are located within one mile of Casandro Wash. SCS estimates are based on sediment survey data and the "Range Method." SCS estimates are described in "*Watershed Work Plan: Wickenburg Watershed, Maricopa and Yavapai Counties, Arizona*," Soil Conservation Service, December 1974.

- FCDMC Sediment Maintenance Data. The FCDMC periodically removes sediment from Sunset and Sunnycove Dams in Wickenburg. Although no systematic sediment removal data is maintained, anecdotal information was used to roughly estimate potential sedimentation at Casandro Dam.

Results. Estimates of average annual sediment supply at Casandro Wash detention basin from the sedimentation investigation are shown in Table 2-4. Estimates of sediment supply for specific recurrence interval design floods are shown in Table 2-5. It was assumed that the reservoir trapping efficiency was 100 percent due to the high percentage of bed load transport, orifice-type outlet design, and relatively long drain time relative to the design storm duration.

Table 2-4. Casandro Wash Sediment Supply Estimates	
Methodology	**Average Annual Supply (AF/yr)**
PSIAC	0.3
MUSLE	0.6
SCS Studies	0.3
Yang Equation	0.4
FCDMC Maintenance	0.1 - 11.9

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Table 2-5 Casandro Wash Sediment Supply for Design Storms		
Recurrence Interval	**MUSLE (AF/yr)**	**Yang Equation (AF/yr)**
Q2	0.5	0.3
Q5	0.8	0.6
Q10	1.1	0.8
Q25	1.5	1.1
Q50	1.7	1.4
Q100	2.0	1.6

Discussion. Sediment supply estimates are relatively consistent between all methodologies used. Estimates based on anecdotal sediment maintenance information supplied by the FCDMC exceed the upper limit of sediment yields expected at the Casandro Wash site, but illustrate well the variability of sediment supply in an arid environment. It is likely the upper limit of sediment yield shown in Table 5 is skewed upward as a result of several large events occurring upstream of Sunset Dam during recent years; the long-term average is likely to be lower. It is also noted that estimated sediment supply does not increase dramatically with return period. This is probably due to the relatively short duration of the design flood, as well as the relatively intense design rainfall and steep channels which produce high velocity turbulent flow even for more frequent flood events.

Given the results reported above, sediment supply rates to be used for design of the detention basin are based on the average of the methods reported, and are summarized in Table 2-6. For the purposes of sizing the detention basin, approximately 2 acre-feet should be allowed for sediment storage during the 100-year event.

Table 2-6 Casandro Wash Design Sediment Volumes	
Recurrence Interval	**Sediment Volume**
Average Annual	0.4 AF/yr
Q100	1.8 AF

Sediment Maintenance

Sediment maintenance requirements for the Casandro Wash detention basin are directly related to the sediment supply rates. The average annual sediment yield of 0.4 AF/year can be used to predict annual sediment maintenance needs. However, since annual sedimentation may be highly variable, as indicated by anecdotal information obtained for the nearby Sunset and Sunnycove Dams, actual sediment removal requirements may vary significantly in any given year. Therefore, monitoring of sediment accumulation should be included in the detention basin maintenance plan. According to FCDMC staff, a regular maintenance schedule of about 5 years may be expected if no large floods occur on Casandro Wash. If maintenance occurs every five years, about 2 acre-feet of sediment will be removed on average (5 x .4 AF/yr.).

Downstream Impacts

Construction of the detention basin will interrupt the natural sediment supply from the upper watershed to the portion of the watershed downstream of the dam. In addition, water flowing over the spillway and through the low-flow orifice will probably experience higher velocities than naturally occur in Casandro Wash under existing conditions. These factors will tend to increase channel bank and bed erosion in the reach of the wash between the dam and the downstream storm drain. Erosion will be expressed as reduced sediment clogging of culvert inlets at road crossings, and accelerated scour on the downstream side of road crossings. Scour downstream of road crossings occurs under existing conditions. Design of structures to mitigate erosion in the downstream channel is not part of this study, but would likely include grade control structures to maintain a stable slope in the channel reach.

Bank erosion is also undercutting channel banks at several locations immediately upstream of the detention basin site. Property owners should be notified of this existing condition. It is not anticipated that operation of the detention basin will affect existing bank erosion upstream of the inundation area.

Hydraulic Structures Design

Hydraulic structures associated with the Casandro Wash Detention Dam include the low-flow outlet, spillway, spillway chute, energy dissipator at the end of the spillway chute, and a sedimentation reservoir within the detention basin.

Detention Basin Outlet

Orifice. Outflow from the detention basin includes a low flow orifice, and the emergency spillway. The low flow outlet is a 36-inch reinforced concrete pipe (RCP) with a 1.4 ft^2 orifice plate. The orifice is sized to discharge a maximum of 20 cfs at the time of the downstream watershed hydrograph peak at the storm drain inlet. Maximum downstream discharge at the storm drain inlet occurs at 4:05 hours, according to the FCDMC HEC-1 model. The difference between the downstream peak discharge (6-hour storm) and the 339 cfs capacity of the storm drain is 20 cfs. The orifice rating curve was developed by the HEC-1 model assuming an orifice coefficient of 0.6 and an inlet elevation of 2132 feet. A gated cover for the orifice is proposed to facilitate maintenance, and to allow opening of the orifice in the event of debris clogging. The inlet to the orifice will be placed in a grated concrete box to reduce the potential for debris and sediment clogging.

Spillway. As currently planned, the emergency spillway will consist of an ogee crest, with the crest apex at elevation 2153.0 feet. The spillway length will be 80 feet, and the design head will be 7 feet for the 0.5_PMF event. The total spillway height will be 10 feet, or enough head to pass the full PMF without freeboard. The spillway chute and energy dissipator will be sized for the 0.5_PMF, and withstand, with some potential damage, the full PMF. A spillway rating curve for the ogee crest was developed using the procedures outlined in the *"Design of Small Dams"* by the Bureau of Reclamation (1987). Design of the spillway will be optimized for constructibility and cost-effectiveness, and is likely to have some design changes prior to final design.

Energy Dissipator. The proposed spillway chute has slope of 4:1, which is sufficient to maintain supercritical flow. A BUREC Type III energy dissipator is proposed to force a hydraulic jump before flow exits to the natural channel downstream of the dam. The detention basin will be placed approximately 6 feet below natural grade to insure that the computed jump height will match the tailwater elevation of the downstream channel. Riprap will be placed downstream of the dissipator to mitigate impacts on the dam backslope during the spillway design event, and during lesser flows exiting the dissipator.

Sedimentation Detention basin. The sedimentation detention basin will be designed according to guidelines presented in the FCDMC Hydraulic Design Manual, following approval of the site grading plan. The required sediment storage volume is 2 acre-feet, both for the 100-year event, and for the average annual yield during a 5-year period of no maintenance. The sedimentation detention basin will be located near the detention basin inlet to concentrate deposition of coarser sediment material. Sedimentation markers will be used to allow quick assessment of overall deposition within the detention basin, especially near the low-flow outlet.

Section 3.
Geotechnical Investigation

The purpose of the geotechnical investigation was to obtain subsurface information at the proposed damsite and detention basin area for development of geotechnical recommendations for design and construction. The field exploration included 13 soil borings and 21 test pits. Laboratory tests were performed to characterize the onsite materials and determine their engineering properties.

Field Investigations

Previous Site Geotechnical Work

No evidence of previous geotechnical work was found for the Casandro Wash project site. However, geologic investigation reports for two previously constructed floodwater-retarding structures in the Wickenburg watershed are available. The Sunny Cove and the Sunset floodwater-retarding structures are located within the town limits of Wickenburg, and are within about one mile of the Casandro Wash project site to the south and southeast, respectively.

The Sunny Cove and Sunset damsites contain alluvial deposits overlying dense, carbonate-cemented sand and gravel, generally similar to the subsurface conditions found at Casandro Wash. Both dams have cutoff trenches excavated into the cemented material and the embankments are constructed with material excavated within the detention basins.

Contingency item - Additional ex. for trench

Field Exploration

Between January 18 and 28, 1994, CH2M HILL conducted a field exploration of the project site. The exploration consisted of excavating 21 test pits, drilling 13 soil borings, and performing 9 infiltration tests. The infiltration tests were performed in both boreholes and test pits. A CH2M HILL engineer specified test pit and boring locations, determined sampling intervals, and provided general oversight during all exploration operations. Locations of the test pits and soil borings are shown in Figure 3-1.

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NOTES: TP-6, TP-10, AND TP-19 WERE NOT EXCAVATED

FIGURE 3-1. LOCATIONS OF TEST PITS AND SOIL BORING

CASANDRO WASH DETENTION BASIN
WICKENBURG, AZ.

CH2M HILL

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Test Pits

Riggs Enterprises of Wickenburg, Arizona, was subcontracted to excavate all of the test pits for this exploration. Depths of the test pits ranged from 5 to 18 feet. As indicated in Figure 3-1, the test pits were located near the proposed dam alignment and throughout the detention basin and banks of Casandro Wash. All of the test pits were completed with a Caterpillar EL 200B trackhoe.

Disturbed soil samples were obtained from each of the major soil layers encountered in the test pits. Each soil sample was composed of a bulk sample portion, weighing approximately 40 pounds, and a moisture sample portion. Bulk samples were enclosed in doubled, plastic bulk soil sample bags, and in doubled, gallon-size plastic bags with zip-lock enclosures. A CH2M HILL engineer visually classified all soil samples following the Unified Soil Classification System, in general accordance with ASTM D 2488.

Soil encountered in the test pits was classified in the field as gravelly sand with varying amounts of silt or clay. Two major soil layers were commonly identified, consisting of a loose-to-medium-dense sand overlying dense-to-very-dense cemented sand. Samples taken from the cemented zone were typically highly reactive to hydrochloric acid, indicating a carbonate cementing agent in the soil. Depth to the cemented layer varied from near ground surface to about 16 feet below ground surface below ground surface. In some of the test pits the cemented layer was not encountered, even after reaching a maximum pit depth of 20 feet bgs.

After sampling and logging the soil profile, all test pits were backfilled with the excavated soil. The trackhoe operator used the bucket and tracks of the trackhoe to compact the fill as much as possible while backfilling the test pits.

Soil Borings

From January 24 through January 28, 1994, Enviro-Drill, Inc., from Phoenix, Arizona, drilled 13 soil borings using a CME 75 drill rig. All soil borings were advanced using 8-inch-outside-diameter (OD), hollow-stem augers. Soil Borings B-1, B-2, B-9, and B-10 were drilled to a final depth of 100 feet bgs. The remaining borings along the proposed dam alignment and on the banks of Casandro Wash were drilled to a final depth of 50 feet. Locations of the soil borings are shown in Figure 3-1.

Disturbed soil samples were obtained in each of the soil borings using a 2-inch-OD split-spoon sampler. Sampling was performed on 2.5-foot intervals between zero and 20 feet. After 20 feet, sampling continued on 5-foot intervals until the maximum depth of the boring was

reached. In some soil borings the sampling interval was extended to 10-foot intervals after drilling 20 feet into the cemented zone. In these cases, the 10-foot sample interval was continued to the total depth of the boring.

Standard Penetration Tests (SPTs) were performed in accordance with ASTM D1586. The SPT uses a 140-pound hammer, dropped 30 inches, to drive the sampler 18 inches into the soil. The number of hammer blows for each 6-inch interval of sampler penetration is counted and recorded. The sum of the blows during the last two 6-inch penetration intervals determines the "N" value expressed as blows per foot (blowcounts) for the sample. The SPT hammer used for this project was an automatic, fully enclosed hammer fastened to the drill rig. No rope, cable, or cathead was used.

In-place density samples were obtained typically between ground surface and 10 feet below ground surface. A 3-inch-OD, 12-inch-long split barrel sampler, equipped with two 6-inch brass-sleeve liners, was used to obtain density samples. This sampler was driven in the same manner as the standard split-spoon sampler described above in general accordance with ASTM D 3550.

Where fine-grain soil was encountered, or SPT blow counts were comparatively low, 3-inch-OD Shelby tube samplers were used to obtain relatively undisturbed soil samples. The thin-walled Shelby tubes were advanced in general accordance with procedures described in ASTM D 1587.

A CH2M HILL engineer visually classified soils recovered during the drilling program following the Unified Soil Classification System, and in general accordance with ASTM D 2488. Soil samples obtained from the SPTs were placed in plastic bags with zip-lock-type enclosures. In-place density samples collected in the 6-inch brass sleeves, as well as Shelby tube samples, were sealed with plastic end caps and black plastic tape. Sample descriptions, blowcounts recorded during the SPTs, and related information were recorded on the soil boring logs. Upon completion of the soil borings, all boreholes were grouted to ground surface with a sand/cement grout poured from the ground surface. No borehole caving was observed.

Soil encountered in the borings was consistent with soil found in the test pits. At various depths in all of the borings the cemented layer was encountered. As indicated by the blowcounts, visual classification, and reaction to hydrochloric acid, once this layer was identified, it continued through to the final depth of the soil boring. Therefore, total thickness of the cemented layer was not observed.

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Infiltration Testing

In Test Pits TP-8 and TP-9 and in Soil Borings B-1, B-2, B-3, B-5, B-8, B-9, and B-10 infiltration testing was performed. The borehole infiltration tests were performed on selected boreholes. After drilling to the predetermined depth for the test, the augers were pulled up approximately 3 feet off the bottom of the borehole. Approximately 500 gallons of water were pumped down the auger. Water was generally observed to flow up near or at the borehole collar in the annular space outside the augers. An electric water level sounder was used to determine the water level inside the hollow stem auger as it declined. Water level measurements were generally recorded every 30 seconds for a 10-minute period.

Infiltration tests were performed in selected test pits by driving a stake calibrated with 0.1-foot increments into the bottom of the test pit. Water was added to the test pit, and the depth of water was recorded periodically over a 10-minute period.

A summary of the results from the infiltration test is presented in Table 3-1, below. Data from the infiltration tests are included in the Geotechnical Data Report, Volume 1.

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Table 3-1 Casandro Wash Field Permeability Test Results	
Infiltration Test Location	**Estimated Permeability (cm/sec)**
B-1	1.1 (10^{-4})
B-2	6.1 (10^{-5})
B-3	1.7 (10^{-4})
B-5	1.4 (10^{-4})
B-8	7.0 (10^{-5})
B-9	2.3 (10^{-5})
B-10	2.9 (10^{-5})
TP-8	7.5 (10^{-3})
TP-9	4.2 (10^{-4})

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Laboratory Testing

Laboratory testing included Atterberg limits, sieve analysis, specific gravity, bulk density, and moisture content to establish index properties and verify field classifications. Standard Proctor compaction tests, direct shear, unconsolidated-undrained triaxial shear, and consolidated-undrained triaxial shear with pore pressure measurements on remolded samples were performed to assess strength characteristics for embankment design. Laboratory triaxial permeability testing of remolded samples was performed to aid in assessing seepage potential and slope stability. The data for all laboratory results is included in the Geotechnical Data Report. A summary of the soil classification and index property testing is shown in Table 3-2.

Concept Design Criteria

The concept design criteria for the dam are based on the results of field exploration and laboratory testing. They provide the basis for the project's conceptual design and for final geotechnical analysis and design.

Table 3-2
Summary of Laboratory Analyses
Casandro Wash Detention Basin

				Field Soil Properties		Particle Size Distribution % Passing by Weight (a)		Atterberg Limits		Moisture Density Relationship			Shear Strength (b)		Triaxial Shear (c)		Permeability (f)
Test Pit/ Boring #	Depth (ft)	Sample I.D.	Classification	Dry Density (pcf)	Moisture Content (%)	#4	#200	LL	PI	Max Dry Density (pcf)	Optimum Moisture Content (%)	Specific Gravity	C (ksf)	0 (Deg)	C (ksf)	0 (Deg)	K (cm/sec)
TP-1	5	TP-1, B-1	SW-SM		2.5	65.0	9.3										
TP-1	9	TP-1, B-2	SW									2.62					1.1E-03
TP-2	3	TP-2, B-1	SW		3.8								0.4	39			
TP-3	5	TP-3, B-1	SP		3.9	86.0	3.5										
TP-3	17	TP-3, B-2	SW-SC			67.0	11.7										
TP-4	3	TP-4, B-1	SW-SM		4.0												
TP-4	14	TP-4, B-2	SW-SM			52.0	6.0						0.0	45			
TP-5	7	TP-5, B-1	SM		5.8												
TP-5	16	TP-5, B-2	SW-SM			67.0	9.3										5.0E-04
TP-7	4	TP-7, B-1	SW-SM		3.9												7.6E-04
TP-7	15	TP-7, B-2	SW-SM			90.0	9.8										
TP-8	4	TP-8, B-1	SM		7.4										2.88	0.0	
TP-8	15	TP-8, B-2	SW-SM			71.0	7.6						0.5	40			1.2E-04
TP-9	2	TP-9, B-1	SW-SM		6.8	64.0	8.3										
TP-11	2	TP-11, B-1	SP		6.1	88.0	3.4										
TP-11	5	TP-11, B-2	SC		7.6	74.0	12.1			113.0	14.2						
TP-11	14	TP-11, B-3	SM										0.0	45			
TP-12	4	TP-12, B-1	SM		5.0					118.0	11.5		1.55	27			
TP-12	9	TP-12, B-2	GW-GM			37.0	6.3										1.1E-04
TP-13	4	TP-13, B-1	SP-SM										0.0	45			
TP-15	5	TP-15, B-1	SM		6.2	75.0	25.6	27.0	6.0						0.72	22.0	
TP-15	10	TP-15, B-2	SP										0.0	0			1.6E-03
TP-15	13	TP-15, B-3	SW-SM			51.0	6.3										4.2E-04
TP-16	2	TP-16, B-1	SM		4.3												
TP-16	8	TP-16, B-2	SW-SM		9.1	81.0	7.3										
TP-18	3	TP-18, B-1	SW-SM		6.9	51.0	5.4			114.0	12.9						8.3E-05
TP-18	9	TP-18, B-2	SW-SM			61.0	5.1										

Table 3-2
Summary of Laboratory Analyses
Casandro Wash Detention Basin

Test Pit/ Boring #	Depth (ft)	Sample I.D.	Classification	Field Soil Properties		Particle Size Distribution % Passing by Weight (a)		Atterberg Limits		Moisture Density Relationship		Specific Gravity	Shear Strength (b)		Triaxial Shear (c)		Permeability (f)
				Dry Density (pcf)	Moisture Content (%)	#4	#200	LL	PI	Max Dry Density (pcf)	Optimum Moisture Content (%)		C (ksf)	0 (Deg)	C (ksf)	0 (Deg)	K (cm/sec)
TP-20	3	TP-20, B-1	SW-SM		5.0	63.0	10.3			118.0	11.8	2.57					2.1E-06
TP-20	8	TP-20, B-2	SW-SM	124 (d)		69.0	11.8										
TP-21	3	TP-21, B-1	SW		5.2	74.0	4.3										
TP-21	5	TP-21, B-2	SM		5.7												
TP-22	3	TP-22, B-1	SM		4.8	86.0	18.7			120.0	11.0						1.1E-04
TP-23	5	TP-23, B-1	SW		4.6	66.0	2.7										
TP-24	2	TP-24, B-1	SW		7.9	85.0	5.9			109.0	14.6						
TP-24	2	TP-24, B-2	SW-SM		7.5	63.0	5.9										
B-1	17.5	B-1, SS-8	CL					33.0	12.0								
B-6	10	B-6, ST-5	SW	106.0	5.6												
B-10	4	B-10, ST-3	SM	98.0	9.3												
B-10	20	B-10, SC-9	SW-SM	92.0	9.6												
Sediment (e)	0		SW			90.0	3.0										

Notes

(a) 100% of every sample passed 2-inch sieve

(b) Direct shear test with normal stresses of 1, 2, and 3 ksf

(c) Triaxial shear test with confining pressures of 10, 20, and 30 psi

(d) Sample was cemented. Density determined by paraffin coating method. (ASTM D1188)

(e) Surface sample collected near TP-21

(f) Permeability determined in laboratory on sample compacted to 95% of ASTM 698 at optimum moisture.

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Dam Alignment

Several dam alignments were evaluated during concept design. All proposed alignments extended off the same high point on the right abutment (Ryan's property) to varying points on the left abutment. The foundation soils are similar for all proposed alignments. The foundation material encountered consisted of recent alluvial deposits comprised of loose-to-medium-dense sand overlying dense-to-very-dense cemented sand. The depth to the partially cemented material varied greatly. The overlying loose soil in the detention basin should be removed and the dam founded on the cemented or very dense sand. The abutment conditions were similar to the foundation except for an increase in the amount of fines present to approximately 12 percent. The right abutment is thin in cross section and should be buttressed with fill.

Because geotechnical conditions are similar at the proposed alignments, the final alignment should be determined based on other conditions such as spillway size and orientation, detention basin storage, and minimizing earthwork.

Dam Type

The proposed dam should be a homogenous earthfill dam constructed of materials excavated from the detention basin. Field exploration and laboratory test results did not reveal suitable low permeable material for use as a core for a zoned earth dam. Therefore, a homogenous dam with a chimney drain is preferred over importing clay soil for a core. The material in the detention basin may be suitable for use in construction of a RCC dam, but cost and potentially compressible foundation conditions eliminated RCC from further consideration.

Dam Construction

The proposed dam cross section should have 3:1 (horizontal to vertical) slopes upstream and downstream. Preliminary analysis indicates 3:1 slopes would have an adequate factor of safety for slope stability under steady state seepage and rapid drawdown conditions. Steeper slopes will be evaluated if significant cost savings can be achieved. Slopes steeper than 3:1 are easily eroded and more costly to maintain. Detention basin sideslopes below the high water line should also be graded to a 3:1 slope and be well vegetated to prevent failures and rapid erosion.

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During final design, slope stability of the dam and detention basin will be analyzed under the following conditions:

- Short and long duration seepage
- Rapid drawdown of detention basin
- Earthquake shaking

The minimum top width of the dam is required to be 14 feet to meet SCS requirements. We recommend that the top crest width be increased to 20 feet to allow for a wider access road and to increase stability of the dam. Necessary ?

Preliminary analysis indicates that under seepage conditions of several weeks, water could flow through most of the dam. To protect the dam from seepage erosion at the downstream toe, a chimney drain should be constructed in the dam. The drain should extend from just below the crest of the dam to the bottom keyway. Pipes should be install to provide positive drainage from the chimney drain to the downstream face. A keyway should be installed into the cemented foundation soil to reduce seepage along the foundation/embankment interface. The keyway should extend a minimum of 4 feet into the cemented material for the length of the dam.

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Seismicity

An investigation of the existing seismic information was performed for the region around the dam. This investigation included:

- Data search of the USGS National Information Earthquake Center records for seismic activity within 150 km of the site.

- Review of seismotectonic data for the New Waddell Dam site approximately 45 km east of Wickenburg.

- Review of seismic zoning maps from the Uniform Building Code, Soil Conservation Service, Applied Technology Council, and Federal Emergency Management Agency.

- Evaluation of the known active faults, the maximum credible earthquake (MCE) from these faults, and the peak acceleration at the site from the MCE of each fault.

Based on the above investigation, a design peak rock acceleration of 0.1g is recommended for final design. This is the same value recommended in the SCS design manual. Details of the seismic investigation will be included in the Geotechnical Design Report.

Section 4.
Site Civil

This section describes the field surveys, existing utilities, and right-of-way information obtained for the Casandro Wash Detention Dam project.

Field Surveys

Field surveys of the project area were performed from mid-January through mid-April 1994. The surveys established the project control points using state plane coordinates. Section corner monumentation along Mariposa Drive was used as the basis of bearing. A preliminary survey line (P-line) was established by placing 4 control points (½-inch rebar) along the bottom of the wash for locating test pits and borings. Two centerline alignments were initially set for the dam, which consisted of end control points and staking along the centerline at 25-foot intervals indicating the proposed dam elevations. The 100-year water surface elevation (initially 5,954 feet) was also staked around the detention basin area to provide a visual perspective of the size of the basin.

Bluestake was contacted to identify existing utilities within the project area. Additional utility information was collected from the Town of Wickenburg for the sewer, water, and right-of-way. The information is collectively shown in the preliminary plans submittal provided in Appendix A.

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Existing Utilities

The only known utility within the detention basin is a 10-inch vitrified clay sewerline. The sewer was designed by Yost & Gardner Engineers, Phoenix, for the Town of Wickenburg. It was constructed in 1987, and serves the residential and commercial properties along U.S. 60, west of the site. The sewer alignment generally extends through the project area from southwest to northeast. The depth of cover through this reach ranges from 11 feet near the west end, to 5 feet at the east end, with an average depth of approximately 9 feet under the proposed detention basin area. There are three manholes located within the detention basin area, and four manholes located downstream between the dam and Mariposa Drive. Existing manhole frames and covers are generally at grade and are standard items per MAG Detail No.424.

The slope of the sewer varies from 10.37% as it enters the detention basin area just north of US 60, to 0.80% west of Mariposa Drive. Although its design capacity is not known (data are not available from the engineer of record), only a small depth of flow was observed during

the field survey. However, calculations show that the capacity of the line at full depth and a slope of 0.80% could handle a flow of 1.7cfs.

A 6-inch waterline is located north of the detention basin which serves the adjacent residential properties. It generally parallels the wash alignment and is approximately 200 feet north of the wash centerline. There are three fire hydrants located on the waterline west of Mariposa Drive. It is anticipated that the waterline could be used for water supply during construction. An effort is being made to contact Wickenburg's Public Works Director to verify this assumption.

Other public utilities were identified, but are outside the immediate project area. These utilities should not be impacted by the dam and basin construction. They consist of the following:

- Overhead power serving the residences to the north
- Waterline along the north side of U.S. 60
- Overhead power along the north side of U.S. 60
- Gas line along the north side of U.S. 60

The utilities provide service to the residents and commercial buildings along U.S. 60.

Residents on the north side of the detention basin have sewer, water, and electrical services that extend along their private access drives. The service connections for the residents and commercial buildings along the south side of the detention basin extend to the south (toward U.S. 60), and away from the project area. Service connections do not appear to be in conflict with the dam or detention basin. However, the south access road alignment will likely be located over the sewer and water service connections to the Ryan property on the right abutment of the proposed dam. Also, the overhead power pole for service to the residents is located within the dike prism and may need to be relocated.

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Right-of-Way and Easements

Existing right-of-way maps for the project area were obtained from the Town of Wickenburg. Property lines are depicted in the Preliminary Plans. These property delineations will require verification by the FCDMC as part of their effort in acquiring right-of-way for the detention basin, dam, and access roads. Updated information, provided by FCDMC, will be incorporated into the plans.

The 10-inch sewerline has an easement of varying width through the project area. The easement is shown on the as-built drawings prepared by Yost & Gardner. Partial relocation of

the sewer will require an amendment to the easement description and resubmittal to the Town of Wickenburg for their approval.

The Grading Plan shown in the plan submittal depicts the property parcels in the project area. Consideration was given during development of the plan to minimize right-of-way needed for the facility. It is anticipated that in lieu of purchasing right-of-way, fill slope easements could be obtained for certain (as yet undefined) areas that require grading.

Access easements will be required for the north and south maintenance roads. The maintenance road on the north side extends from the top of dam to the nearby residential access drive. The south maintenance road extends from the dam and wraps around the north and east sides of the residential property, using their entrance from U.S. 60 as a common entrance drive. A separate access permit to U.S. 60 will not be required. Both maintenance roads will require a minimum 24-foot-wide easement. The north maintenance road is approximately 300 feet long, and the south road is approximately 750 feet long. Exact lengths and widths of these easements will be determined during the preliminary plan review.

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Section 5.
Permits

Construction of the Casandro Wash Detention Dam requires the acquisition of two permits: the Dam Safety Permit issued by Arizona Department of Water Resources (ADWR) Dam Safety Division; and the U.S. Army Corps of Engineers (COE) Section 404 Fill and Dredge permit. FCDMC is primarily responsible for obtaining these permits, however, CH2M HILL is assisting in preparing applications and in coordinating the permitting efforts. Prior to construction, a U.S. EPA Stormwater NPDES permit for construction activities will also be required.

ADWR Dam Safety Permit

The objective of ADWR's Dam Safety Permit is to ensure that the dam is designed in accordance with state standards and regulations. Under ADWR criteria, the dam will be classified as a "small, high hazard" dam. This designation places certain design criteria on the spillway capacity and freeboard requirements.

CH2M HILL has coordinated with ADWR during the concept design analyses. The hydrologic analyses have been submitted to ADWR for review. This Concept Design Report and 25% design submittal will be provided to ADWR following review by the District.

U.S. COE Section 404 Permit

Section 404 of the federal Clean Water Act regulates the "discharge of fill material into 'Waters of the U.S.'." This permit, administered by the COE, requires that various resource agencies and interested parties be given the opportunity to review and comment on the project. To streamline the process for certain types of projects, a number of Nationwide Permits have been granted. This project appears to meet the requirements of Nationwide Permit 26, which covers certain projects affecting less than 10 acres.

A pre-application meeting has been scheduled with the COE by the District for June 13, 1994. Based on the results of that meeting, the permit application will be prepared and submitted to the U.S. Army Corps of Engineers for review.

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Section 6.
Concept Design Recommendations

Dam and Spillway

As part of the concept design analysis, two dam alignments were identified and staked in the field during the initial field and geotechnical investigations. They were based on the geotechnical setting (for instance, the location of abutments) as well as the storage capacity needed to impound the 100-year storm. Both alignments are consistent with the concept location first presented by the FCDMC. Figures 6-1 and 6-2 show the alignments with respect to the existing topography.

A number of assumptions were made regarding the basic earth dam and spillway geometry. They are as follows:

- The soils excavated from the detention basin would be used to construct the earth dam
- The dam would be homogeneous with a 4-foot-wide granular chimney drain to control seepage
- Overexcavation for the foundation would be required to approximately 6 feet deep
- Top width of the dam would be 20 feet for accessibility and dam stability
- Side slope on both faces would be 3:1 based on an initial geotechnical evaluation and maintenance requirements
- Spillway crest width would be 200 feet, and crest elevation 5954.5 (initial hydraulic analysis)
- Top of dam elevation would be 5960.5 feet based on hydrologic study
- The spillway would be an Ogee-type configuration, and taper to an 80-foot-wide stilling detention basin with energy dissipaters
- The detention basin outlet works would consist of a 36-inch-diameter pipe with a 20-inch-diameter orifice plate

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04-07-94 5441C005.DWG

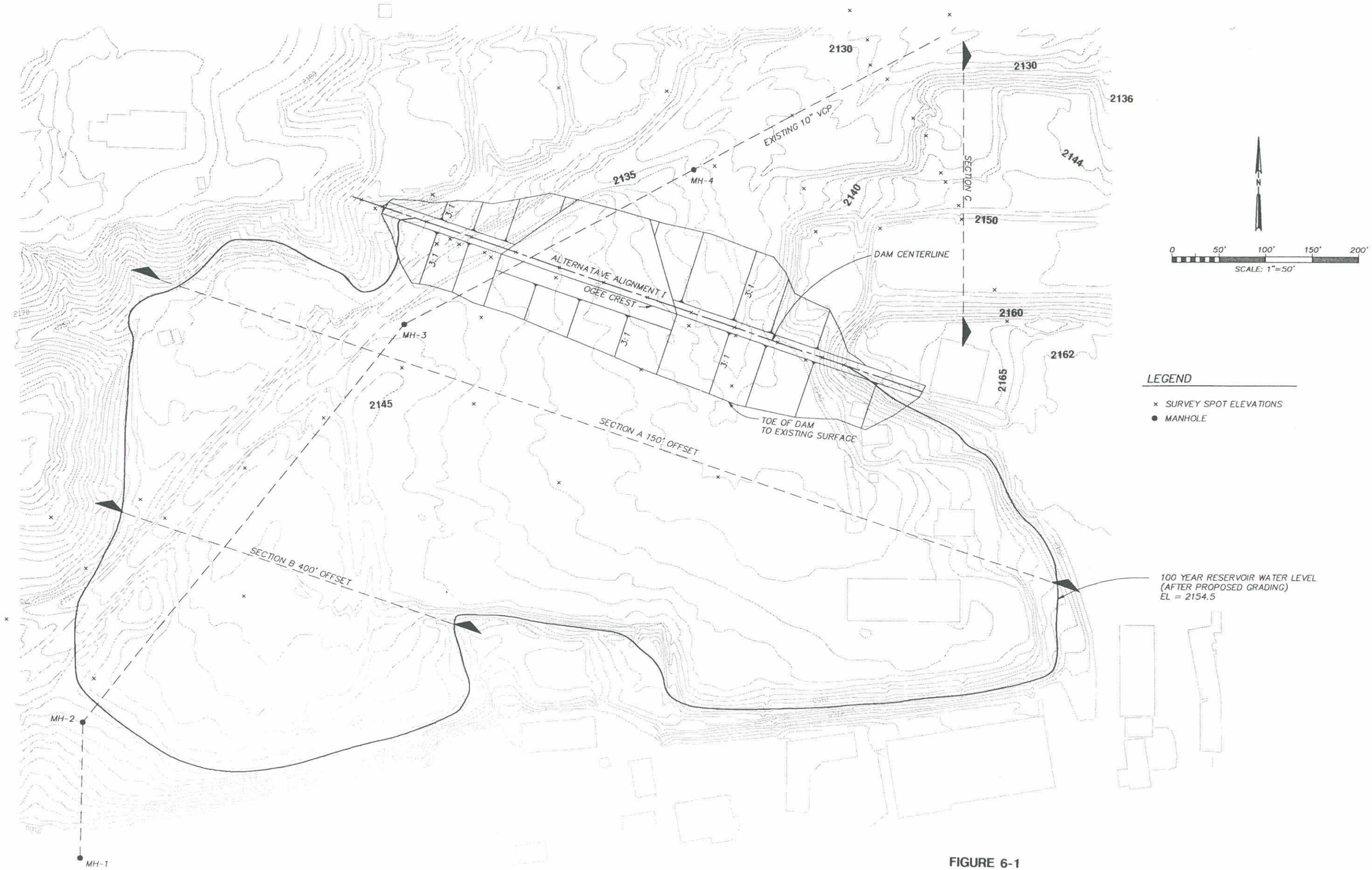

FIGURE 6-1

CH2M HILL	DSGN					
	DR SWW35441\5441C005					
	CHK					
	APVD	NO	DATE	REVISION	BY	APVD

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VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

ALTERNATIVE DAM ALIGNMENT I

CASANDRO WASH DETENTION BASIN
WICKENBURG, AZ.

SHEET 1
DWG NO.
DATE
PROJ NO.

PRELIMINARY

04-07-94 5441C003.DWG

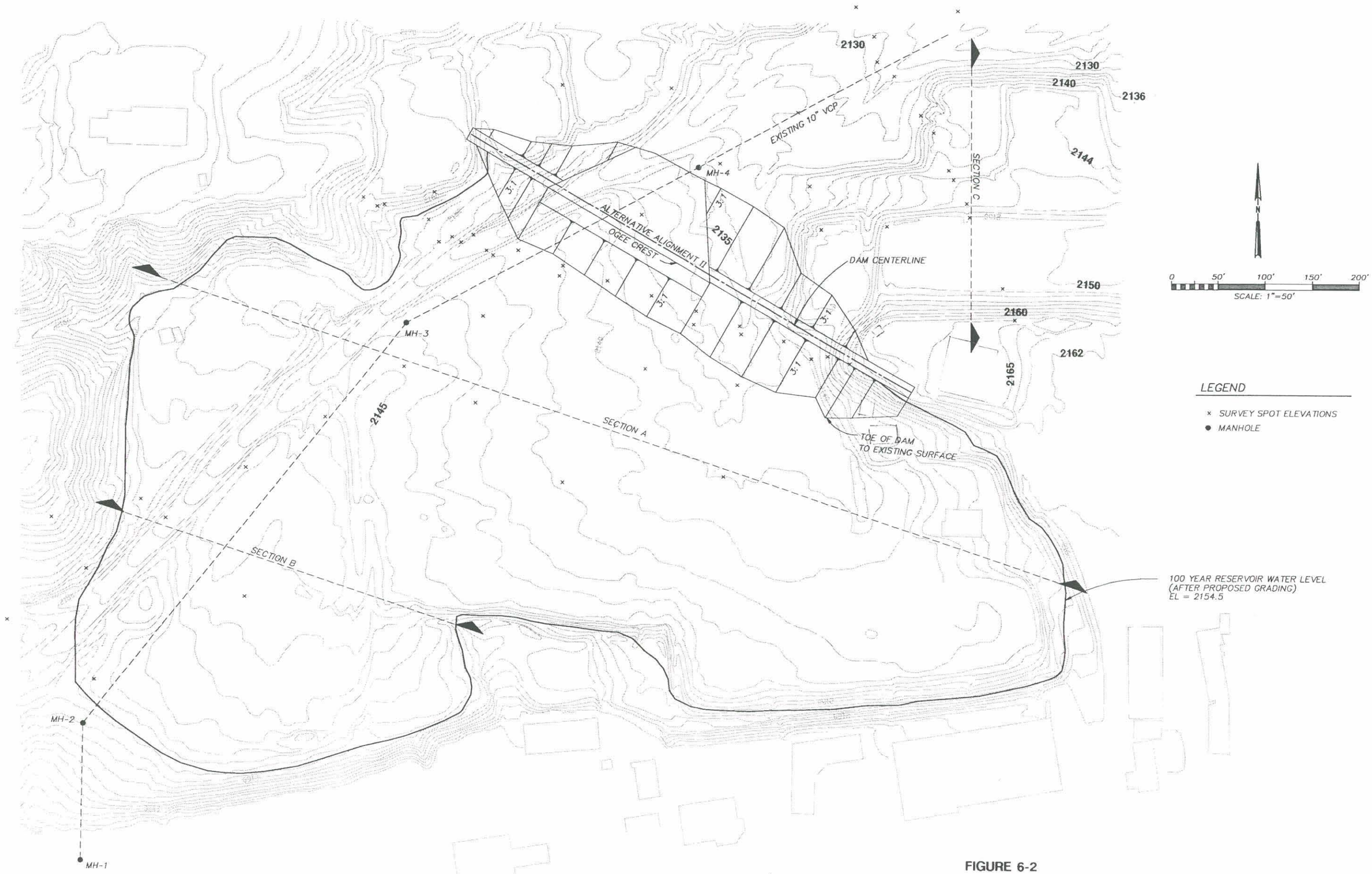

FIGURE 6-2

CH2M HILL	DSGN					
	DR SWW35441\5441C003					
	CHK					
	APVD	NO.	DATE	REVISION	BY	APVD

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ALTERNATIVE DAM ALIGNMENT II

CASANDRO WASH DETENTION BASIN
WICKENBURG, AZ.

SHEET 2
DWG NO.
DATE
PROJ NO.

PRELIMINARY

The concept design alternative analysis consisted of developing preliminary earthwork quantities and order-of-magnitude construction cost estimates to determine the preferred layout. The results of this analysis showed that the Alignment II alternative was more cost effective than Alignment I. Alignment II is shorter, requires less earthwork, and provides better hydraulics for the spillway.

Using the Alignment II alternative, a digital terrain model was prepared to verify the detention basin's storage capacity, check the earthwork calculations, and prepare typical sections through the detention basin. The model and manual calculations checked within less than two percent of each other.

A concept design grading plan was prepared consistent with the storage capacity needs for the detention basin. The grading plan used adjacent land east of the dam as a disposal site for the excess soil. The prospective disposal area is presently graded in a tiered fashion and is within the 100-year floodplain delineation. It was thought that by filling this site with the overexcavated material from the detention basin, the site could be regraded and become developable property. Consideration has already been given (by others) to develop this land as a park.

Two options were reviewed for the spillway construction: structural concrete and RCC. Several construction contractors having experience with RCC placement were contacted to discuss constructibility and costs. The cost of setting up and operating a pug mill to produce approximately 1,500 CY of the RCC mix made that option more costly than structural concrete. Thus, structural reinforced concrete appears to be the most cost-effective option for constructing the spillway and energy dissipator.

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Sewer Relocation

The dam location and detention basin grading were the primary factors in determining the extent of sanitary sewer relocation. A profile of the existing sewer was prepared from as-built drawings. The digital terrain model, proposed grading plan, and dam alignment were superimposed on the profile to determine the extent of required sewer relocation. Approximately 950 lineal feet of sewerline and three manholes had to be relocated to avoid conflicts. Two alignments were investigated for the relocated sewer. The first alignment routed the sewerline around the north side of the dam. This alignment requires trench excavation and manhole depths over 35 feet. It was dismissed as impractical to construct. The second alignment consisted of routing the sewer under the dam, which became the preferred alternative. Relocation under the dam and detention basin requires lowering the sewer by flattening its slope. This can be accomplished with a constant slope on the pipe and relocating the sewer alignment as shown in the plans submittal. The full flow capacity of the

proposed sewer pipe is approximately 4.2 cfs, more than twice the existing pipe through the same reach. Since the detention basin will likely impound water several times per year, watertight frames and covers will also be required within the detention basin. Under the dam the pipe will have to be encased in concrete.

The Town of Wickenburg's Public Works Department and consulting engineer were contacted to discuss the limiting criteria for the sewer relocation. These criteria are summarized in Section 6, Concept Design Recommendations.

Design recommendations for the sewer relocation are:

- Sewer and manhole details should be in accordance with MAG standards.
- Relocated sewer pipe should be 12-inch RGRCP, ASTM C-76
- D-Load = 18,000 lbs\ft.
- Trench condition should be Class B (Compacted granular bedding), except for within 20 feet of toe of dam where trench should be concrete encased to 0.7D above pipe invert
- Minimum slope should be 0.01 percent
- Maximum length of sewer line between manholes should be 500 feet
- Maximum depth of manholes should be 20 feet
- Manholes within the detention basin and downstream manholes subjected to flood conditions should be retrofitted with watertight frames and covers.

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Other Utilities

If required, adjustments to service connections will be designed in accordance with UBC and MAG standards.

Maintenance Roads

Maintenance roads are not for general public use. Therefore, the recommendations for roadway design stated in the AASHTO Policy on Geometric Design of Highways and Streets may not be fully applicable. Access to the dam will use portions of existing private drives off the public streets. Roads for maintenance access will spur off the private drives and extend to the top of the dam on both the north and south side of the spillway, as well as to the upstream and downstream toes. The maintenance road design must accommodate county maintenance and emergency vehicles. The road on the north side will also provide access around the dam for occasional nonvehicle recreational use. Therefore the maintenance roads will be based on

less than a 20-mph design speed. The following criteria are recommended based on the types of maintenance vehicles anticipated:

- Turning radius based on SU-30 vehicles.
- Maximum grade of 12 percent, with 80-foot vertical curves.
- Roadway width will be approximately 14 feet.
- Minimum structural section of maintenance roads will be 6-inch ABC.

Outlet Pipe through Dam

The following criteria are recommended for the outlet pipe through the dam:

- Outlet pipe shall be 36-inch RGRCP, ASTM C-76. D-Load = 18,000 lbs/ft. Trench shall be encased in concrete to 6 inches above spring line

Structural Elements

The following criteria are recommended for structural elements:

- Structural elements will be designed in accordance with AISC and ACI requirements.

Landscaping

The landscaping plan and recommendations are presented in Appendix B.

Preliminary Construction Costs and Schedule

The budget level opinion of probable cost for the detention basin and dam project are summarized in Table 6-1. Detailed estimate is presented in Appendix D. Estimates were developed for the major elements as shown in the concept design submittal. A 20-percent contingency was applied for minor items not specifically identified or shown.

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Table 6-1 Budget Level Opinion of Probable Cost Casandro Wash	
Description	**TOTAL**
A. Detention basin Construction	$252,650
B. Dam Construction	$194,350
C. Structures	$383,650
D. Sewer Realignment	$58,450
E. Site Development	$31,650
F. Down Stream Improvements	$70,200
Subtotal Construction Cost	**$991,000**
Construction Contingency	$258,000
Construction Testing and Administration	$89,000
Total Construction Cost	**$1,338,000**

Figure 6-3 presents the preliminary construction schedule showing the bid, award, and construction phases, as well as the major items of work within each phase. The purpose of the schedule is to obtain an understanding of the overall project sequencing, to verify the project's constructibility, and to determine an approximate duration of construction.

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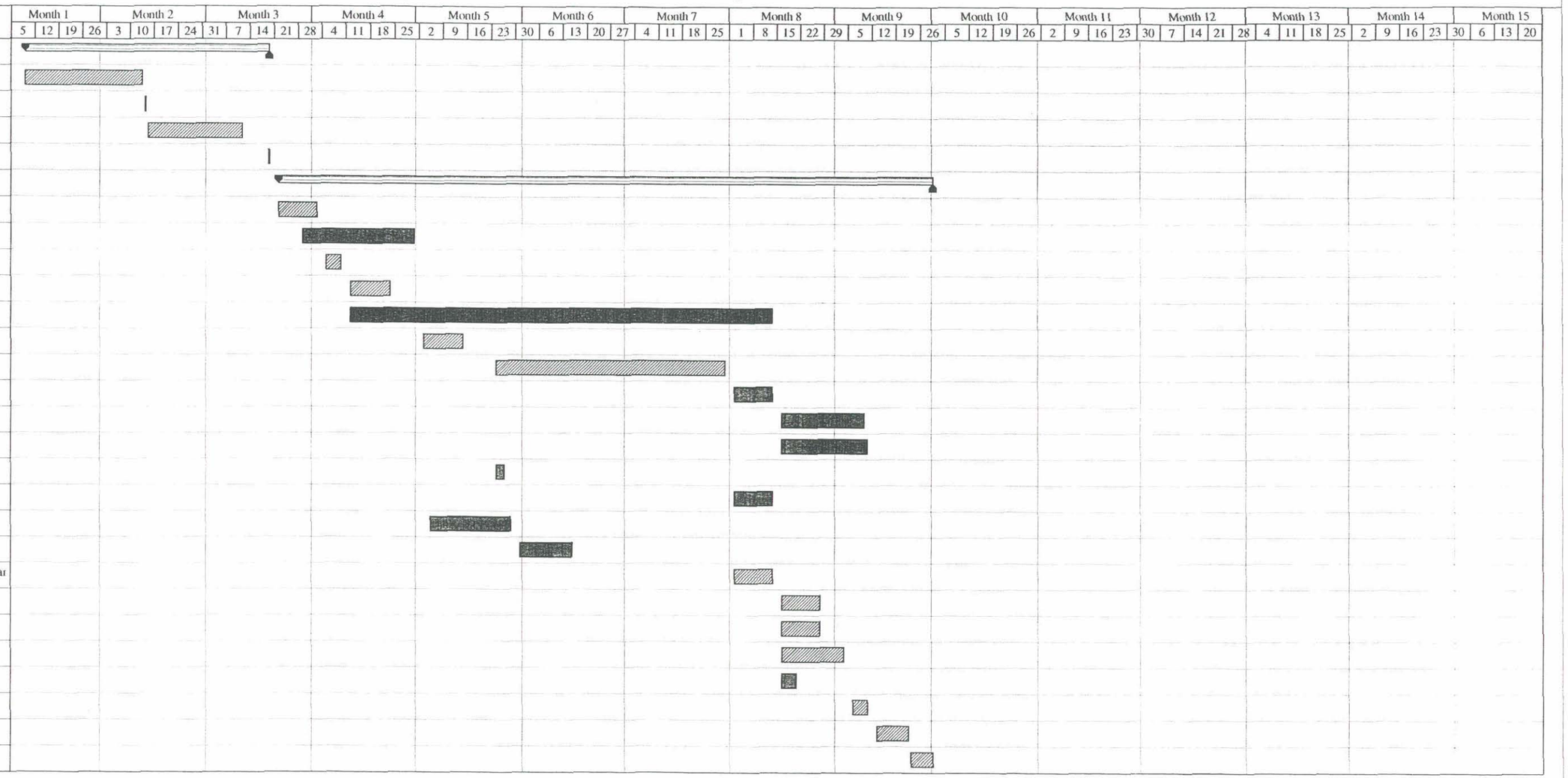
Figure 6-3. Casandro Wash Preliminary Construction Schedule

ID	Name
1	BID/AWARD PHASE
2	Adv to Bid
3	Bid Opening
4	Award Contract
5	Notice to Proceed
6	CONSTRUCTION PHASE
7	Mobilization
8	Construction Survey
9	Develop Water Supply
10	Prewet Borrow Area
11	Excavate Basin (70,000cy)
12	Foundation Excavation
13	Dam Embankment
14	Excavate Spillway
15	CIP - Spillway Conc.
16	CIP Dissipator Conc.
17	Outlet Pipe
18	CIP Inlet/Outlet Structure
19	Install New MH & Line
20	Remove Existing MH & Line
21	Finish Grade Detention Basin/Dar
22	Access Road
23	Landscaping
24	Fencing
25	Signing
26	Downstream Grading
27	Rip/Rap
28	Demobilization



Project:
Date: 6/9/94

Critical Noncritical Progress Milestone Summary Rolled Up

Appendixes

Appendix A.

Plan Sheets

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
9	AZ.		1		

PRELIMINARY-NOT FOR CONSTRUCTION OR RECORDING

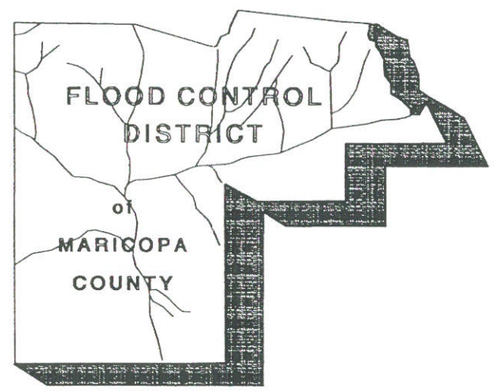
SYTIME DGN SPECIFICATION 5441p100.dgn

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Construction Plans
For

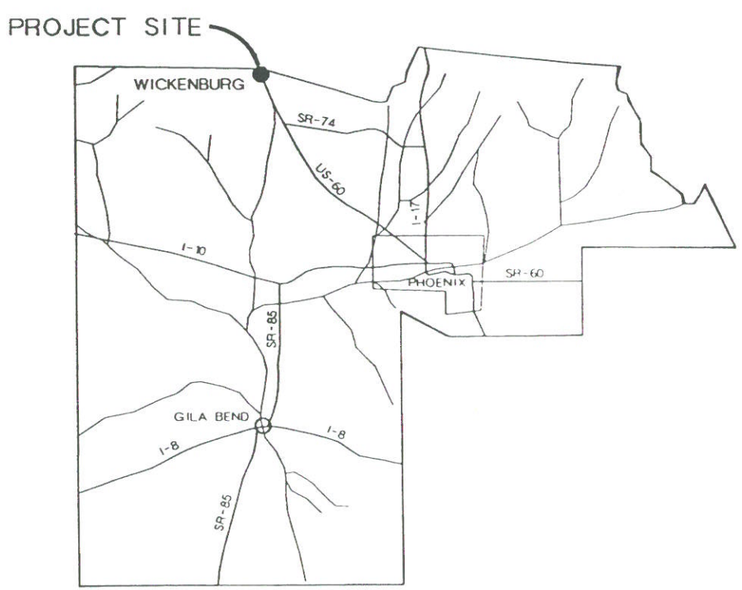
CASANDRO WASH - DAM AND RESERVOIR

FCD-94-XX

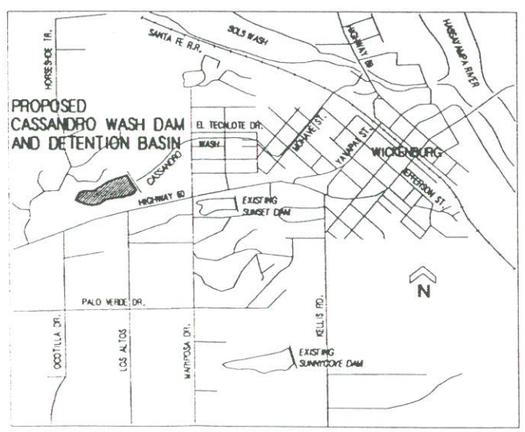


DRAWING LIST

1. COVERSHEET/LOCATION MAP
2. GENERAL NOTES/ABBREVIATIONS/LEGEND
3. SITE LAYOUT/SURVEY CONTROL
4. GRADING PLAN
5. PLAN & PROFILE - ACCESS ROAD A
6. PLAN & PROFILE - ACCESS ROADS B AND C
7. RESERVOIR SECTIONS
8. DAM SECTIONS
9. SPILLWAY/STILLING BASIN PLAN
10. STRUCTURAL SECTIONS
11. STRUCTURAL DETAILS - OGEE CREST
12. STRUCTURAL DETAILS - SPILLWAY
13. STRUCTURAL DETAILS - STILLING BASIN
14. STRUCTURAL DETAILS - STILLING BASIN
15. SANITARY SEWER RELOCATION - PLAN & PROFILE
16. SANITARY SEWER DETAILS
17. OUTLET PIPE PROFILE AND DETAILS
18. OINTACE PLATE AND RELIEF GATE DETAILS
19. SITE CIVIL & FENCE DETAILS
20. LANDSCAPING PLAN
21. PLANTING SCHEDULE AND DETAILS



VICINITY MAP



PROJECT SITE

NO.	REVISION	BY	DATE
3			
2			
1			

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
FLOOD CONTROL DISTRICT

COVER SHEET

NOT FOR CONSTRUCTION

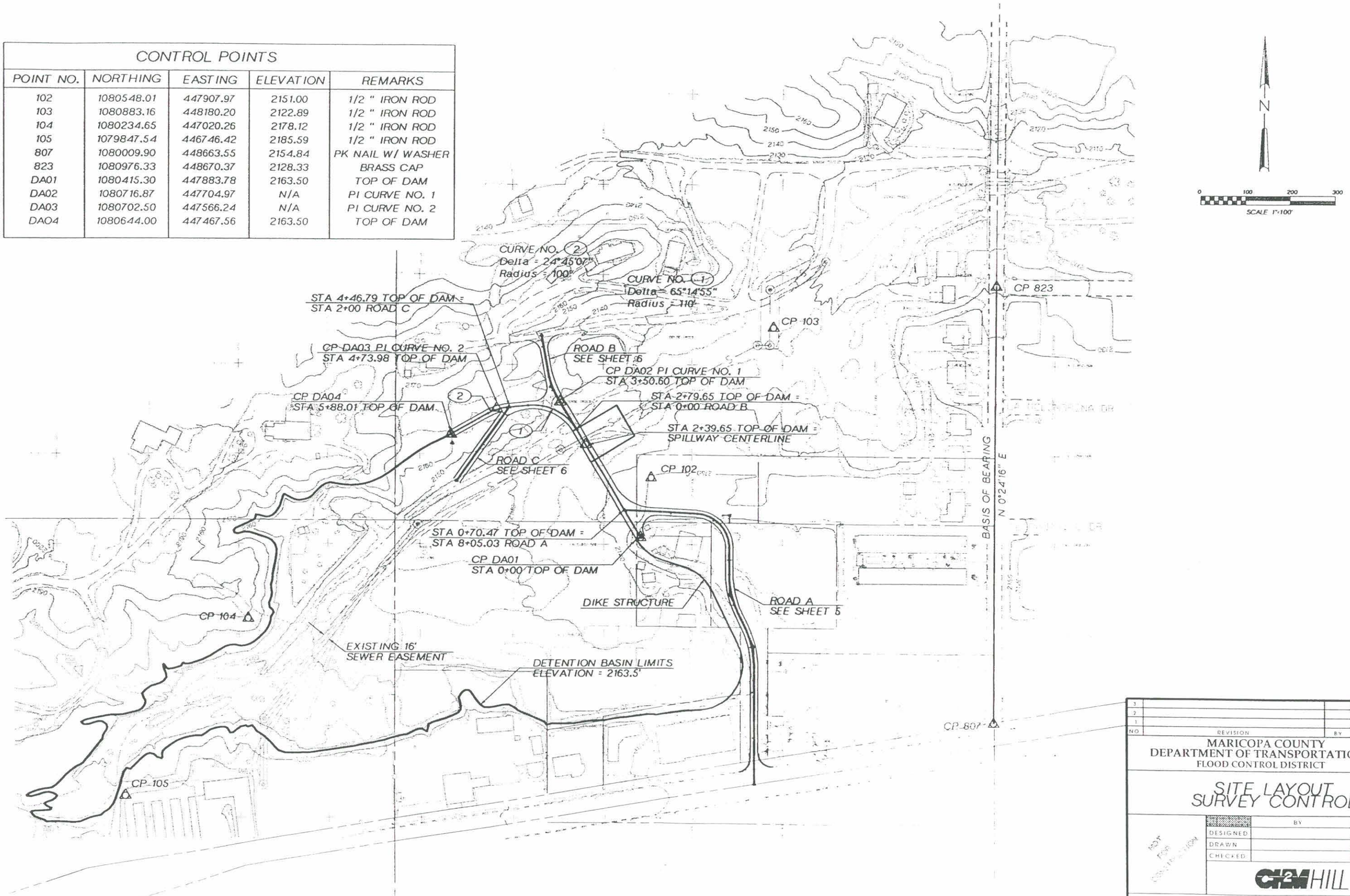
	BY	DATE
DESIGNED		
DRAWN		
CHECKED		

CH2M HILL

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
9	AZ.		3		

CONTROL POINTS

POINT NO.	NORTHING	EASTING	ELEVATION	REMARKS
102	1080548.01	447907.97	2151.00	1/2 " IRON ROD
103	1080883.16	448180.20	2122.89	1/2 " IRON ROD
104	1080234.65	447020.26	2178.12	1/2 " IRON ROD
105	1079847.54	446746.42	2185.59	1/2 " IRON ROD
807	1080009.90	448663.55	2154.84	PK NAIL W/ WASHER
823	1080976.33	448670.37	2128.33	BRASS CAP
DA01	1080415.30	447883.78	2163.50	TOP OF DAM
DA02	1080716.87	447704.97	N/A	PI CURVE NO. 1
DA03	1080702.50	447566.24	N/A	PI CURVE NO. 2
DA04	1080644.00	447467.56	2163.50	TOP OF DAM



NO	REVISION	BY	DATE
3			
2			
1			

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
FLOOD CONTROL DISTRICT

SITE LAYOUT SURVEY CONTROL

NOT FOR CONSTRUCTION

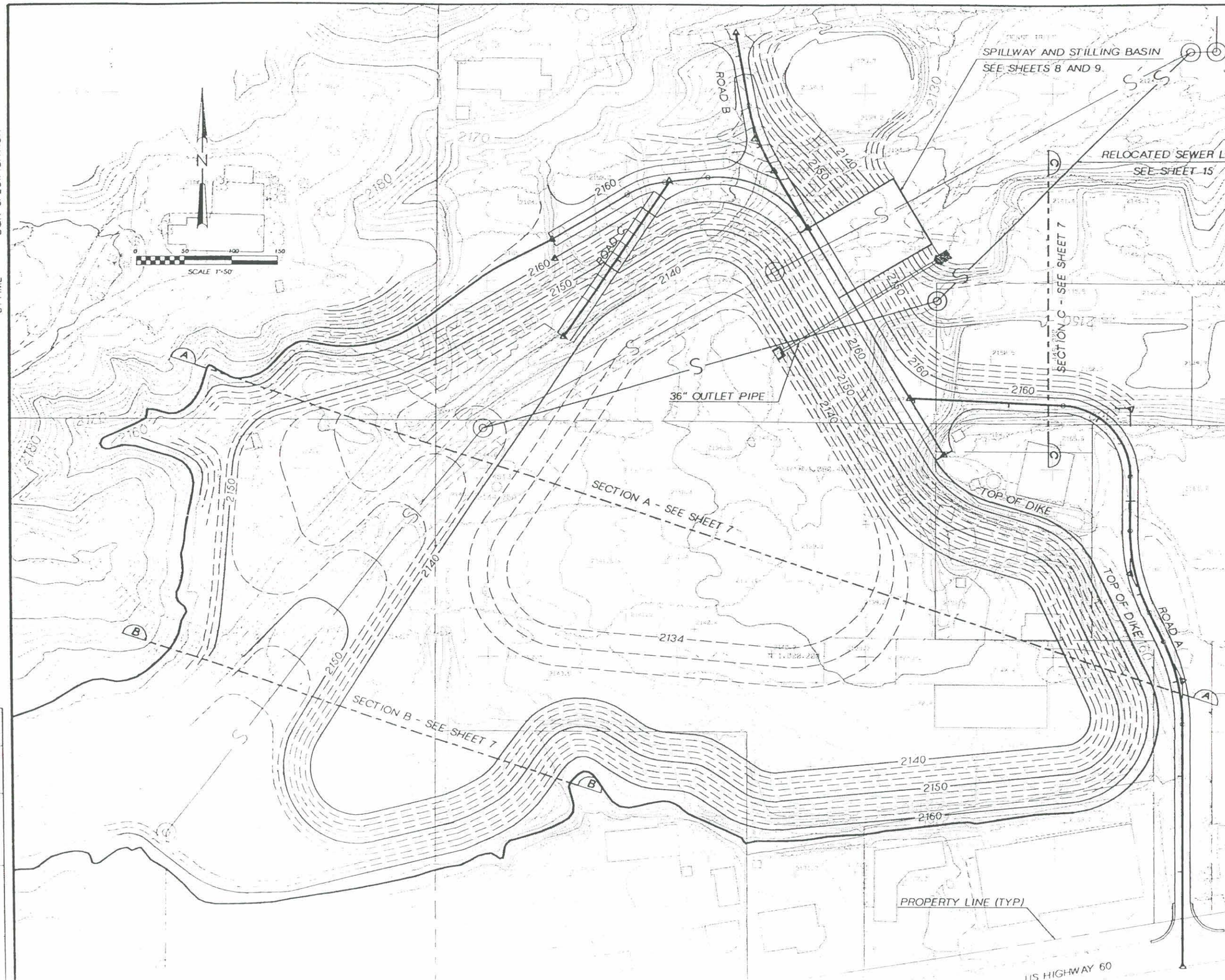
	BY	DATE
DESIGNED		
DRAWN		
CHECKED		

CH2M HILL

SYTIME DGN SPECIFICATION 5441P102.DGN

F IM RY. T F OC TRL TION 3 R DRE 3

F.H.W.A. REGION	STATE	PROJECT NO	SHEET NO	TOTAL SHEETS	RECORD DRAWING
9	AZ		4		



MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
FLOOD CONTROL DISTRICT

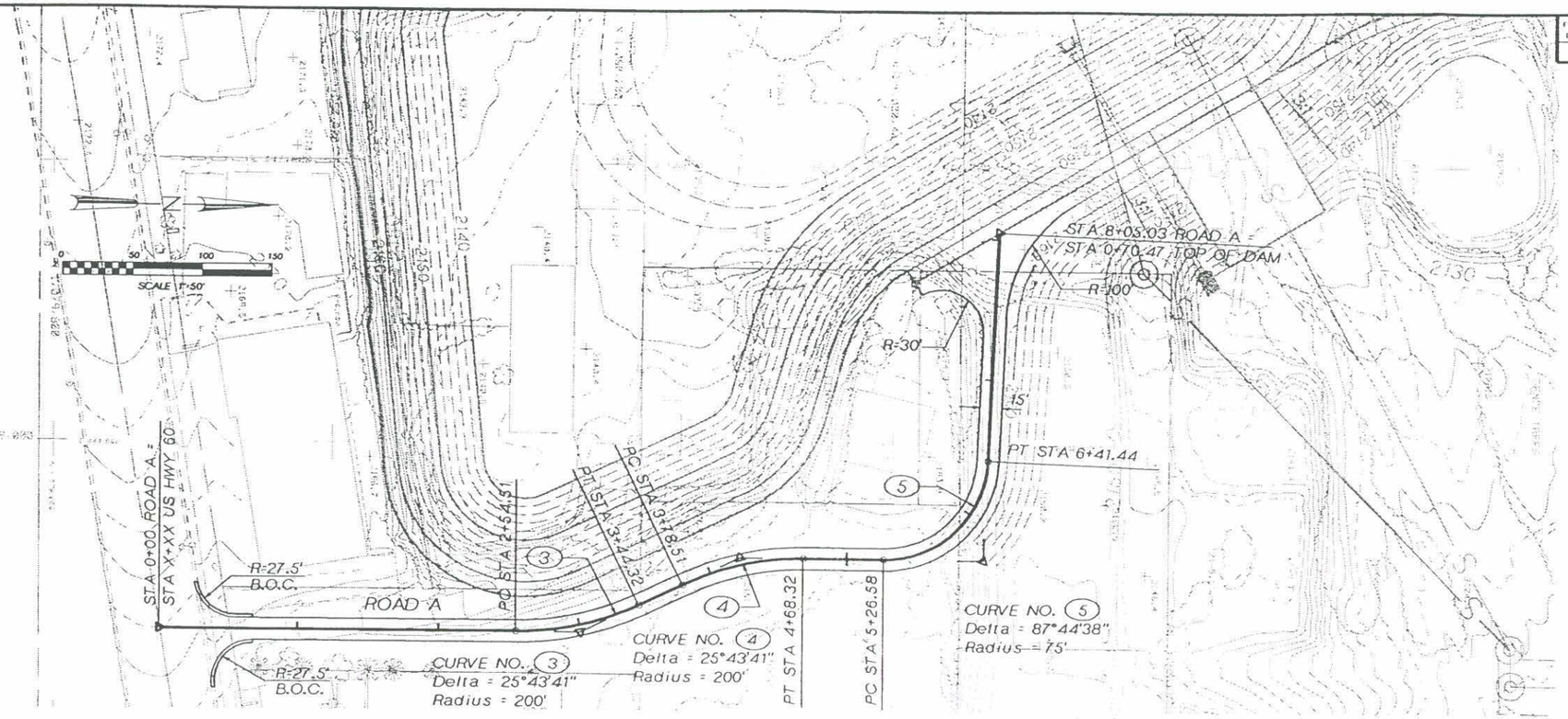
GRADING PLAN

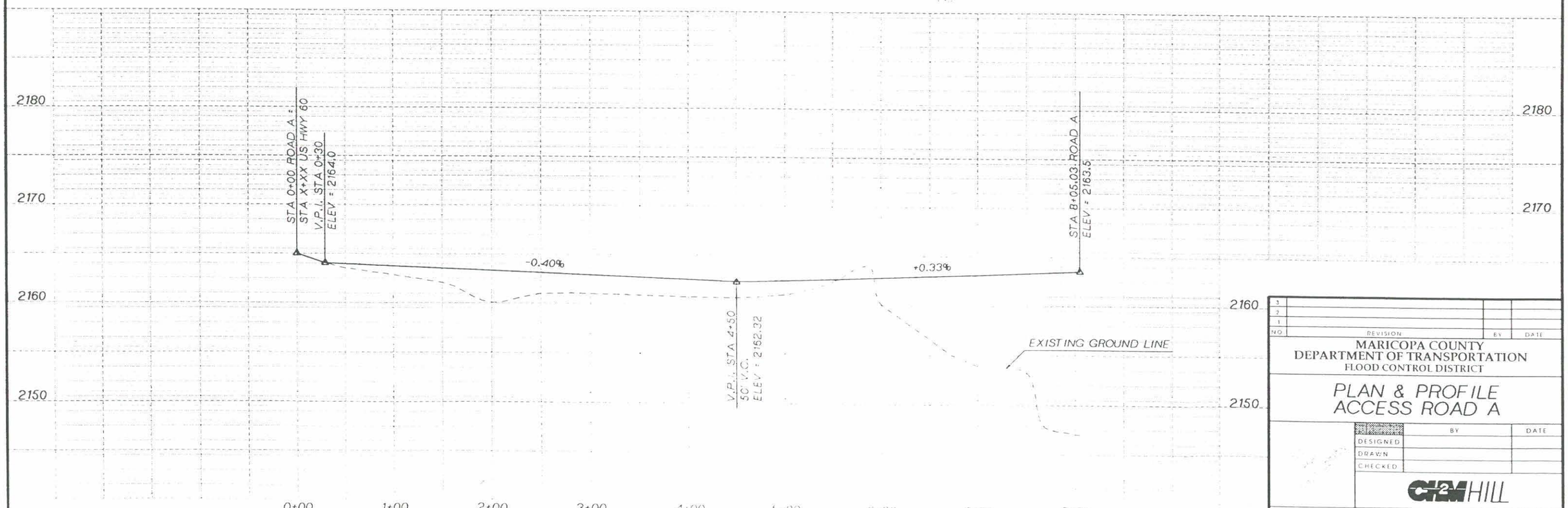
CH2M HILL

SYTIME DGN SPECIFICATION 5441p103.dgn

PRELIMINARY - NOT FOR CONSTRUCTION OR RECORDING

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
9	AZ.		5		





NO	REVISION	BY	DATE
3			
2			
1			

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
FLOOD CONTROL DISTRICT

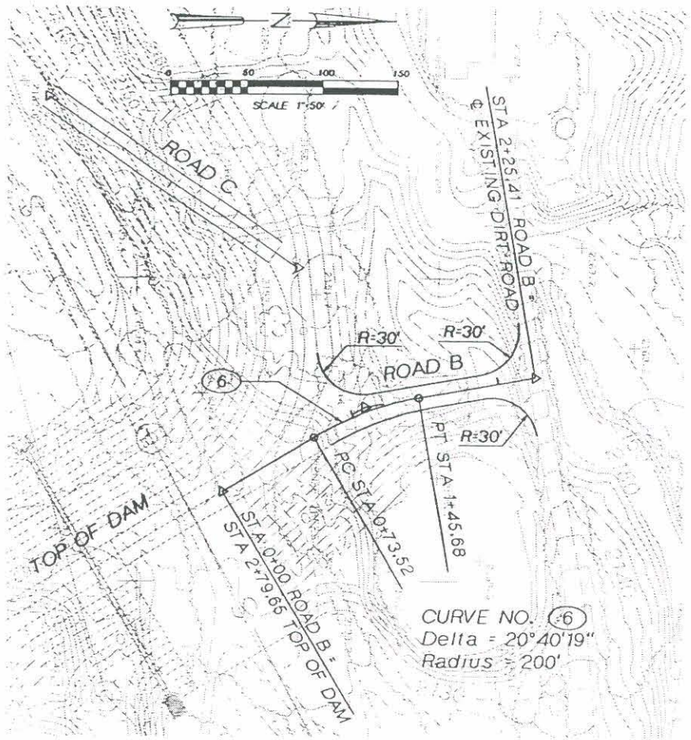
PLAN & PROFILE ACCESS ROAD A

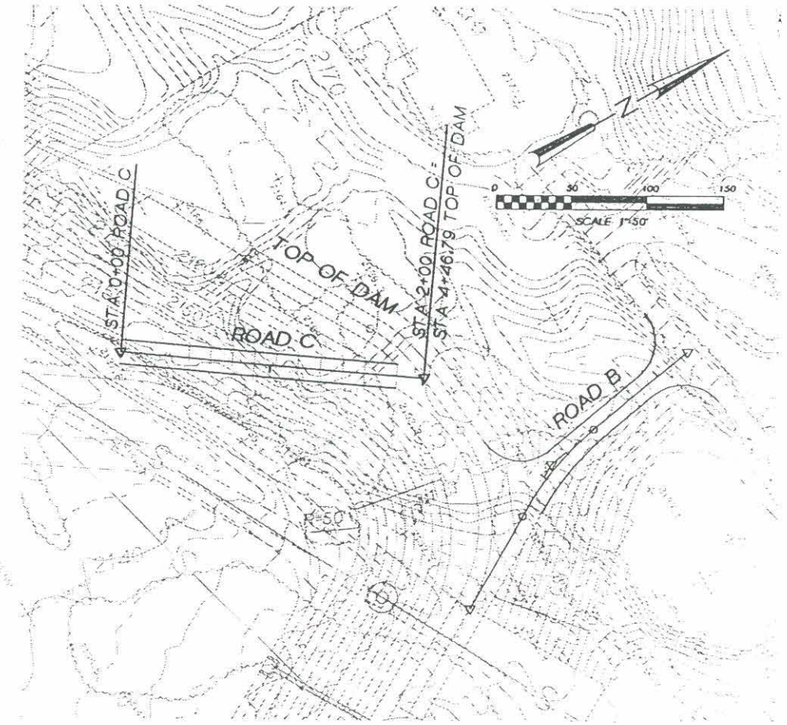
	BY	DATE
DESIGNED		
DRAWN		
CHECKED		

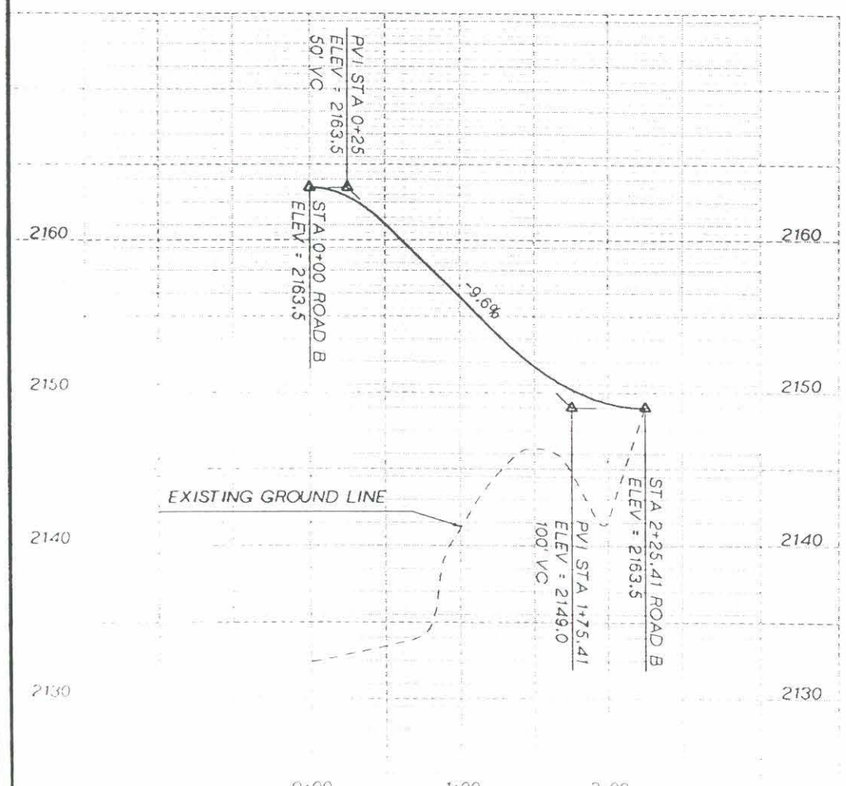
CH2M HILL

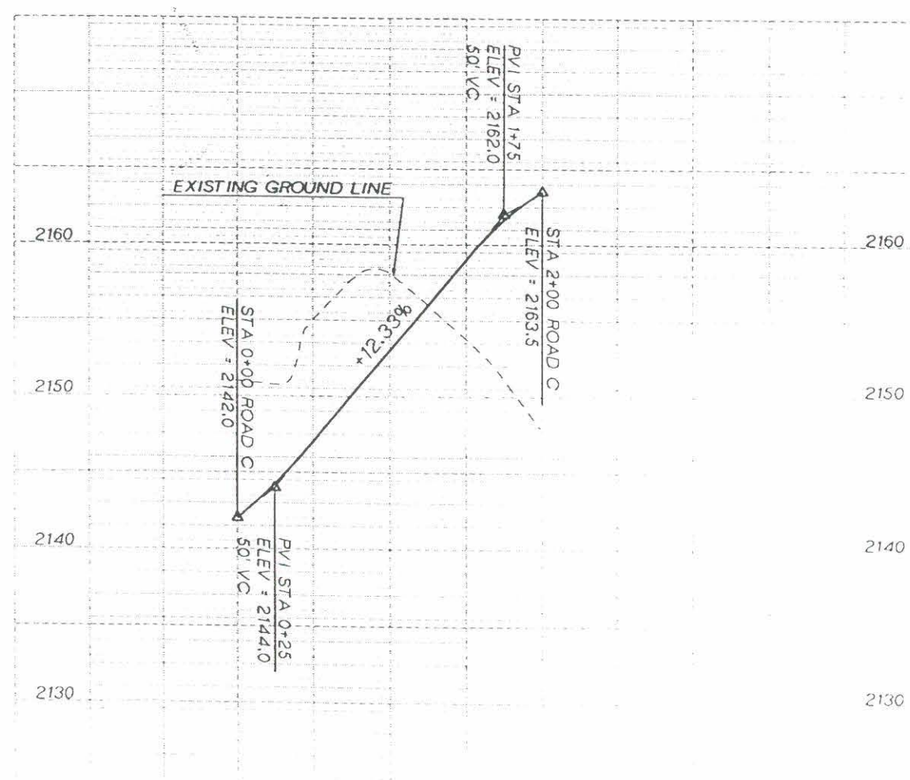
SYTIME DGN SPECIFICATION 5441P105.DGN

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
9	AZ.		6		









			DATE

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
FLOOD CONTROL DISTRICT

PLAN & PROFILE
ACCESS ROADS B & C

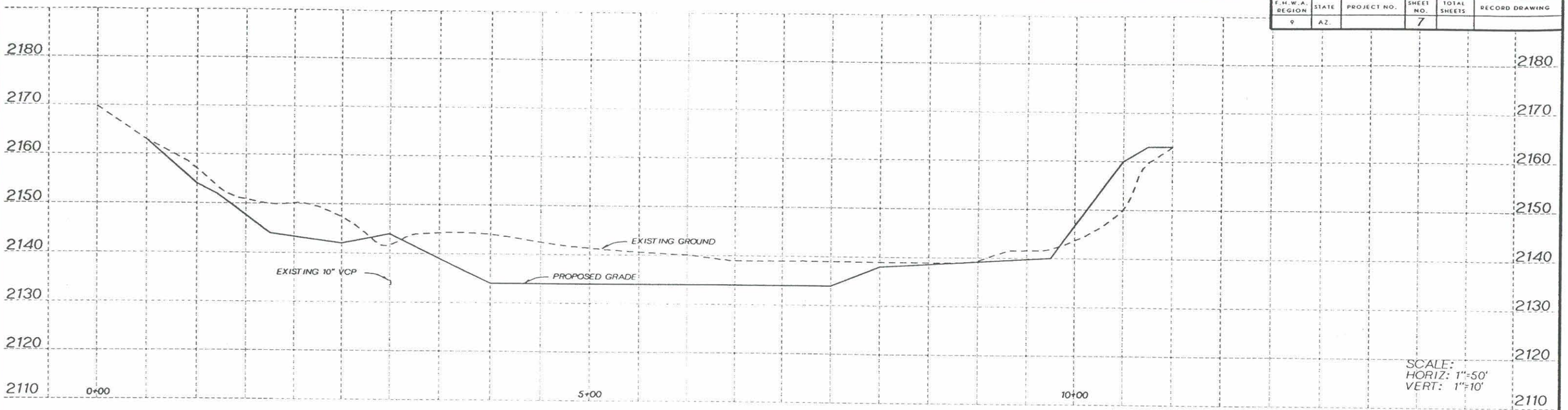
			DATE

CH2M HILL

SYTIME DGN SPECIFICATION 5441P106.DGN

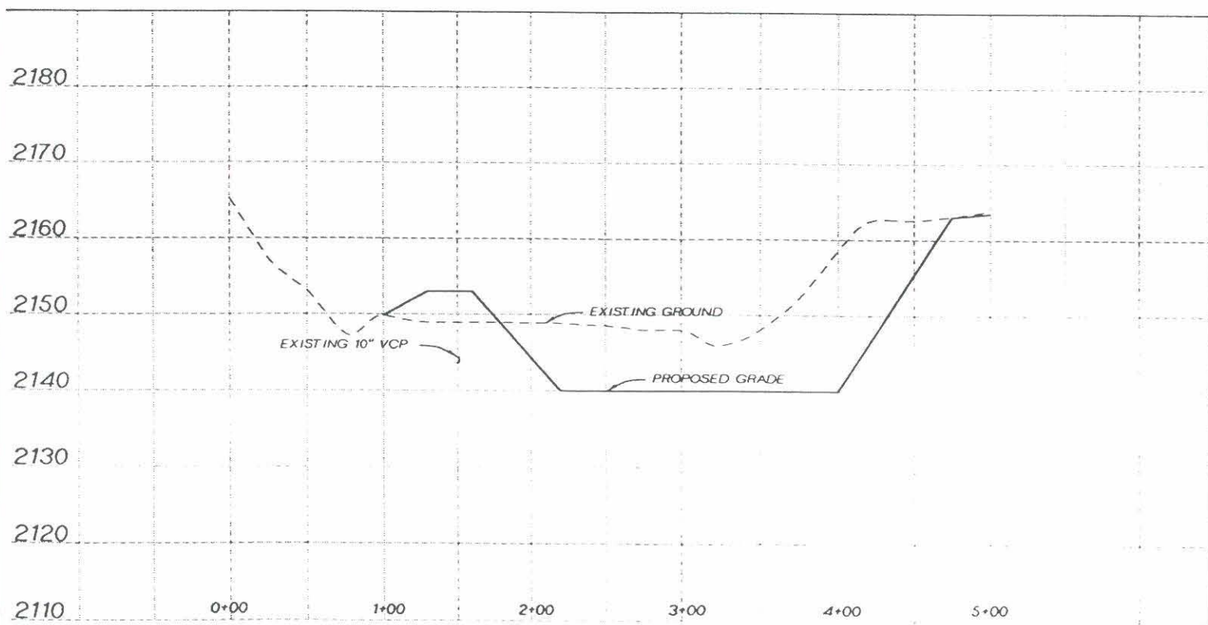
PLOT FOR CONSTRUCTION OR RECORDING

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
9	AZ.		7		



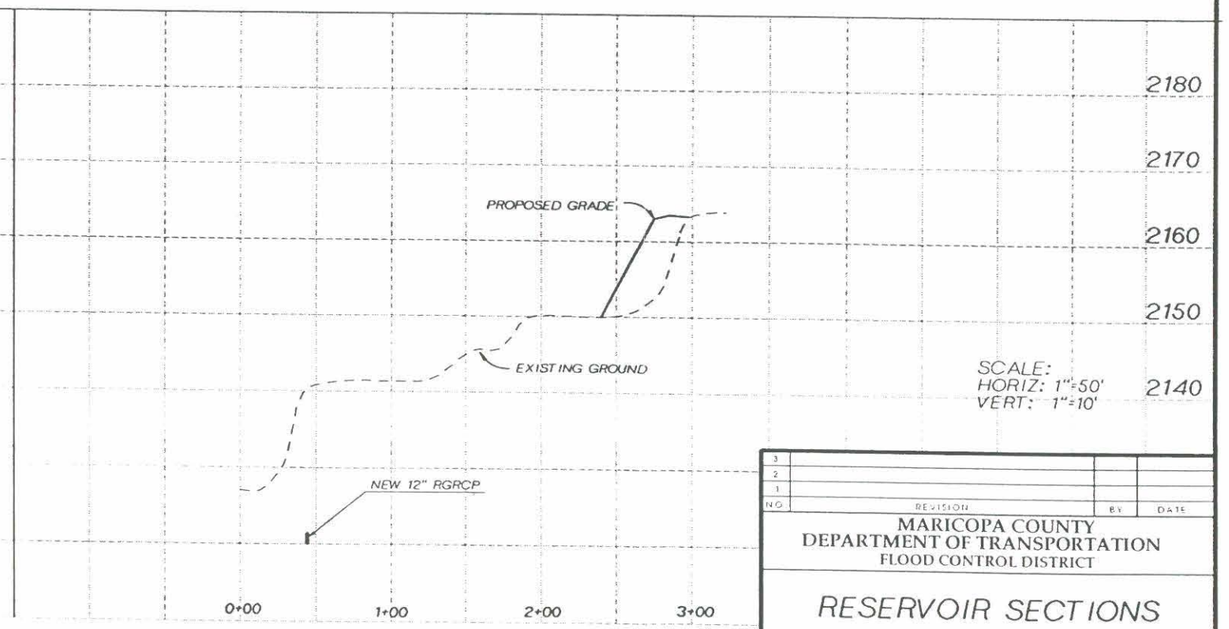
SECTION (A)

SEE SHEET 4



SECTION (B)

SEE SHEET 4



SECTION (C)

SEE SHEET 4

NO.	REVISION	BY	DATE
3			
2			
1			

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
FLOOD CONTROL DISTRICT

RESERVOIR SECTIONS

	BY	DATE
DESIGNED		
DRAWN		
CHECKED		

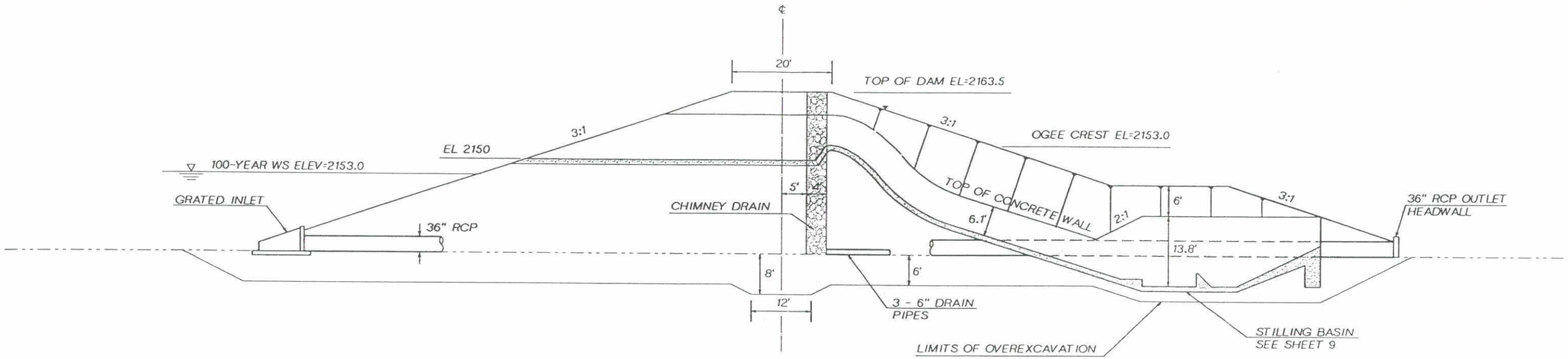
NOT FOR CONSTRUCTION

CH2M HILL

PRELIMINARY - NOT FOR CONSTRUCTION OR RECORDING

SYTIME DGN SPECIFICATION 5441P107.DGN

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
9	AZ.		8		



TYPICAL SECTION

SCALE: 1"=10'

NO	REVISION	BY	DATE
3			
2			
1			

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
FLOOD CONTROL DISTRICT

DAM SECTIONS

	BY	DATE
DESIGNED		
DRAWN		
CHECKED		

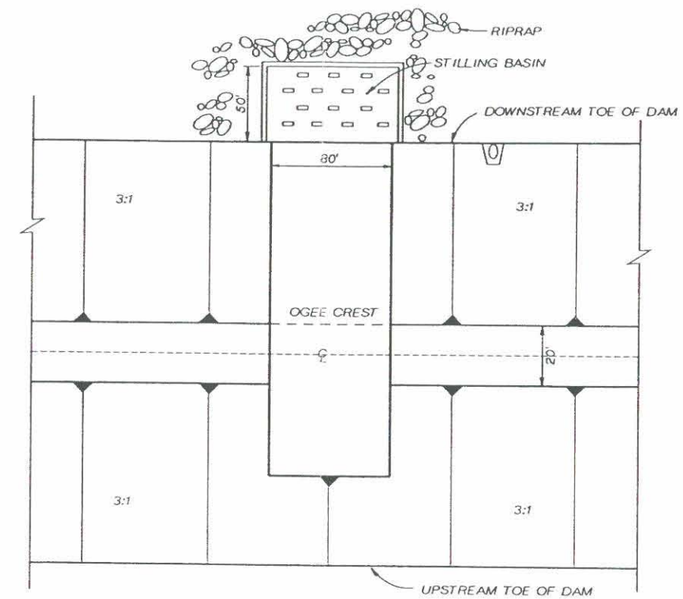
CH2M HILL

DGN SPECIFICATION 5441P108.DGN

SYTIME

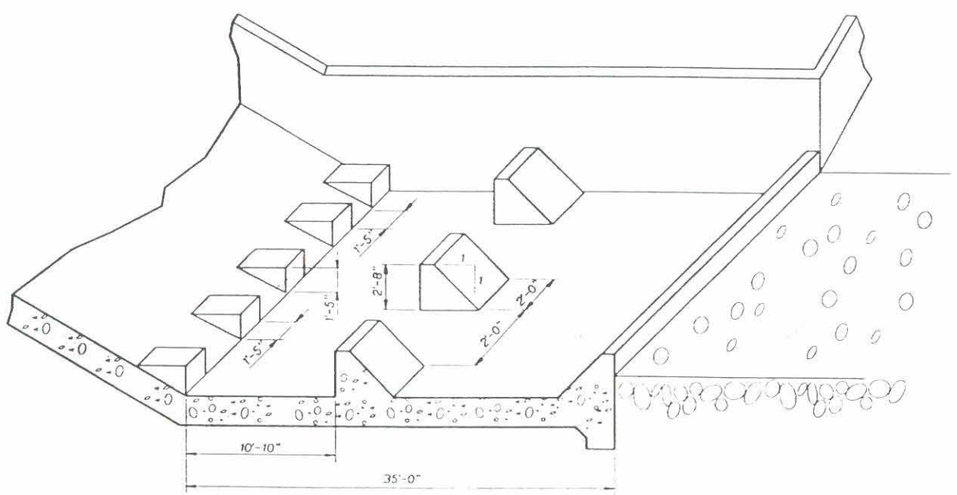
F IM RY- T F CC TRUCTION AS RECORDED

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
9	AZ.		9		



SPILLWAY PLAN VIEW

SCALE: 1"=50'



STILLING BASIN DETAIL

NTS

Drain basin

NO	REVISION	BY	DATE
3			
2			
1			

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
FLOOD CONTROL DISTRICT

SPILLWAY/STILLING BASIN

NOT FOR CONSTRUCTION

	BY	DATE
DESIGNED		
DRAWN		
CHECKED		

CH2M HILL

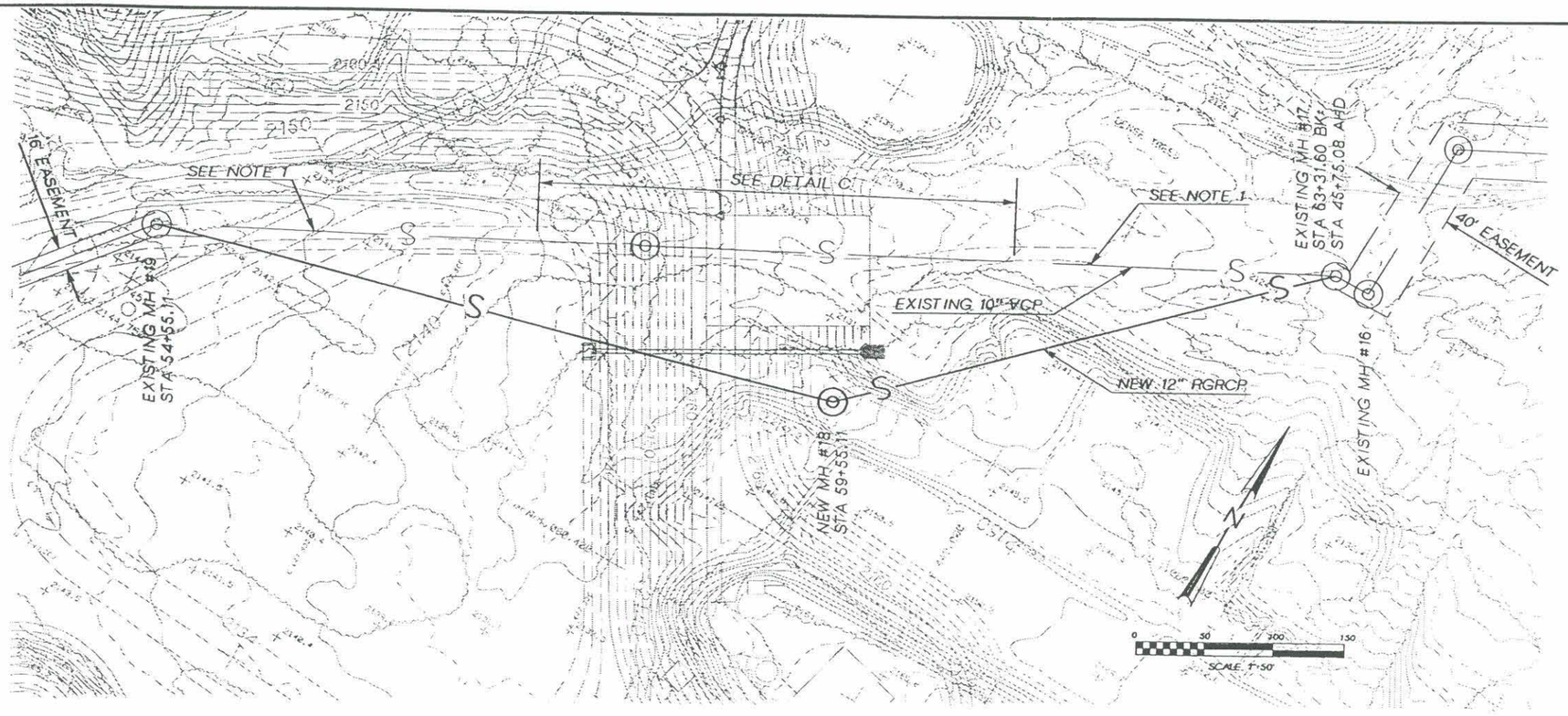
SYTIME DGN SPECIFICATION 5441P109.DGN

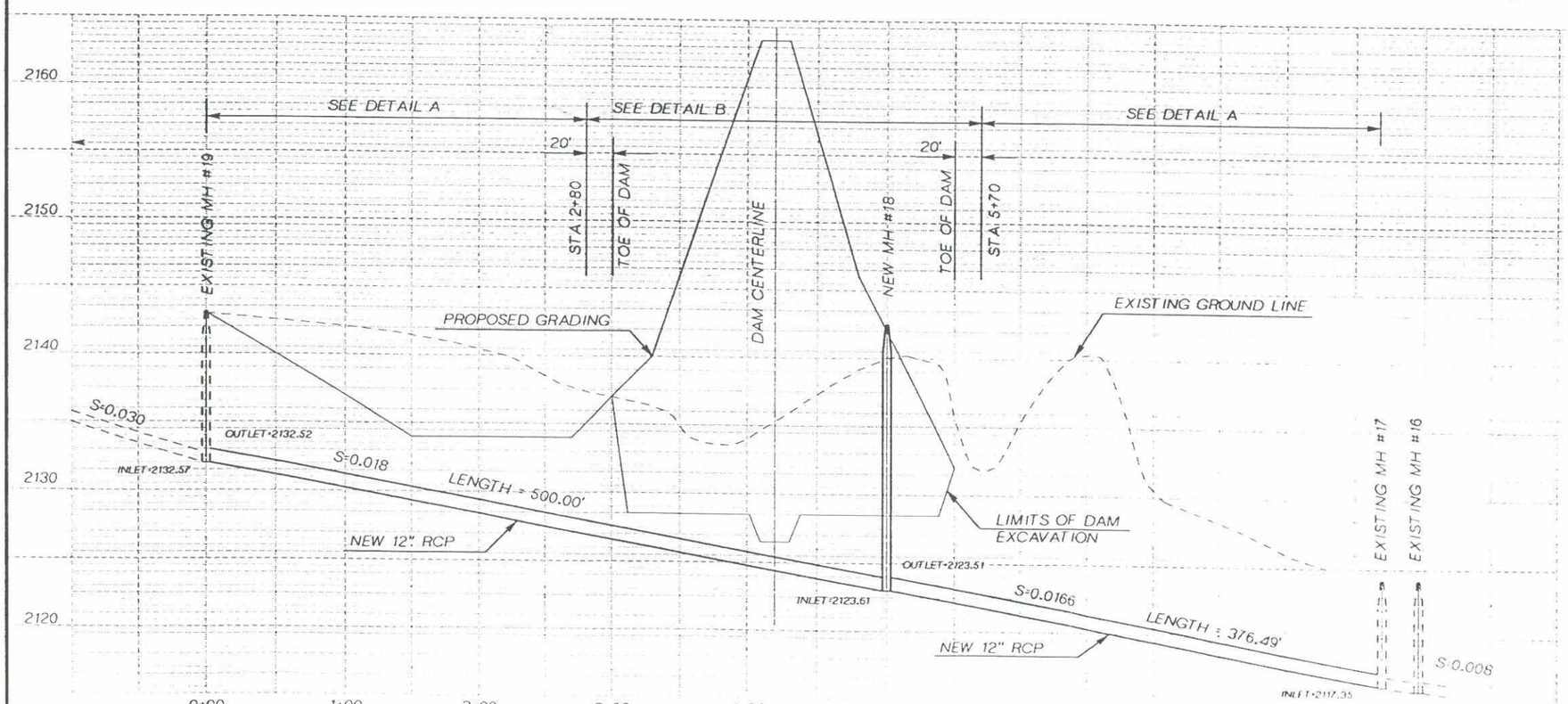
F... .IM... RY... T FOR CONSTRUCTION OR RECORD

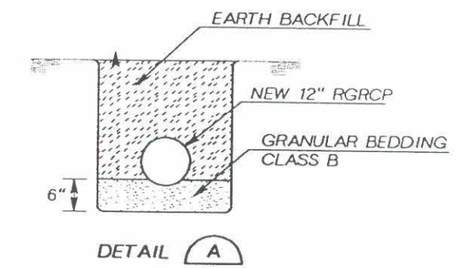
F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
9	AZ.		15		

NOTES:

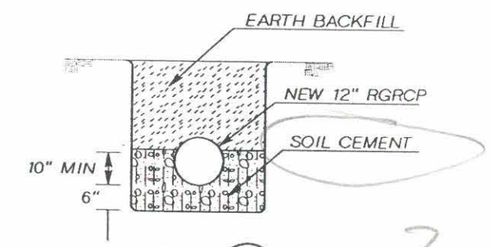
1. REMOVE EXISTING 10" VCP AND BACKFILL TRENCH.



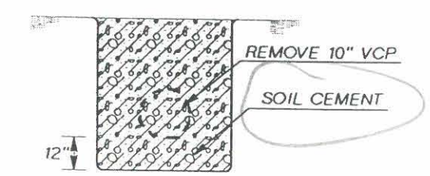




DETAIL A



DETAIL B



DETAIL C

NO	REVISION	BY	DATE
3			
2			
1			

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
FLOOD CONTROL DISTRICT

PLAN & PROFILE
SEWER RELOCATION

NOT FOR CONSTRUCTION

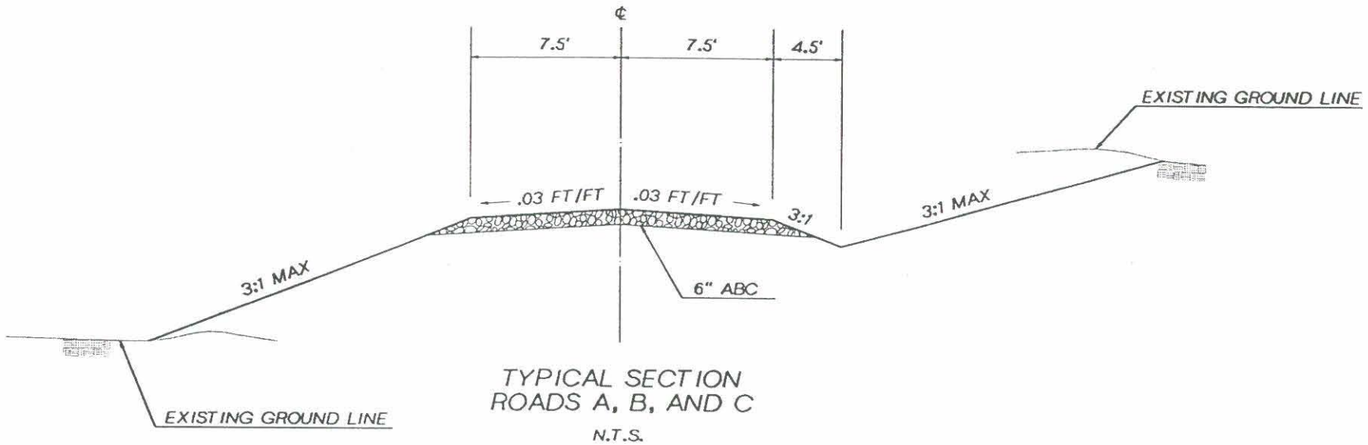
	BY	DATE
DESIGNED		
DRAWN		
CHECKED		

CH2M HILL

SYTIME DGN SPECIFICATION 5441P116.DGN

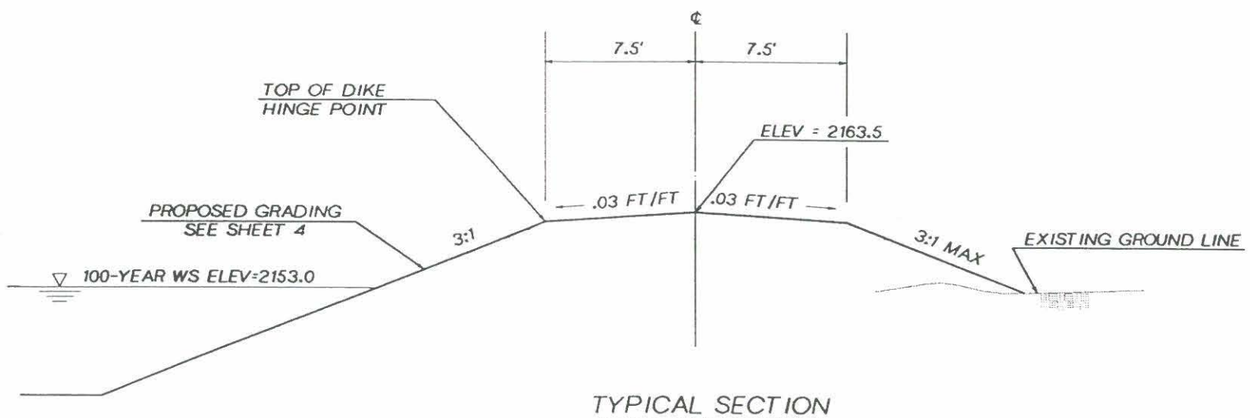
PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
9	AZ.		19		



TYPICAL SECTION
ROADS A, B, AND C

N.T.S.



TYPICAL SECTION
DIKE STRUCTURE

N.T.S.

NO	REVISION	BY	DATE
3			
2			
1			

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
FLOOD CONTROL DISTRICT

SITE CIVIL DETAILS

NOT FOR CONSTRUCTION

	BY	DATE
DESIGNED		
DRAWN		
CHECKED		

CH2M HILL

SYTIME DGN SPECIFICATION 5441P104.DGN

Appendix B.

Landscaping

CASANDRO WASH DAM PROJECT
(Town of Wickenburg)

LANDSCAPE CONCEPT SUBMITTAL

Prepared For

Maricopa County Flood Control District
2801 West Durango Street
Phoenix, Az. 85012-3393

Prepared By:

Boyd C. Winfrey
Landscape Architect
1420 Oak Lane
Prescott, Arizona 86301

June 6, 1994

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LANDSCAPE CONCEPT SUBMITTAL OUTLINE

1.0 INTRODUCTION

- 1.1 LIMITS OF SUBMITTAL
- 1.2 SITE DESCRIPTION
  1. LOCATION
  2. GENERAL CHARACTER
  3. EXISTING PLANTS
  4. GENERAL SOILS DESCRIPTION
- 1.3 WICKENBURG PARK PLANS
- 1.4 DESERT TORTOISES

2.0 LANDSCAPE CONCEPT

- 2.1 RETAIN EXISTING VEGETATION
- 2.2 PLANTING APPROACH
- 2.3 PROPOSED SEED LIST
- 2.4 NATIVE PLANT SALVAGE
  1. ARIZONA STATE NATIVE PLANT LAW

3.0 SOILS TEST

- 3.1 TEST RESULTS
- 3.2 COMMENTS

4.0 IRRIGATION RECOMMENDATIONS

- 4.1 SEEDED AREAS
- 4.2 MESQUITE TRANSPLANTS

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CASANDRO WASH DAM PROJECT
(Town of Wickenburg)

LANDSCAPE CONCEPT SUBMITTAL

1.0 INTRODUCTION

1.1 The landscape concept submittal is limited to the proposed seed and plant list and the feasibility of using a temporary watering system. To arrive at these recommendations it is important to review the following related information.

1.2 Casandro Wash project site is located in the Town of Wickenburg approximately 1500 feet upstream of Mariposa Drive in what is predominately a residential neighborhood. The site varies in elevation with typical arroyo carved bluffs and canyons bordering the wash on the north and south.

The site is vegetated with typical Sonoran desert vegetation. The Casandro Wash Vegetation Survey list the following plants within the project site:

Mesquite	Prosopis juliflora
Desert Broom	Baccharis sarathroides
Catclaw	Acacia greggii
Creosote	Larrea tridentata
Wolfberry	Lycium andersonii
Grey Thorn	Zizyphus obtusifolia
Burro Bush	Hymenoclea salsola
Turpentine Broom	Thamnosma montana
Triangle Leaf Bursage	Ambrosia deltoidea
Desert Mallow	Sphaeralcea ambigua
Desert Marigold	Baileya multiradiata

Native grasses and Palo Verde are not listed as a part of this survey.

The soils are typical desert wash sandy gravely soils with a high pH and low plasticity index. This soil would be considered poor for agricultural purposes but for reintroducing native plants it is acceptable.

1.3 In the early stages of this project the Town of Wickenburg had requested the detention basin be graded to allow for a future park. This is no longer the case and the Town of Wickenburg will not be establishing a park.

1.4 The Arizona Game & Fish Department's Heritage Data Management System does not indicate the presence of any special status species of wildlife in the project vicinity. However, it is possible that Sonoran desert tortoise could be encountered

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during construction. This species is a Category 2 Candidate for listing under the Endangered Species Act and if encountered should be handled in accordance with established guidelines.

2.0 LANDSCAPE CONCEPTS

2.1 It is recommended that native vegetation be retained in the project area by selective grading. These pockets of vegetation will provide wildlife habitat and at the same time provide a seed source for natures revegetation process.

2.2 It is recommended that revegetation of the Casandro Wash Dam Project be accomplished in two approaches, seeding and salvage of existing mesquite. The seed mix for the dam should not contain mesquite or desert broom but they should be included in the mix for slopes and the floor of the basin.

Salvage, holding and replanting native mesquite is recommended for this project providing it can be accommodated within the project budget. The cost for transplanting native trees has typically been running $55 to $60 per caliper inch trunk. Further inventory and tagging of existing mesquite would be necessary to determine the number of potential transplant candidates. This effort is not currently in our scope of work. Further comments and recommendations on this issue are requested.

2.3 The following preliminary seed list is included for review and comment:

Filaree	Erodium circutarium
Indian Wheat	Plantago insularis
Purple heliotrope	Phacelia tenacetifolia
Annual brome	Bromus rubens
Big galleta	Hilaria rigida
Desert needlegrass	Stripa speciosa
Sand dropseed	Sporobolus cryptandeus
Plains bristlegrass	Setaria macrostachya
Meaquite	Prosopis juliflora
Desert Broom	Baccharis sarathroides
Catclaw	Acacia greggii
White Thorn	Acacia constricta
Creosote Bush	Larrea tridentata
Triangle Leaf Bursage	Ambrosia deltoidea
Desert Marigold	Baileya multiradiata

2.4 The Arizona Native Plant Law applies to this project. State agencies clearing land exceeding one-fourth acre are required to submit a written notice of intent to clear land 60 days prior to beginning work. Salvaged plant material retained on the project site do not require a non fee permit by the state agency performing the salvage.

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3.0 SOILS TEST

3.1 The horticultural soils test results are as follows:

TEST	STANDARD	TEST RESULTS	COMMENT
pH	6.0 to 8.3	Average 8.6	High
Soluble salts	2000 PPM Max	Average 362	Acceptable
P.I.	5 to 20	Average 2.2	Low
Gradation			
2 Inch	100%	100%	Acceptable
1/2 Inch	85% to 100%	91.5%	Acceptable
No. 40 sieve	35% to 100%	26.8%	Low

3.2 Generally speaking the soils of this region are alluvial deposits which consist of gravel, sand, silt, and clay. This soil, as mentioned earlier, is of poor agricultural quality but quite suitable for the natural selection of native plants. Natural selection implies that, when a broad variety of native seed is broadcast over a wide are, only seed which is in a ideal location receiving the appropriate amounts of sun and water will germinate.

The high pH is indicative of Arizona desert region and would be a problem if a large amount of container grown plants were introduced into the project. Ideally it would be better if the pH did not exceed 8.3. To lower the pH, soil sulfur or sulfuric acid can be applied to planted areas which in turn will result in increased soluble salts. The tested soluble salts for Casandro Wash are very low consequently any increase should not be a problem. Having taken all this into consideration We do not recommend a soil pH modification. The natural selection process for seeded native plants should overcome the high pH.

The plasticity index is notably low. This will not negatively affect plant growth but it does point out the need for erosion protection in the form of native grasses. A quick establishment of native grasses will not only help prevent erosion but will enhance the growth of seeded shrubs and trees.

4.0 IRRIGATION RECOMMENDATIONS

4.1 Seeded areas within the project do not require and should not have supplemental irrigation. However the ideal time of year for seeding large areas is in the late fall.

4.2 If it is deemed feasible to salvage, hold and replant native mesquite, for this project, a temporary drip irrigation system is recommended for approximately the first year after transplant. Temporary water will also be needed for the mesquite holding area.

Water can be accessed from a 2 inch water main located in the roadway at Sunset Terrace just North of the project site.

Appendix C.

Computations

Spillway

SUBJECT CASANORO DAM SPILLWAY DESIGN	BY JSF	
	SHEET NO. 1 of ___	DATE 5-11-94
	PROJECT NO. SWW35441.CV.	

PROCEDURES:

① USE BUREC, 1987 "DESIGN OF SMALL DAMS"

(a) OGEE CREST p 365 - 373

- GEOMETRY
- RATING
- APPROACH

(b) SPILLWAY CHUTE (O/S OGEE) p 383 - 386

(ALSO VEN TE CHOW, 1959 CHAPTER 14)

(c) ENERGY DISSIPATOR p 387 -

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CH2M HILL	SUBJECT	BY JRF
		SHEET NO. 2 of ____ DATE 5/94
	CASANORA DAM	PROJECT NO. SWW35441

DESIGN CRITERIA

1) PASS ½ PMF (5400 CFS) WITH 3 FT FREEBOARD INCLUDING ROUTING AFFECTS

2) PASS FULL PMF (10940 CFS) WITH MINIMAL (0 FT) FREEBOARD, INCLUDING ROUTING AFFECTS

3) SPILLWAY CREST AT 2153 ELEVATION

4) DAM TOP @ 2163 ELEVATION

5) MINIMIZE SPILLWAY LENGTH (80 FT)

6) STORE Q100 + SEDIMENT YIELD OF 2 AF - ORIFACE FLOW WITHOUT SPILLING IN EXCESS OF D/S STORM DRAIN CAPACITY OF 339 CFS

7) DESIGN SPILLWAY FOR MAXIMUM EFFICIENCY (MINIMUM INLET LOSSES)

8) MINIMIZE COST

CONSIDER ROUTING OF DRAINAGE?

- ALLOWABLE TO ROUTE ½ PMF SINCE RESERVOIR NORMALLY EMPTY
- FROM DS INTO SEWER DRAIN TOWARD NOT ROUTING ½ PMF, ROUTE FULL PMF

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SUBJECT: CASANDRO DAM	BY: DRF	
	SHEET NO. 3 of ____	DATE 5/94
DESIGN OF OGEE CREST SPILLWAY	PROJECT NO. SWW35441	

GIVEN $L = 80$ FT (FOLLOW BUREC, 1987 PROCEDURE)

$H_o = 7$ FT

$P = 3.0$ FT → { CREST @ 2153; TOP DAM @ 2163 (7' + 3' FREEBOARD)

STEP ONE DETERMINE H_o

$H_e = 7$ FT

ESTIMATE VELOCITY OF APPROACH

ASSUME $C = 3.8$

$$q = C H_e^{1.5}$$

$q = 70.4$ cfs/ft (UNIT DISCHARGE OVER WEIR)

VELOCITY, $V_a = \frac{q}{(H_e + P)} = \frac{70.4}{10} = 7.04$ FT/S

APPROACH VELOCITY HEAD, h_a

$$h_a = \frac{V^2}{2g} = \frac{(7.04)^2}{64.4} = 0.77 \text{ FT}$$

ENTRANCE LOSS $= 0.1\ h_a = 0.08$

FRICTION SLOPE, S_f

$$S_f = \left(\frac{V_a \cdot n}{1.486\ r^{2/3}}\right)^2$$ WHERE: $n = 0.02$

r = hydr. radius $= \frac{A}{P} = \frac{(H+P)L}{L+2(H+P)} = \frac{10 \cdot 80}{80+2(10)} = 8.0$

$S_f = 5.6 \times 10^{-4}$

$= 0.00056$ FT/FT

FRICTION LOSS, h_f

$h_f = S_f (\ell)$

$= 0.02$ FT

WHERE ℓ = APPROACH CHANNEL LENGTH ≈ 40 FT

TOTAL APPROACH LOSS, h_t

$h_t = h_f + h_e = 0.08 + 0.02$

$= 0.10$ FT

∴ EFFECTIVE HEAD, $H_o = 7$ FT $- h_t = 6.9$ FT

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SUBJECT: CASANDRO SPILLWAY	BY: JEF	
	SHEET NO. 3A of ____	DATE 6/2/94
	PROJECT NO. SWW35441	

EFFECTIVE HEAD DIAGRAM

$Q = CLH_e^{3/2}$

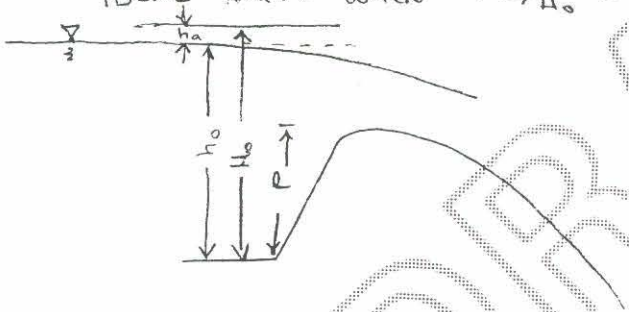
H_e = ACTUAL HEAD ON CREST, INCLUDING APPROACH VELOCITY HEAD (h_a)

= DOES NOT INCLUDE
1. APPROACH CHANNEL FRICTION LOSS
2. INLET ENTRANCE LOSS
3. TRANSITION LOSS
4. CURVATURE LOSS - UPSTREAM CHANNEL

(MUST BE ADDED TO H_e TO DETERMINE RESERVOIR ELEVATION (PONDING SURFACE)

H_o = DESIGN HEAD (H_e @ Q_{DESIGN})

IDEAL NAPPE WHEN $H_e/H_o = 1$ ($H_e = H_o$)



H_o, EFFECTIVE HEAD = H_e - APPROACH LOSS. (P. 373 BUREC)

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SUBJECT	BY JBF	
	SHEET NO. 4 of ____	DATE 5/94
CASANDRO	PROJECT NO. SWW35441	

STEP TWO : ESTIMATE WEIR COEFFICIENT & ADJUSTMENTS

① ESTIMATE C_o (FIGURE 9-23)

↳ SEE SHEET 8, THIS PACKET

$$\frac{P}{H_o} = \frac{3}{6.9} = 0.43$$

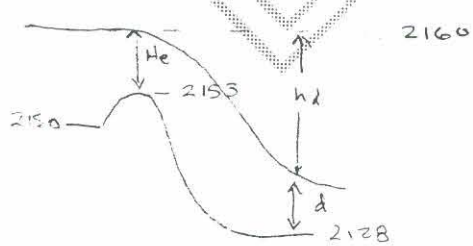
$$C_o = 3.77$$

② ADJUST C TO ACCOUNT FOR INCLINED FACE, FIGURE 9-25 (INCLINED AT 2:3)

$$\frac{P}{H_o} = 0.43$$

$$\frac{C_i}{C_o} = 1.017 \rightarrow C_i = 3.83$$ (SEE SHEET 9)

③ ESTIMATE DOWNSTREAM IMPACTS



(*SUMMARY NO DOWNSTREAM IMPACTS AT CURRENT, CMX IS GREATER THAN TW DEPTH - ENERGY)

DOWN: D/S

$$Q = \frac{1.49}{n} A S^{1/2} R^{2/3}$$

$$10900 \text{ cfs} = \frac{1.49}{.03} (.02)^{1/2} (y)^{2/3} (100)\, y$$

$$y^{5/3} = 15.6$$

$$y = 5.2 \text{ FT}$$ (MAY 7 ALLOWANCE)

$$\frac{h_d + d}{H_e} = \frac{32}{7} = 4.6$$

$$\frac{h_d}{H_e} = \frac{27}{7} = 3.9$$

FROM FIGURE 9-26 & 9-27

NO AFFECT ON C

C = 3.83 DESIGN WEIR COEFFICIENT

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APRON / TAILWATER EFFECTS

A) APRON

IF $\frac{h_d + d}{H_e} > 1.68$, NO EFFECT ON C (FIGURE 9-27) p. 373

$H_e = 7$

$\therefore h_d + d \geq 11.76$

APRON ELEVATION ≈ 2124 (2153+7' - 2124 = 36')

TAILWATER DEPTH ≈ 5'

B) TAILWATER (DEGREE OF SUBMERGENCE)

IF $\frac{h_d}{H_e} > 0.7$, NO TAILWATER EFFECTS ON C, (FIGURE 9-28 p. 374)

IF $h_d > 4.9$

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CH2M HILL

SUBJECT: CASANDRO

BY: JBF

SHEET NO. 6 of ____ DATE 5/94

PROJECT NO. SWW 35441

STEP THREE: ESTIMATE WEIR RATING CURVE

H_e/H_o	H_e	C/C_o	C	$q=CH^{1.5}$	H_e+P	V_a	h_a	S_f	Entrance Loss $0.1h_a$	Total Approach Loss
0.1	0.69	0.80	3.06	1.75	3.69	0.48	.0038	.0001	.0004	0

Gross Head	Discharge $CLH^{3/2}$
0.69	140

REMAINDER OF CALCULATIONS ON "SPILLWAY.XLS"

SEE SHEET 7

H_e/H_o	H_e	C/C_o	C	$q=CH^{1.5}$	H_e+P	V_a	h_a	S_f	Entrance Loss $0.1h_a$	h_f	h_t	Gross Head	$Q=CLH_e^{3/2}$
1.0	6.9	1.0	3.83	69.42	9.9	7.01	0.76	.00056	.08	.022	.10	7.0	5553

C/C_o: f_{i_o} 0.24

V_a: $\left(\frac{q}{H_e+P}\right)$

h_a: $\frac{V^2}{2g}$

S_f: $\left(\frac{V_a n}{1.486 R^{2/3}}\right)^2$

$R = \frac{80(9.9)}{80+2(9.9)} = 5.88$

h_f: $S_f \times L_{(ent)}$

h_t: $h_f + 0.1h_a$

Gross Head: $H_e + H_t$

$C = 3.83$

$P = 3$ FT

$n = 0.02$

$L_{ent} = 40.0$ FT

CHECK CALC'S (BY HAND) OF SPREADSHEET

DRAFT

Casandro Wash Spillway Design				Length =	80	ft.								
				Lip Ht. =	3	ft.								
				Ho =	6.9	ft								
				C at Ho =	3.83									
				n =	0.02									
				Apr. Len=	40	ft.								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	
								Entrance			Total	Gross	Discharge	
He/Ho	He	C/Co	Ci	q	He+P	Va	ha	0.1ha	Sf	hf	Approach	Head		
		(fig.9-24)		CHe^1.5							Loss			
0.1	0.69	0.80	3.06	1.76	3.69	0.48	0.0035	0.0004	0.0000	0.0003	0.00	0.69	140	
0.2	1.38	0.85	3.26	5.28	4.38	1.20	0.0225	0.0023	0.0000	0.0017	0.00	1.38	422	2154
0.4	2.76	0.90	3.45	15.81	5.76	2.74	0.1169	0.0117	0.0002	0.0063	0.02	2.78	1264	
0.6	4.14	0.94	3.60	30.33	7.14	4.25	0.2801	0.0280	0.0003	0.0118	0.04	4.18	2426	2157
0.8	5.52	0.97	3.72	48.18	8.52	5.66	0.4966	0.0497	0.0004	0.0172	0.07	5.59	3855	
1.0	6.90	1.00	3.83	69.42	9.90	7.01	0.7635	0.0763	0.0006	0.0225	0.10	7.00	5553	
1.2	8.28	1.03	3.93	93.53	11.28	8.29	1.0677	0.1068	0.0007	0.0274	0.13	8.41	7483	
1.4	9.66	1.05	4.02	120.74	12.66	9.54	1.4124	0.1412	0.0008	0.0322	0.17	9.83	9659	
1.6	11.04	1.07	4.10	150.33	14.04	10.71	1.7801	0.1780	0.0009	0.0366	0.21	11.25	12026	2163

SPILLWAY
3.6%
2153
2154
2157
2160
2163

FOX
USGS
RATING
CURVE
(SEE SHEET
10)

Q WEIR
0
267
1447
5553
9942

$\frac{.31}{.69} = \frac{x}{282}$ x = 127

$\frac{.22}{1.40} = \frac{x}{1162}$ x = 183

$\frac{.17}{1.42} = \frac{x}{2367}$ x = 283

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stream apron and is independent of any submergence effect from the tailwater. Figure 9-27 shows the effect of downstream apron conditions on the discharge coefficient. It should be noted that this curve plots, in a slightly different form, the same data represented by the vertical dashed lines on figure 9-26. As the downstream apron level nears the crest of the overflow, $(h_d + d)/H_e$ approaches 1.0, and the discharge coefficient is about 77 percent of the coefficient for unretarded flow. On the basis of a coefficient of 4.0 for unretarded flow over a high weir, the coefficient when the weir is submerged will be about 3.08, which is virtually the coefficient for a broad-crested weir.

From figure 9-26, it can be seen that when $(h_d + d)/H_e$ exceeds about 1.7, the downstream floor position has little effect on the coefficient, but there is a decrease in the coefficient caused by tailwater submergence. Figure 9-28 shows the ratio of the discharge coefficient where affected by tailwater conditions to the coefficient for free flow conditions. This curve plots, in a slightly different form, the data represented by the horizontal dashed lines on figure 9-26. Where the dashed lines on figure 9-26 are curved, the decrease in the coefficient is the result of a combination of tailwater effects and downstream apron position.

9.13. ***Examples of Designs of Uncontrolled Ogee Crests.***—The two examples cited below illustrate the methods of designing uncontrolled ogee crests, including the computation of approach channel losses and velocity head, the determination of the total length of the crest, and the correction of the discharge coefficient for various effects.

(a) *Example 1.*—Design an uncontrolled overflow ogee crest for a chute spillway that will discharge 2,000 ft³/s at a 5-foot head, and prepare a discharge-head curve. The upstream face of the

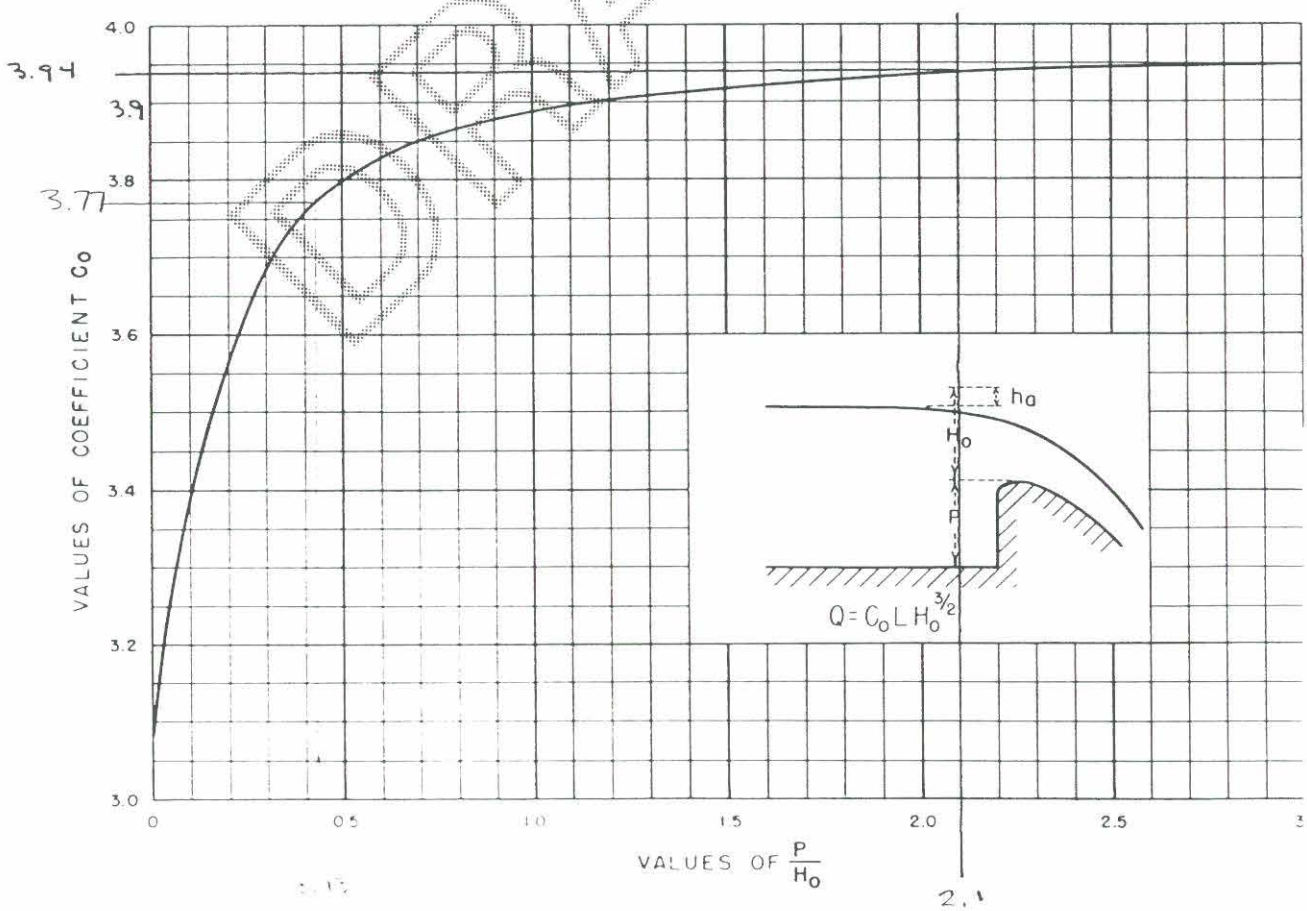

Figure 9-23.—Discharge coefficients for vertical-faced ogee crest. 288-D-2409.

JEF 5/94
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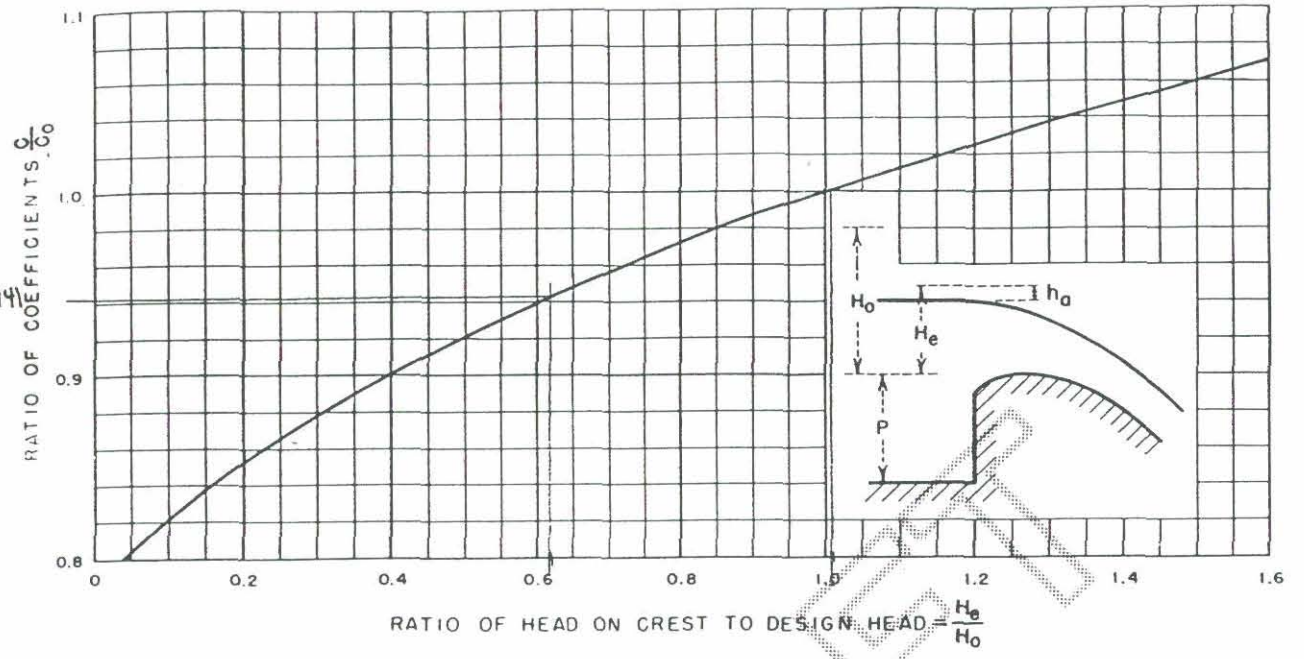

Figure 9-24.—Discharge coefficients for other than the design head. 288-D-2410.

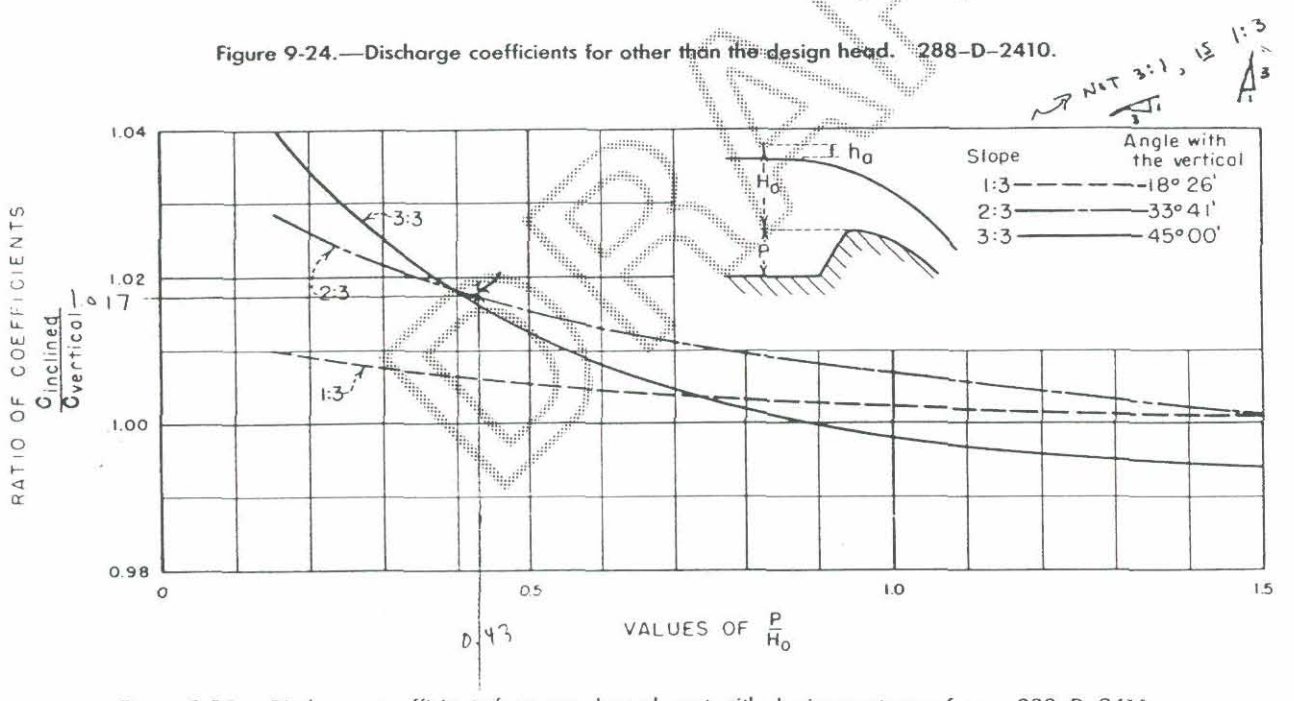

Figure 9-25.—Discharge coefficients for ogee-shaped crest with sloping upstream face. 288-D-2411.

crest is sloped 1:1, and the entrance channel is 100 feet long. A bridge is to span the crest, and 18-inch-wide bridge piers with rounded noses are to be provided. The bridge spans are not to exceed 20 feet. The abutment walls are rounded to a 5-foot radius, and the approach walls are to be placed at 30° with the centerline of the spillway entrance.

To solve the problem, either the approach depth and apron position with respect to the crest must be selected and the appropriate coefficient determined, or an arbitrary coefficient must be selected and the appropriate dimensions determined. The

SUBJECT	BY JBF	
CASANDRO - SPILLWAY	SHEET NO. 10 of ___	DATE 6/2/94
FINAL HEC 1	PROJECT NO. SWW35441.CU	

CONSIDERATIONS

① OUTLET RATING CURVE INCLUDES FINAL OGEE RATING FROM SHEET 7

② SEDIMENT STORAGE

= 2 AF BELOW SPILLWAY

USE RS RECORD RS,2 = STOR & RS,3 = 2

↳ STORES 2 AF AT BEGINNING OF STORM

2134 AREA = 1.8 ac

2132 - 0 AC

① REVISED ORIFACE

AREA = 1.4 ft², INVERT @ 2132

FROM HEC1 "TEMPALT4.HC1" - ORIFACE RATING CURVE

	Q
2132	0
2134	9.5
2136	13.5
2140	19.1
2144	23.3
2150	28.6
2153	30.9
2154	32.0
2157	
2160	
2163	

WEIR Q DOMINATES
USE $Q_{ORIFACE}$ = 32 CFS

	R.I	MAX ELEV	MAX Q	TIME MAX Q	MAX STORAGE AF	SPILLWAY Q DURATION
FINAL100.HC1	Q100	2153.93	251	[illegible]	131	4:50 - [illegible]
		(21 cfs @ 4.05 [illegible])				
FINAL½PM HC1	½ PMF	2158.85	374	[illegible]	[illegible]	3:25 - [illegible]
		(4.2 ft [illegible])				
FINAL PMF HC	PMF	2162.8	[illegible]	[illegible]	[illegible]	3:15 - [illegible]

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SUBJECT CASANDIKO - SPILLWAY

BY JEF

SHEET NO. 10A of ____ DATE 6/2/94

PROJECT NO. SWW35441.CV

OUTLET DESIGN CRITERIA

CAPACITY OF DOWNSTREAM STORM DRAIN = 337 CFS

D/S HYDROGRAPH
(FROM HEC 1)

ORIFACE = 1.4 ft
WEIR = 80 @ 2153

TIME	Q	Q EXCESS AVAILABLE		
3:55	243	94		
4:00	297	40		
4:05	317	20	21	~OK
4:10	296	41		OK W/ ROUTING TO D/S PT.
4:15	263	74		
4:20	223	114		
4:25	178	159		
4:30	142	195		
4:35	112	225		
4:40	89	248		
4:45	71	266		
4:50	56	281		
4:55	43	294		
5:00	33	304		
		(ALLOWABLE Q'AD SPILLWAY FLOWS)		
5:05	26	311		
5:10	21	316		
5:15	17	320		
5:20	14	323	292	OK
5:25	12	325		
5:30	11	326		
5:35	10	327		

OUTLET

ORIFACE ACCE[illegible] [illegible] @ 2132

CLTING	ONCE	
2132	[illegible]	
[illegible]	[illegible]	
2 3[illegible]	[illegible]	
2.4[illegible]	[illegible]	
3.4[illegible]	[illegible]	
2.5[illegible]	[illegible]	
2.5[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	

[illegible] CFS

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SUBJECT Casandro Wash
REVISED STORAGE-VOLUME CURVE

BY H. Allen
SHEET NO. 10B of ____ DATE 6/2/94
PROJECT NO. SWW 35441

Plan Scale: 1" = 100'

Contour El, ft	Planimeter Reading	× constant =	Area, ft²	→ 6-2-94 Area, Ac	PREVIOUS AREA (FINAL HEM. HC1)
2132					0
2134	511	160	81760	1.877	1.9
2136	661		105,760	2.428	2.4
2138	817		130,720	3.001	
2140	1550		248,000	5.693	5.6
2142	1700		272,000	6.244	
2144	1864		298,240	6.847	7.0
2146	2040		326,400	7.493	
2148	2227		356,320	8.180	
2150	2408		385,360	8.947	8.7
2152	2582		413,040	9.482	
53				(9.86)	9.7
2154	2785		445,600	10.230	10.0
2156	3097		495,520	11.376	
57				(11.700)	11.3
2158	3274		523,760	12.024	
2160	3455		552,800	12.691	12.3
2163				(13.94)	
2163.5	3851		616,160	14.145	13.7

$\frac{3}{3.5}$ $\frac{x}{1.454}$

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2170
2180
2160
2150
2140
2130
2190
2134
R=50'
33:1 (3%)
2.5:1
3:1
1.5:1
10:1
1.5:1

SUBJECT CASANDRO

BY JBF

SHEET NO. 11 of

DATE 5/94

PROJECT NO. SWW35441

63

REVISED 6/2/94

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59

SPILLWAY RATING CURVE

57

55

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SUBJECT CASAMORO - SPILLWAY

BY JEF

SHEET NO. 11A of ____ DATE 6/2/94

PROJECT NO. SWW 35442

SUMMARY OF SPILLWAY RATING

1. 1/2 PMF PASSES @ 2158.5 (4.5 FT FREEBOARD)

PEAK SPILLWAY Q = 3985

CHECK:

$3985 = CLH^{3/2}$

$= 3.8\,L\,(6.9)^{3/2}$

$58 = L$

FULL PMF $9800 = 3.8(60)H^{3/2}$

$H = 12.3$

FOR ROUTED 1/2 PMF COULD USE 60' SPILLWAY (BUT COULD NOT PASS FULL PMF) FOR SAVINGS OF $150/YD^3 \times 20' \times 140' \times 1' = \$16000$

2. FULL PMF PASSES AT 2162.6 FT .OK

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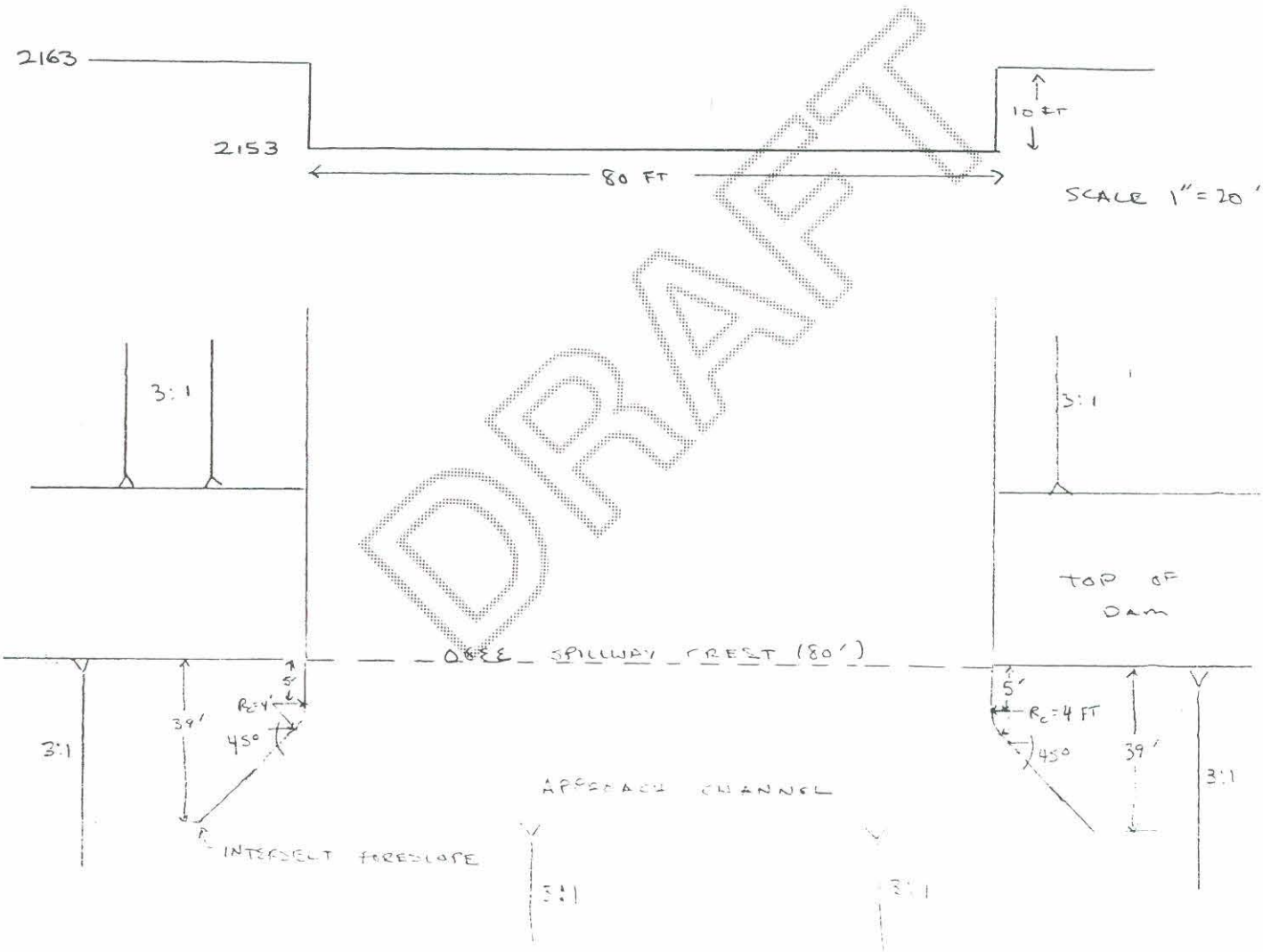
SUBJECT _____ BY JBF

SHEET NO. 12 of ____ DATE 5/94

CASANORO DAM – SPILLWAY SKETCH PROJECT NO. SWW35441



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SUBJECT	BY JBF	
	SHEET NO. 13 of ____	DATE 5/94
CASANDRO - DESIGN OF	PROJECT NO. SWW35441	
SPILLWAY CHUTE		

① DETERMINE SHAPE OF OGEE (NAPPE SUPPORT)
OGEE PROFILE TO SLOPE OF 0.8 : 1

② DETERMINE CHUTE CHARACTERISTICS

a) WIDTH AT CREST = 80

b) RECTANGULAR SHAPE

c) Q = ½ PMF + FREEBOARD, OR PMF W/O FREEBOARD

③ MAINTAIN SUPERCRITICAL FLOW TO PREVENT TAILWATER EFFECT ON "C"

④ MINIMIZE CUT INTO DOWNSTREAM FACE OF DAM (KEEP SPILLWAY CHUTE ELEVATION AS NEAR FACE AS POSSIBLE)

⑤ "TUCK" DISSIPATOR INTO DAM -- MINIMIZE CONCRETE WALL UNSUPPORTED BY FILL

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PROCEDURE

① DESIGN OGEE CREST

② FOLLOW OGEE SHAPE UNTIL SLOPE = 0.8:1 (.125 FT/FT)

③ BEGIN REVERSE TO CURVE, MINIMIZE LENGTH OF REVERSE CURVE

④ END REVERSE CURVE AT STRAIGHT CHUTE TO DISSIPATOR

⑤ DISSIPATOR LIE AT TOE OF DAM SAFE SLOPE

SUBJECT CASANDRA BY JBF

SHEET NO. 14 of ____ DATE ~~5/84~~ 6/2/94

PROJECT NO. SWW35441

① CREST PROFILE - OGEE NAPPE

$\frac{h_a}{H_o} = \frac{0.77}{7.0} = 0.11$

$K = 0.525$ fig. 9-21 (b)

$n = 1.762$ fig 9-21 (c)

FACE SLOPE = 2:3

H_o = 7 FT

$\frac{X_c}{H_o} = 0.203$ fig. 9-21(d)

$X_c = 1.421$

$\frac{y_c}{H_o} = 0.053$ fig. 9-21 (e)

$y_c = 0.371$

$\frac{R}{H_o}$ $\left\{ \begin{array}{l} \frac{R_1}{H_o} = 0.486 \\ R_1 = 3.402 \\ \frac{R_2}{H_o} = 0.344 \\ R_2 = 2.408 \end{array} \right\}$ fig. 9-21 (f)

Eq'n #2 (p. 365) Bureau, 1987

$\frac{y}{H_o} = -K \left(\frac{x}{H_o}\right)^n \Rightarrow y = -0.525 \left(\frac{x}{7}\right)^{1.762} (7)$

$y = -0.119\ x^{1.762}$

y	-.12	-.40	-2.03	-6.89	-14.08	-23.37	-34.63	-.83	-1.37
x	1	2	5	10	15	20	25	3	4

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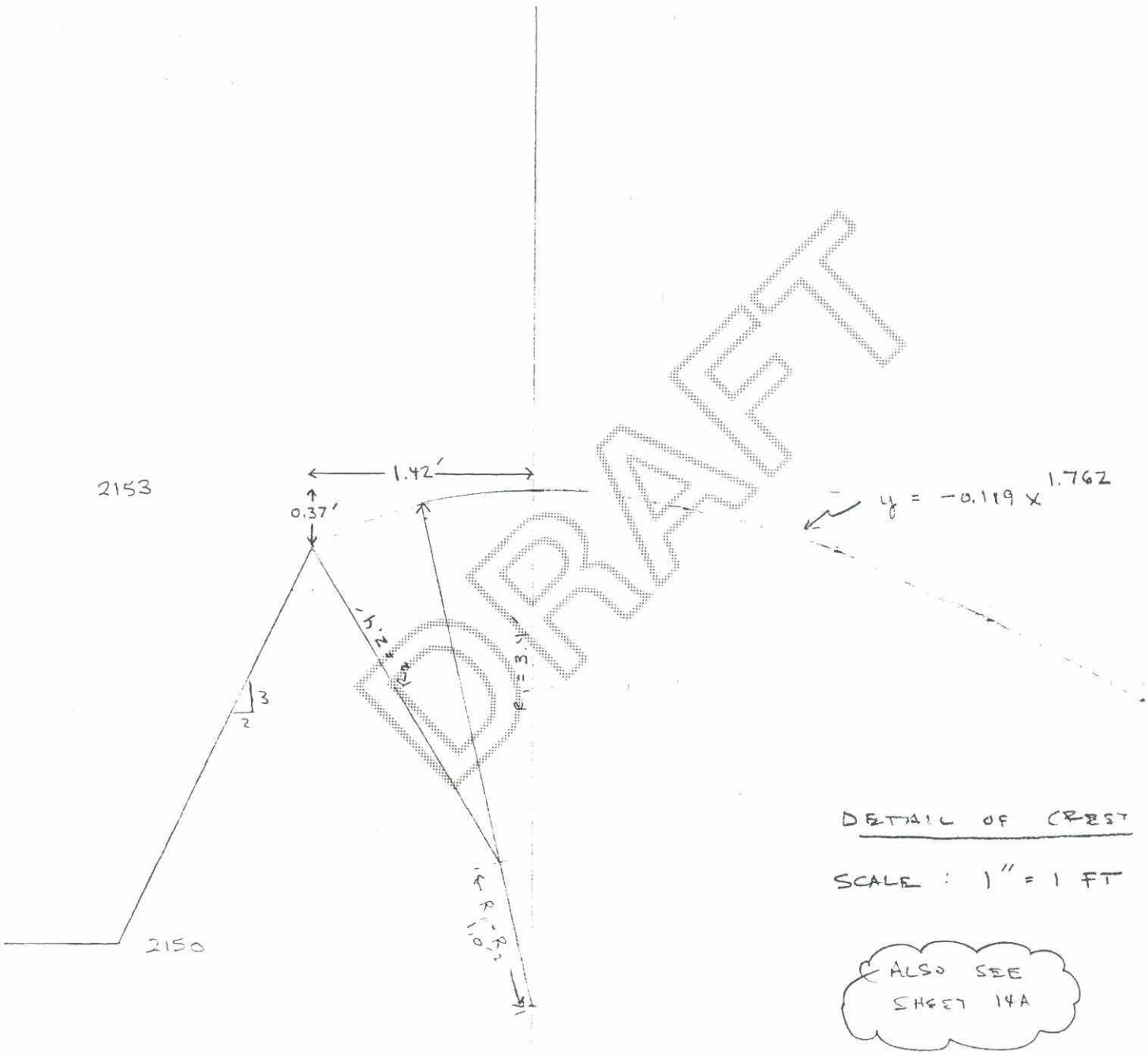
SUBJECT CASANDRO - CREST DETAIL

BY SEF

SHEET NO. 15 of ____ DATE 5/14

PROJECT NO. SWW35441



DETAIL OF CREST

SCALE : 1" = 1 FT

ALSO SEE SHEET 14A

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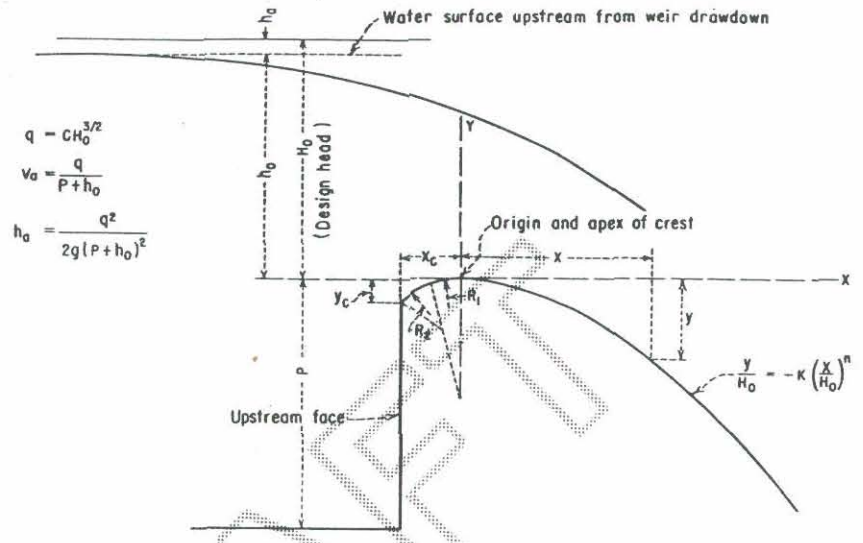
SHEET 14A
JBF 6/2
SWW 35441



(A) ELEMENTS OF NAPPE-SHAPED CREST PROFILES

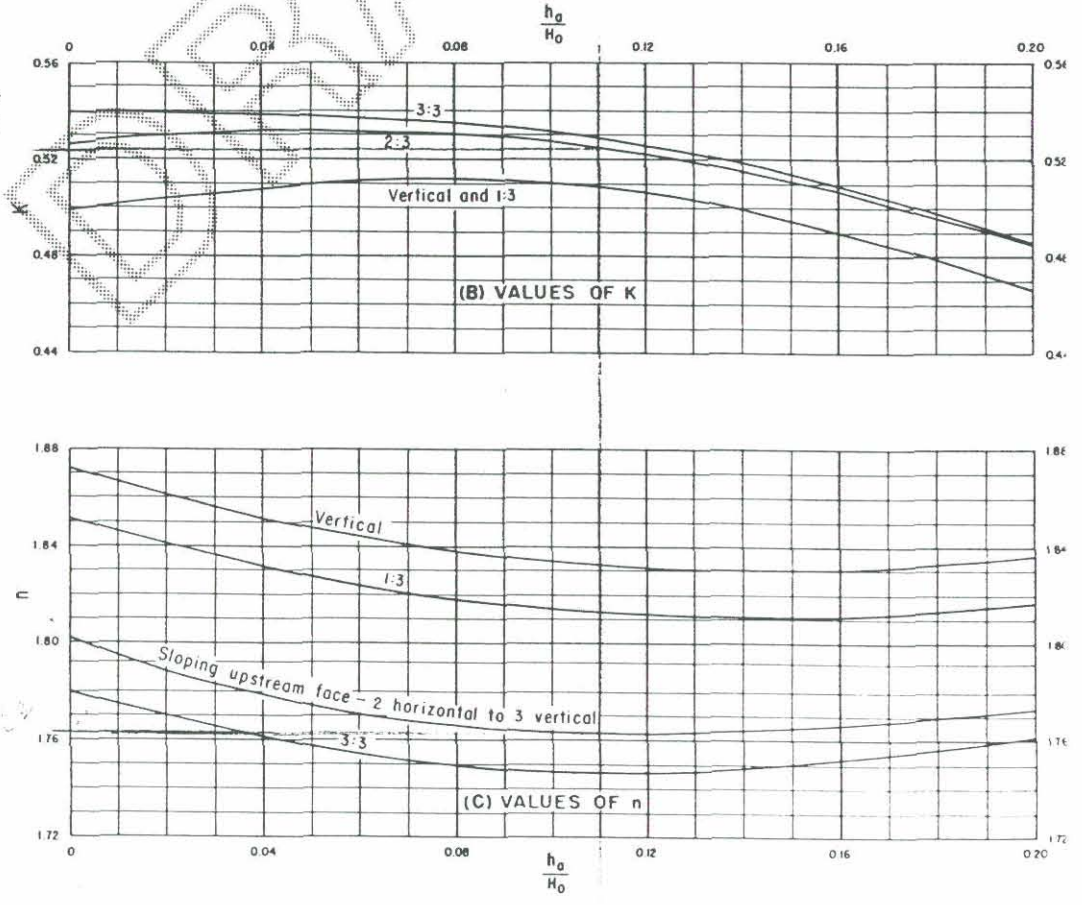


Figure 9-21.—Factors for definition of nappe-shaped crest profiles. 288-D-2406. (Sheet 1 of 2).

SHEET 14B
JBF 6/2
SWW 35441

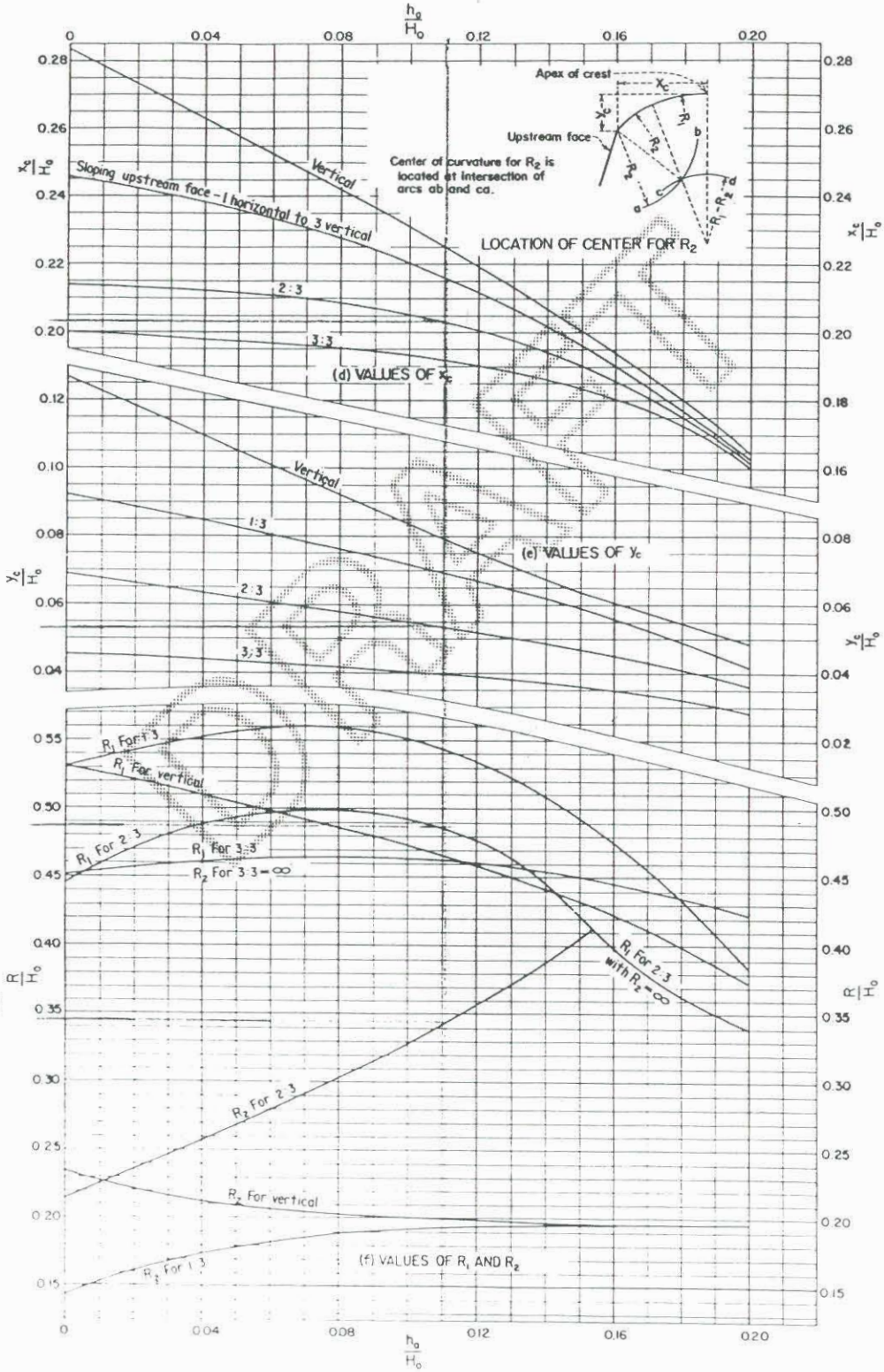


Figure 9-21.—Factors for definition of nappe-shaped crest profiles. 288-D-2407. (Sheet 2 of 2).

SUBJECT CASANDRO BY JRP

SHEET NO. 16 of ____ DATE 6/2

FIND POINT OF S = 0.8:1 PROJECT NO. SWW 35441 . A4

(BEGIN REVERSE CURVE)

SHAPE OF OGEE $y = -.119\, x^{1.762}$

INSTANTANEOUS SLOPE $\frac{dy}{dx} = -0.210\, x^{0.762}$

(PER RICHARD H. FRENCH, PHD P.E. – CONTINUE OGEE SHAPE UNTIL MAX SLOPE ACHIEVED (PHONE ON 5-16-94). CHOW 1959 ALLOWS SLOPE OF 0.6:1 – 0.8:1) FOR STRAIGHT PORTION OF SPILLWAY)

USE 0.8:1 AS END OF OGEE / BEGINNING OF REVERSE CURVE

0.8:1 = 1.25 FT/FT (SLOPE AT REVERSE CURVE POINT)

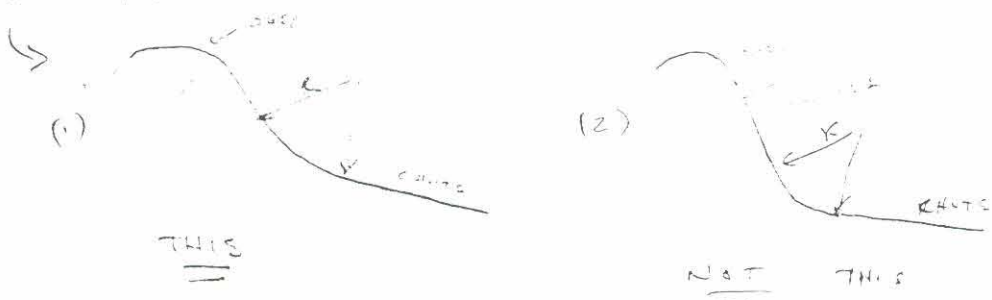
$-1.25 = -0.210\, x^{0.762}$

$x = 10.41$

$y = -0.119\,(10.41)^{1.762} = -7.39$

BEGIN REVERSE CURVE AT A POINT (+10.41, -7.39) FROM OGEE CREST POINT

NO STRAIGHT SLOPE ABOVE REVERSE CURVE TO REDUCE CUT INTO FILL OF DOWNSTREAM FACE OF DAM



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SUBJECT CABANDRO - CHUTE BY JEF

SHEET NO. 17 of ____ DATE ____

DESIGN REVERSE CURVE PROJECT NO. SWW3 5441

MINIMUM RADIUS CURVATURE, CONCAVE CURVE

$$R = \frac{20qv}{P} \quad \text{and} \quad R = \frac{2dv^2}{P}$$

Eqn 20, p. 385, BUREC 1987

WHERE R = minimum RADIUS

q = UNIT DISCHARGE CFS/FT

V = VELOCITY FT/S

d = DEPTH FT

P = NORMAL DYNAMIC PRESSURE ON FLOOR ≈ 1000 PSF

USE HALF IMF FOR DESIGN OF REVERSE CURVE

Q = 5400

$q = \frac{5400}{80} = 67.5 \ FT^3/S/FT$

V = 35 FT/S

VELOCITY = CONTROLLED BY SLOPE, FALL & HEAD MORE THAN Q ; USE CHOW, 1959 FIGURE 14-15, p 383

FALL (Z) ≅ 25 FT ≈ SHEET 18

H_o ≅ 7 FT

VELOCITY = 35 FT/S

USE 35 FT/S

P = 1000 LB/FT², ASSUMED

d = 3.4 FT

$\frac{Q}{V} = A = \frac{5400}{35} = 154 \ FT^2$

A = w d

154 / 80 (d) = 1.93 FT

$R = \frac{2(67.5)35}{1000}$ $\qquad$ $R = \frac{2(1.9)(35)^2}{1000}$

= 4.7 FT $\qquad$ = 4.7 FT

$R = 10^{\left(\frac{V + 6.4H - 16}{3.6H + 64}\right)}$ $\qquad$ CHOW Eqn 14-20, p 384

$= (10)^{\frac{95.8}{29.2}} = 10^{1.07}$ $\qquad$ H = 7

= 11.9 FT $\qquad$ V = 35

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JBF 5/9
SHEET 18
CASANDRO
SWW35441

relationship between the actual velocity and a theoretical value.[1] From the results of this study, a chart (Fig. 14-15) was prepared to show the actual velocity at the toe of spillways under various heads, falls, slopes from 1 on 0.6 to 1 on 0.8, and the condition of average surface roughness. It is felt that this chart is sufficiently accurate for preliminary-design

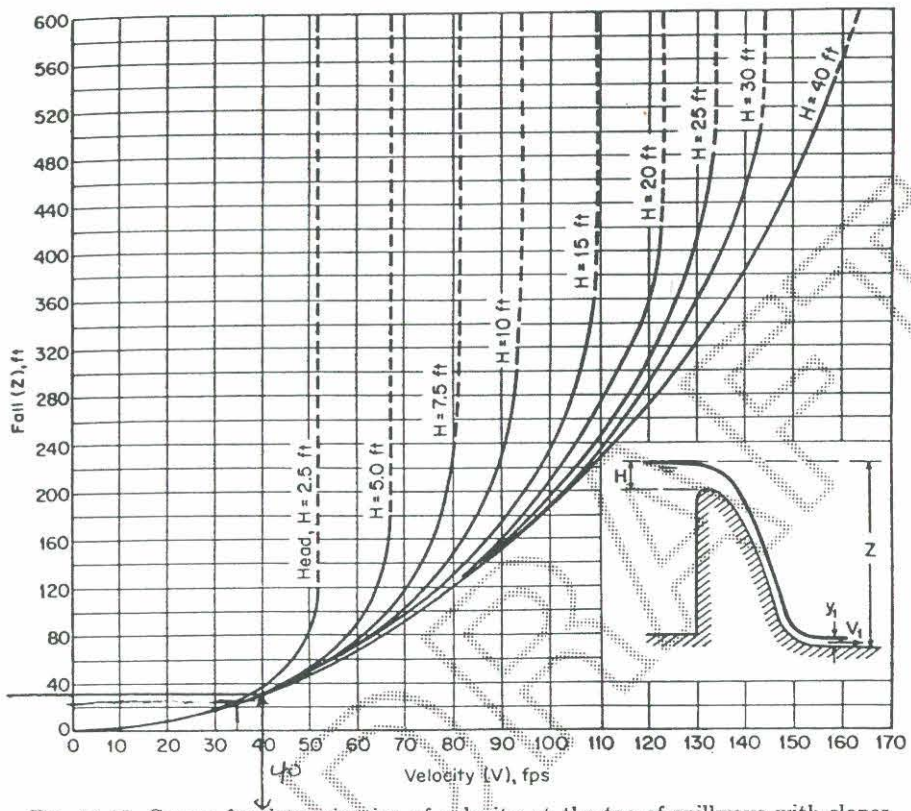


FIG. 14-15. Curves for determination of velocity at the toe of spillways with slopes 1 on 0.6 to 0.8.

H = 7
Reverse Curve
= -7.4

Estimate of Z component of reverse curve = 10 ft

TOTAL Z = 7 + 7.4 + 10
= 24.4

purposes, although it can be refined by additional experimental information which may become available in the future.

Experiments by Bauer [30] indicate that friction losses in accelerating the flow down the face of a spillway may be considerably less than the normal friction loss in flow with well-developed turbulence. Therefore, the friction loss is not significant on steep slopes, but it would become important if the slope were small. For this reason, the chart in Fig.

[1] The theoretical velocity defined by the Bureau is $V_1 = \sqrt{2g(Z - 0.5H)}$.

$R_1 = 4.7$
$R_2 = 4.7$
$R_3 = 11.9$

$\bar{R} = 7.1$ FT

MIN RADIUS = 5d FOR OGEE (BUREC, p.385)

GREATER THAN → = 9.7 /

HOWEVER, R = 10 FT, MINIMUM ALLOWABLE
(FOR FULL PMF R = 11 FT ; 5d = 17) = USE R = 20 FT

LOCATE REVERSE CURVE ON CHUTE PROFILE

TANGENT LINE AT BEGINNING OF REVERSE CURVE HAS -1.25 FT/FT SLOPE (0.8:1)
KNOWN PT = (10.4, -7.4)

ESTABLISH TWO OTHER POINTS

$$m = \frac{y_1 - (-7.4)}{x_1 - (10.4)}$$

$$-1.25x_1 + 13.0 = y + 7.4$$

$$y = -1.25x + 5.6$$

$x = 0$, $y = 5.6$
$x = 20$, $y = -19.4$ } ESTABLISH TANGENT

NORMAL LINE TO TANGENT, L = 10 (RADIUS) TO LOCATE CENTER OF RADIUS

DETERMINE LENGTH OF REVERSE CURVE BY:

(1) ESTIMATE OF STILLING BASIN LENGTH = 35 FT

(2) ESTIMATE OF STILLING BASIN DEPTH BELOW NATURAL GRADE = 6 FT

(3) LOCATE U/S END OF STILLING BASIN, PLACE WITHIN DOWNSTREAM ALIGNMENT

(4) CONNECT REVERSE CURVE TANGENT TO BASIN ENTRANCE

1ST ESTIMATE SLOPE OF STRAIGHT CHUTE = [illegible]

USE 4:1 HORIZONTAL [illegible]

DRAFT

SUBJECT CASANDRO

BY JEF

SHEET NO. 21 of ____ DATE 5/14

PROJECT NO. SNW3544.1

CHUTE CHANNEL CHARACTERISTICS

SEE PROFILE

AT END OF REVERSE CURVE (MINIMUM VELOCITY)

Q = 10940 CFS
V ≈ 40 FT/S
D ≈ 3.4 FT

} CALC PREVIOUSLY

Q = 5400
V = 40 FT/S
D = 1.7 FT

AT END OF STRAIGHT SLOPE REACH - NEAR ENTRANCE ~~OF~~ TO STILLING BASIN - USE NORMAL DEPTH (MAXIMUM VELOCITY)

Q = 10940 CFS Q = 5400 CFS
V = 77.5 FT/S V = 58.4 FT/S
D = 1.8 FT D = 1.2 FT

} SEE "SPILLWAY.XLS"

USE MOST CONSERVATIVE HYDRAULIC CHARACTERISTICS TO ESTIMATE FREEBOARD REQUIREMENTS

$$\text{FREEBOARD} = 2.0 + 0.025\, V \sqrt[3]{d}$$

			DEPTH	TOTAL
AT REVERSE CURVE (Q_{DES} = 5400)	⇒	4.4 FT	1.7	6.1
AT STILLING BASIN (Q_{DES} = 5400)	⇒	3.6 FT	1.2	4.8

TOTAL CHANNEL DEPTH = 6.1 FT
(PASSES FULL PMF W/O FREEBOARD)

USE 6.1 FT

[illegible] OF STRAIGHT [illegible] PORTION OF CHUTE

	5,400 CFS	10,940 CFS	
VELOCITY AT REACH =	46.2 FPS	48.7	FPS
D AT REACH =	1.5 FT	2.8	FT

~ FREE = 3.3 CHANNEL = 4.8 FT OK

NOTE SLOPE = 25%, HEC REQUIRES S_0 < 10%)

DRAFT

SW 54

Casandro Wash Spillway Design				Length =	80	ft.							
				Lip Ht. =	3	ft.							
				Ho =	6.9	ft							
				C at Ho =	3.83								
				n =	0.02								
				Apr. Len=	35	ft.							
								Entrance			Approach	Gross	Discharge
He/Ho	He	C/Co	Ci	q	He+P	Va	ha	0.1ha	Sf	hf	Loss	Head	
0.1	0.69	0.80	3.06	1.76	3.69	0.48	0.0035	0.0004	0.0000	0.0003	0.00	0.69	140
0.2	1.38	0.85	3.26	5.28	4.38	1.20	0.0225	0.0023	0.0000	0.0015	0.00	1.38	422
0.4	2.76	0.90	3.45	15.81	5.76	2.74	0.1169	0.0117	0.0002	0.0055	0.01	2.75	1261
0.6	4.14	0.94	3.60	30.33	7.14	4.25	0.2801	0.0280	0.0003	0.0103	0.01	4.13	2417
0.8	5.52	0.97	3.72	48.18	8.52	5.66	0.4966	0.0497	0.0004	0.0151	0.02	5.50	3838
1.0	6.90	1.00	3.83	69.42	9.90	7.01	0.7635	0.0763	0.0006	0.0197	0.02	6.88	5529
1.2	8.28	1.03	3.93	93.53	11.28	8.29	1.0677	0.1068	0.0007	0.0240	0.02	8.26	7449
1.4	9.66	1.05	4.02	120.74	12.66	9.54	1.4124	0.1412	0.0008	0.0282	0.03	9.63	9616
1.6	11.04	1.07	4.10	150.33	14.04	10.71	1.7801	0.1780	0.0009	0.0320	0.03	11.01	11972
Spillway Chute - Minimum Slope to Maintain Supercritical Flow (Manning's Rating)													
Qdesign =	10940	cfs					Qdesign =	5400	cfs				
n =	0.014						n =	0.014					
	Normal	Vertical	Flow					Normal	Vertical	Flow			
Assume S	Depth, d	d	Area	Vel., V	Froude #		Assume S	Depth, d	d	Area	Vel., V	Froude #	
0.5	1.43	1.60	128.20	85.34	12.56		0.5	0.94	1.05	83.93	64.34	11.71	
0.33	1.62	1.71	136.77	79.99	11.06		0.33	1.06	1.12	89.54	60.31	10.31	
0.1	2.32	2.33	186.76	58.58	6.77		0.1	1.52	1.53	122.26	44.17	6.31	
0.05	2.86	2.86	229.07	47.76	4.98		0.05	1.87	1.87	149.96	36.01	4.64	
0.025	3.52	3.52	281.75	38.83	3.65		0.025	2.30	2.31	184.46	29.28	3.40	
0.01	4.63	4.63	370.79	29.50	2.42		0.01	3.03	3.03	242.75	22.25	2.25	
0.005	5.71	5.71	456.48	23.97	1.77		0.005	3.74	3.74	298.85	18.07	1.65	
0.004	6.10	6.10	488.09	22.41	1.60		0.004	3.99	3.99	319.54	16.90	1.49	
0.003	6.65	6.65	532.08	20.56	1.40		0.003	4.35	4.35	348.34	15.50	1.31	
0.002	7.51	7.51	600.90	18.21	1.17		0.002	4.92	4.92	393.40	13.73	1.09	
0.143	2.09	2.11	168.62	64.88	7.92		0.143	1.37	1.38	110.39	48.92	7.38	

SPILLWAY.HC2
CABANDRO
JBF 5/94
SHEET 23

Spillway Chute 4:1

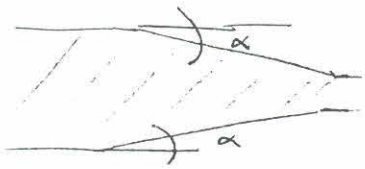
S IMARY PRINTOUT

SECNO	Q	CWSEL	CRIWS	DEPTH	VCH	FRCH	ELMIN	10*KS	K*CHSL
1.000	5400.00	2136.00	2139.49	1.70	39.72	5.37	2134.30	729.39	0.00
1.000	10940.00	2137.70	2142.62	3.40	40.23	3.84	2134.30	313.22	0.00
2.000	5400.00	2133.45	2136.99	1.65	41.01	5.63	2131.80	810.39	-250.00
2.000	10940.00	2135.06	2140.12	3.26	41.87	4.08	2131.80	356.52	-250.00
3.000	5400.00	2130.91	2134.49	1.61	42.20	5.88	2129.30	890.08	-250.00
3.000	10940.00	2132.45	2137.63	3.15	43.41	4.31	2129.30	400.44	-250.00
4.000	5400.00	2128.36	2131.99	1.56	43.31	6.11	2126.80	969.30	-250.00
4.000	10940.00	2129.85	2135.13	3.05	44.85	4.53	2126.80	445.25	-250.00
5.000	5400.00	2125.82	2129.49	1.52	44.33	6.33	2124.30	1046.35	-250.00
5.000	10940.00	2127.26	2132.64	2.96	46.22	4.73	2124.30	490.68	-250.00
6.000	5400.00	2123.29	2126.99	1.49	45.28	6.53	2121.80	1121.30	-250.00
6.000	10940.00	2124.69	2130.14	2.89	47.50	4.93	2121.80	536.33	-250.00
7.000	5400.00	2120.76	2124.50	1.46	46.16	6.73	2119.30	1194.88	-250.00
7.000	10940.00	2122.11	2127.61	2.81	48.73	5.13	2119.30	582.77	-250.00

DRAFT

POSSIBLE CONVERGENCE

$\tan \alpha = \frac{1}{3F}$ WHERE $F = \frac{V}{\sqrt{gd}}$



V & d at start of transition

BEGIN POSSIBLE TRANSITION AT DOWNSTREAM END OF REVERSE CURVE / BEGIN 1:4 CHANNEL

FROM CHOW (FALL) VELOCITY

AT H = 10', FALL = 29

V = 40 FT/S

d = 1.7

FIGURE 9-36

MAX FLARE = 0.064 = TAN α

α = 3.7°

OVER LENGTH OF SPILLWAY, WOULD RESULT IN NARROWING TO

$79 \left(\frac{1}{15.6}\right) = 5.1$ FT / PER SIDE

OR ≈ 10 FT

AREA = 395 FT² / 10 / 79

ASSUME 1.5' THICKNESS
22 Y0³ @ $150/YD
= $3300.00

NOT SIGNIFICANT SAVINGS SO DISREGARD

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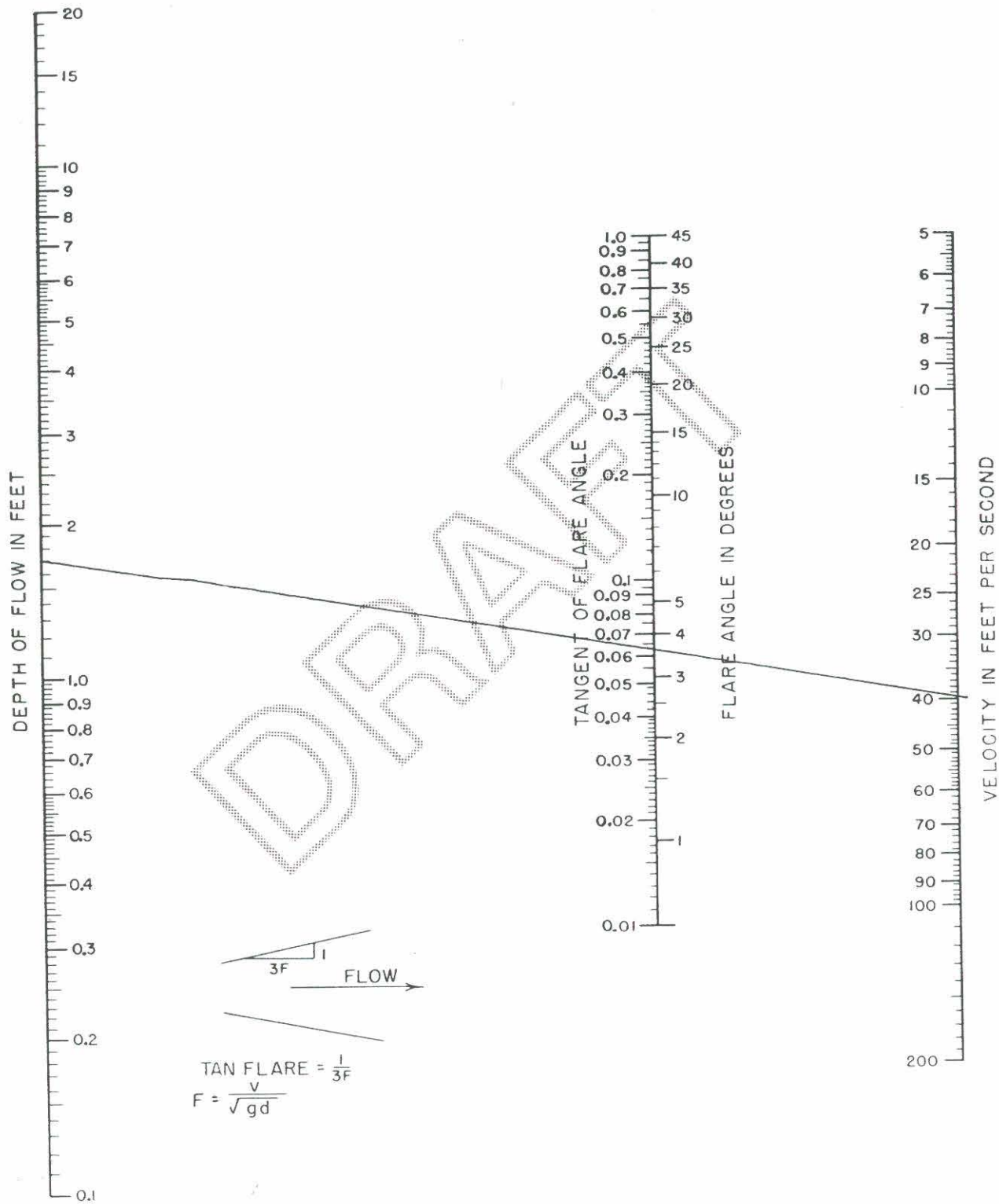
JBF 5/9
SHEET 25
SWW3 5441



DRAFT

Figure 9-36.—Flare angle for divergent or convergent channels. 288-D-2422.

PER HRC-2 "SPILLWAY. HC2" AT ENTRANCE TO BASIN

VEL = 46.2 FT/S
DEPTH = 1.5 FT

F = 6.73 (STRONG HYDRAULIC JUMP)
↳ FIGURE 9-37(c)

BUREC, 1987 PROCEDURE (p 387 ff)

JUMP CHARACTERISTICS
FROM FIGURE 9-38 (p. 389)

d_2 = 13.5 FT

V_2 = 5.2 FT/S

STILLING BASIN

F > 4.5, VEL < 60 FT/S → USE BOR TYPE III

TW NATURAL CHANNEL DEPTH = 8.15 (Q = 5400 CFS)
(AVERAGE DEPTH = 8.00 FT)

MINIMUM TW DEPTH (FIG. 9-41(b))

$\frac{TW}{d_1}$ = 8.5

TW = 12.8 FT

BAFFLE BLOCK HEIGHT (FIGURE 9-41(c))

$\frac{h_3}{d_1}$ = 1.8 ⇒ h_3 = 2.7 FT

END SILL HEIGHT

$\frac{h_4}{d_1}$ = 1.4 ⇒ h_4 = 2.1 FT

LENGTH OF JUMP / BASIN (FIG. 9-41(d))

$\frac{L}{d_2}$ = 2.55

L = 34.4 FT

FREEBOARD (EQ'N 25, p 398)

F = 0.1 (V_1 + d_2)
F = 6.0 FT

DRAFT

SUBJECT _____ BY JBF

SHEET NO. 27 of ____ DATE 5/91

PROJECT NO. SWW35441

TAILWATER RATING CURVE

(FROM TOPO)

x	0	21	25	35	51	60	67	105
y	42	32	28	24	24	26	28	~~105~~ 30

$n = .035$

$S_o = 4\% \quad \frac{2 \text{ FT}}{50 \text{ FT}}$

WSEL = 32.15 "DAM-TW.HC2"

VEL = 12.85 } Q = 5400 CFS

DEPTH = 8.15 FT

(CRITICAL DEPTH) - ASSUME D/S FLOW IS NOT SUPERCRITICAL

THEREFORE DEPTH OF BASIN

12.8 - 8.2 = 4.6 FT

(12.8 - 5.0 = 7.8 FT) - AVERAGE DEPTH

USE 6 FT

DRAFT

JEF 5/84
SHEET 2F

CABANDRO

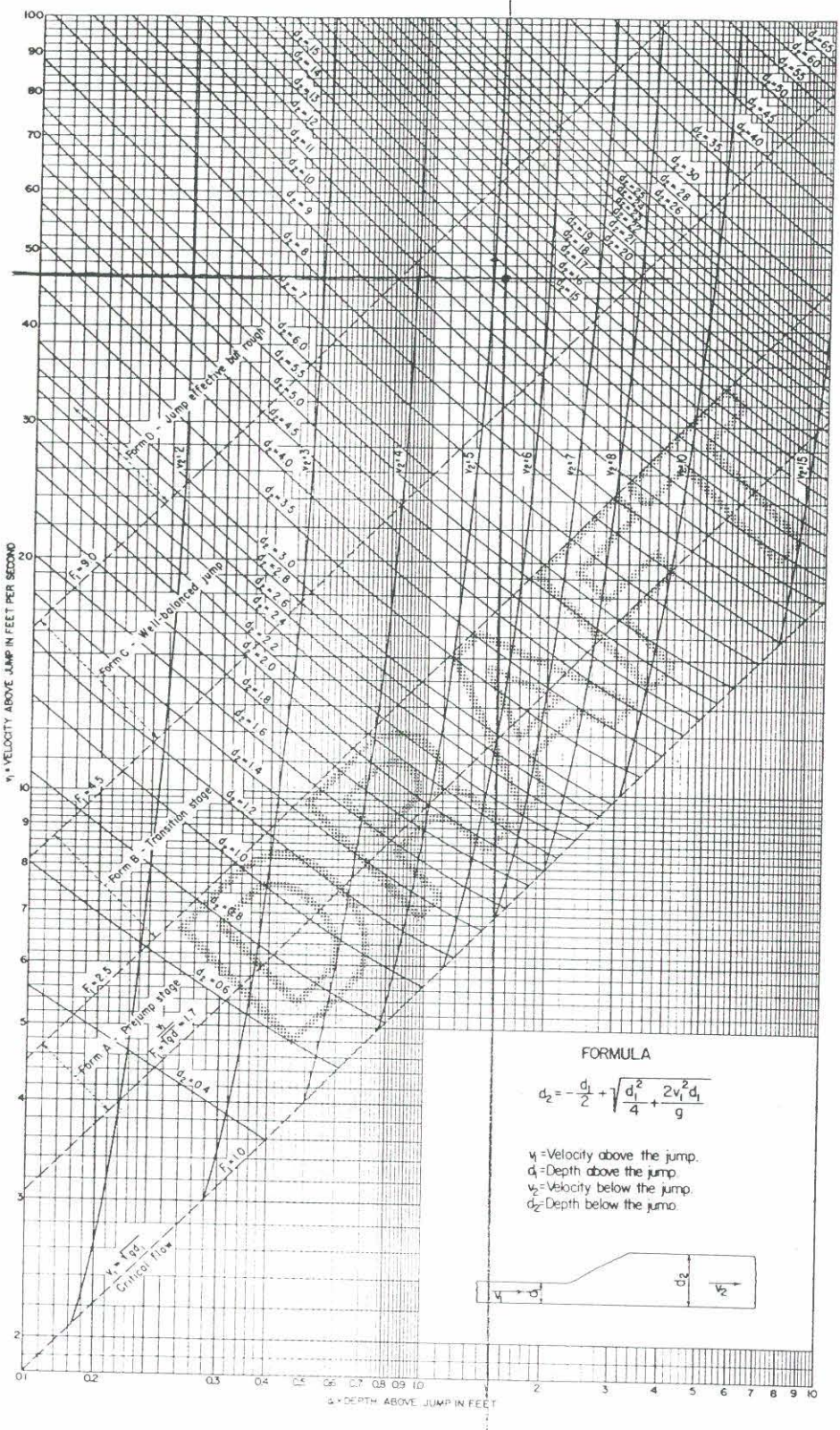


Figure 9-38.—Relations between variables in hydraulic jump for rectangular channel. 288-D-2424.

JBF 5/94
SHEET 29393
CASANDRO

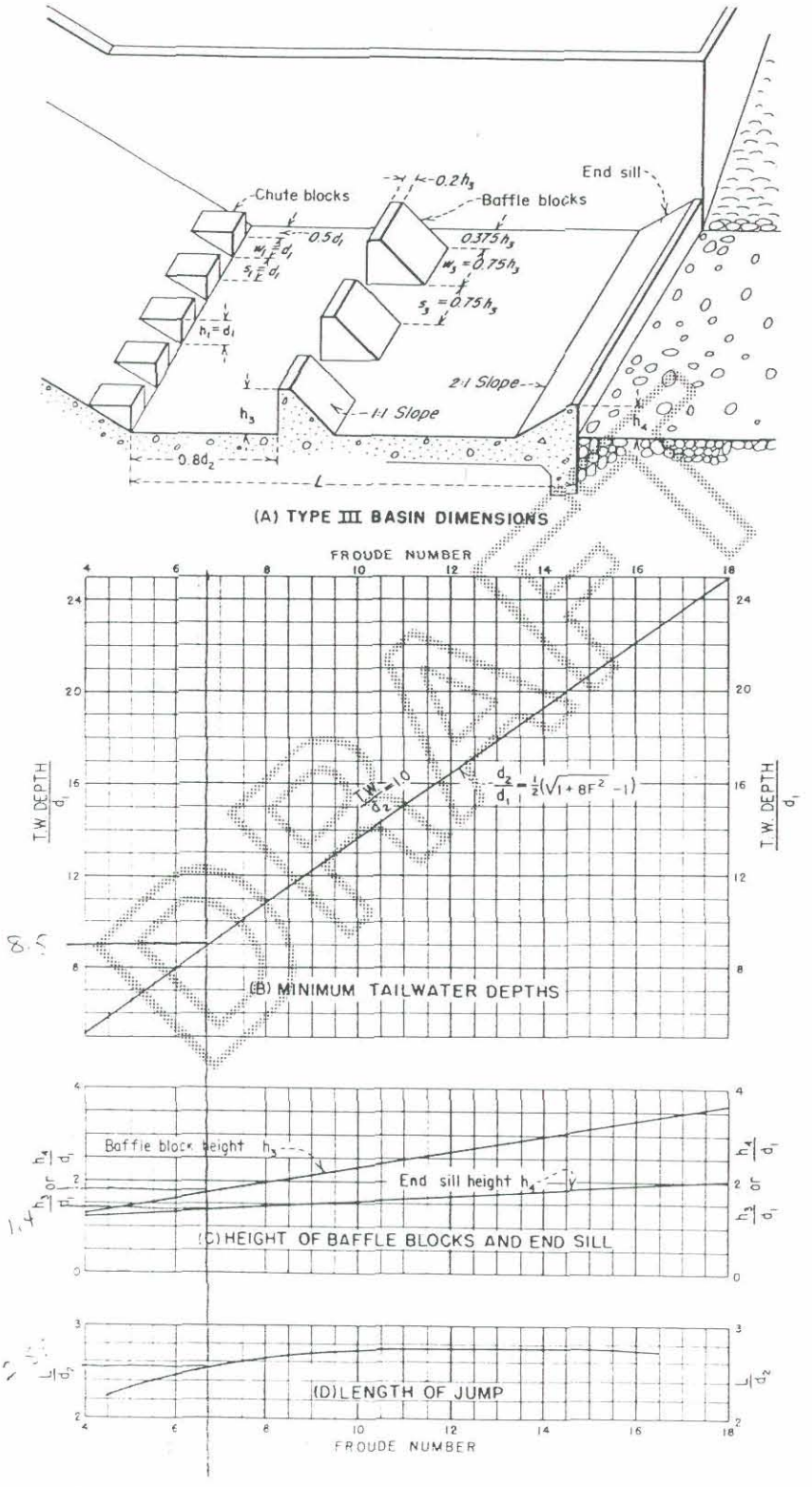


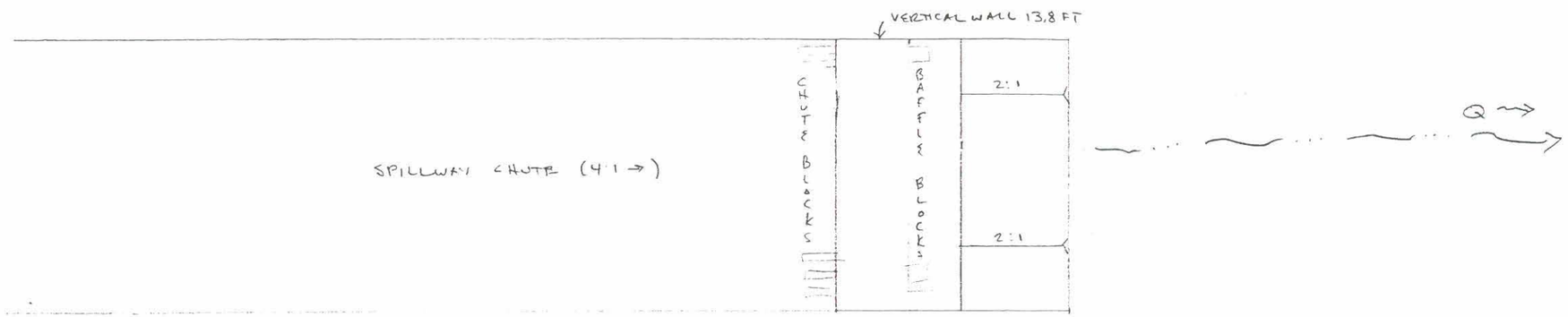
Figure 9-41.—Stilling basin characteristics for Froude numbers above 4.5 where incoming velocity, $V_1 \leq 60$ ft/s. 288-D-2426.

SUBJECT

PROJECT NO. SWW3 FV11 BY JRF SHEET NO. 31 OF

DATE 5/94

SCALE 1" = 20'
PLAN VIEW



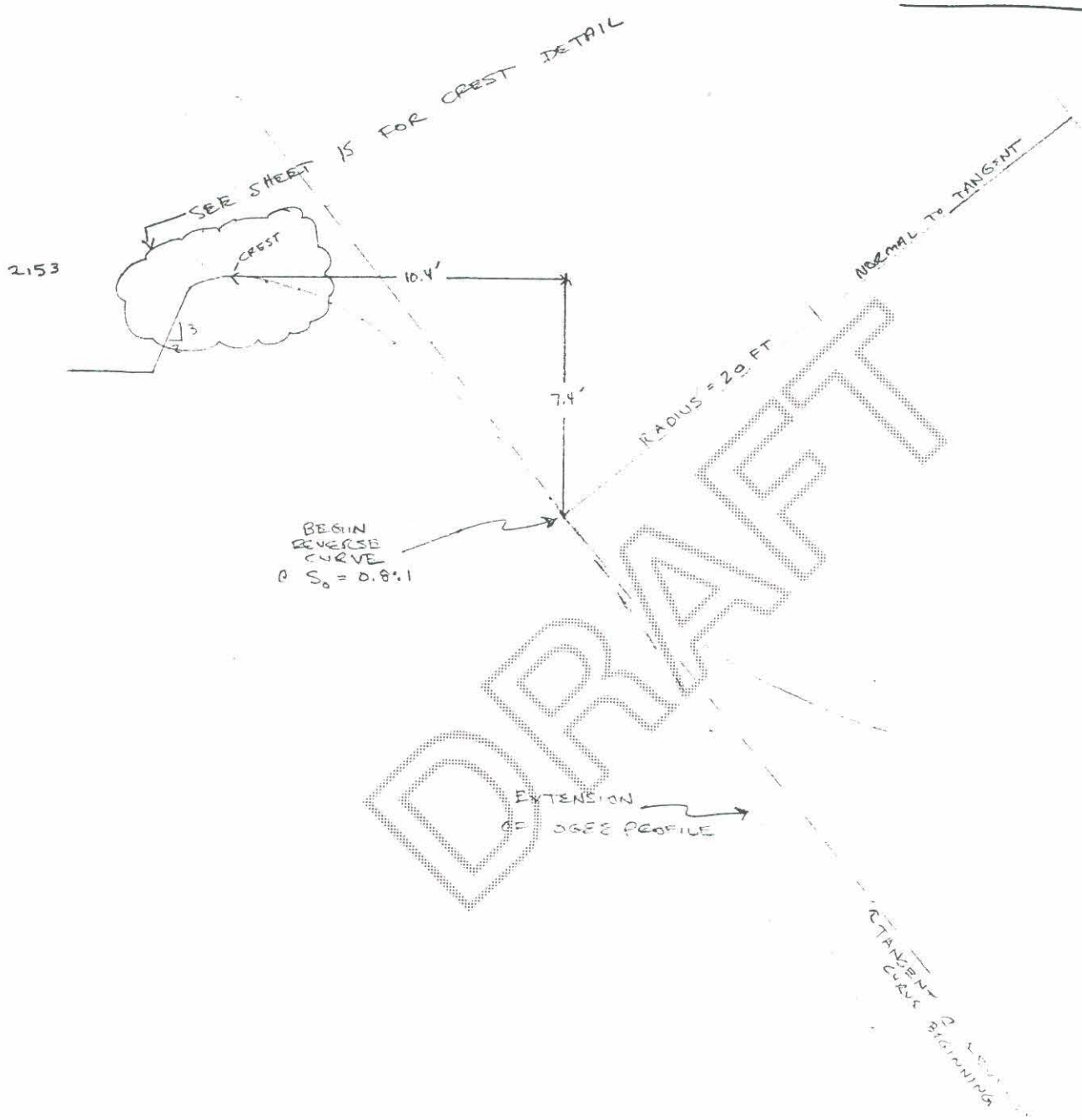
SUBJECT CASANDRO - OGEE PROFILE D/S OF CREST

BY JBP

SHEET NO. 20 of ____ DATE 6/2/94

PROJECT NO. SWW35441

SCALE 1" = 5 FT



DRAFT

SUBJECT	BY JRF
CASANDRO - SPILLWAY	SHEET NO. ____ of ____ DATE 6/3/94
	PROJECT NO.

ESTIMATE TAILWATER CONDITIONS

① MANNING'S RATING OF DOWNSTREAM CHANNEL

TOPO - MEASURED FROM 2 FT C.I. SITE MAP
SLOPE - " " " " " " 0.01
N = 0.035

↳ USE HEC2 "DAM-TW.HC2"

	Q	AVE. VEL	AVE DEPTH	
1/2 PMF	5400	12.85	8.15	(CRIT. ASSUMED)
FULL PMF	10940	15.83	11.24	

② SINCE CHANNEL IS ERODIBLE, ASSUME CRITICAL DEPTH ON DISSIPATOR LIP CONTROLS

$$y_c = \sqrt[3]{\frac{q^2}{g}}$$

BEATZ & KING, '53 p 8-9
Eq #8-31

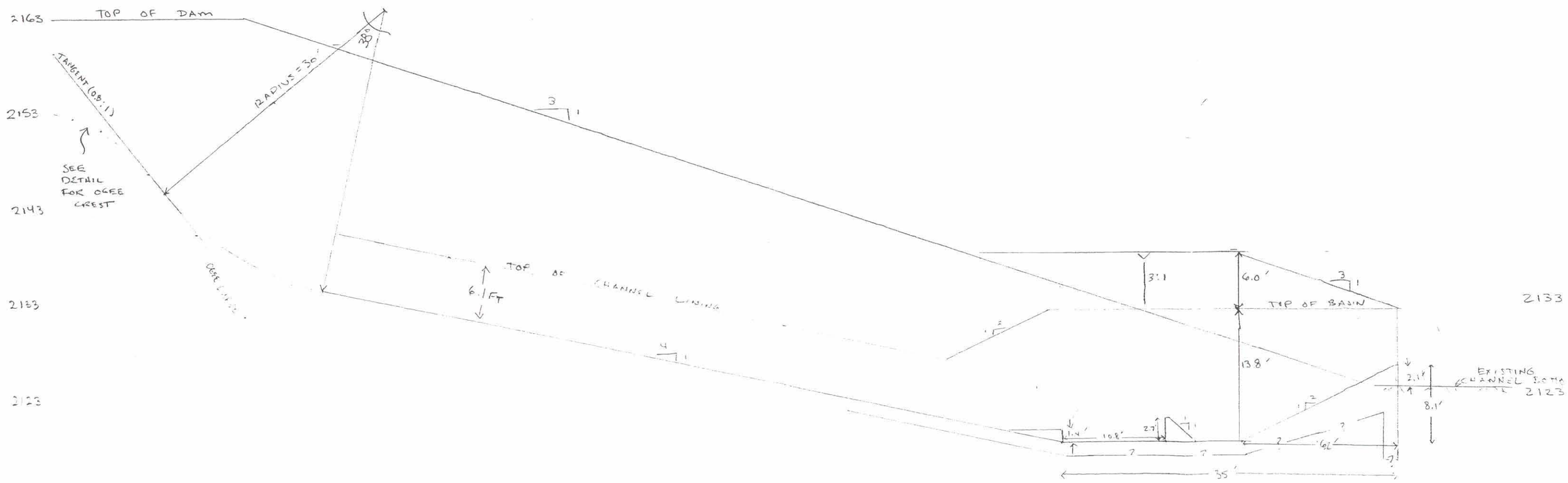
(RECTANGULAR SECTION)

DRAFT

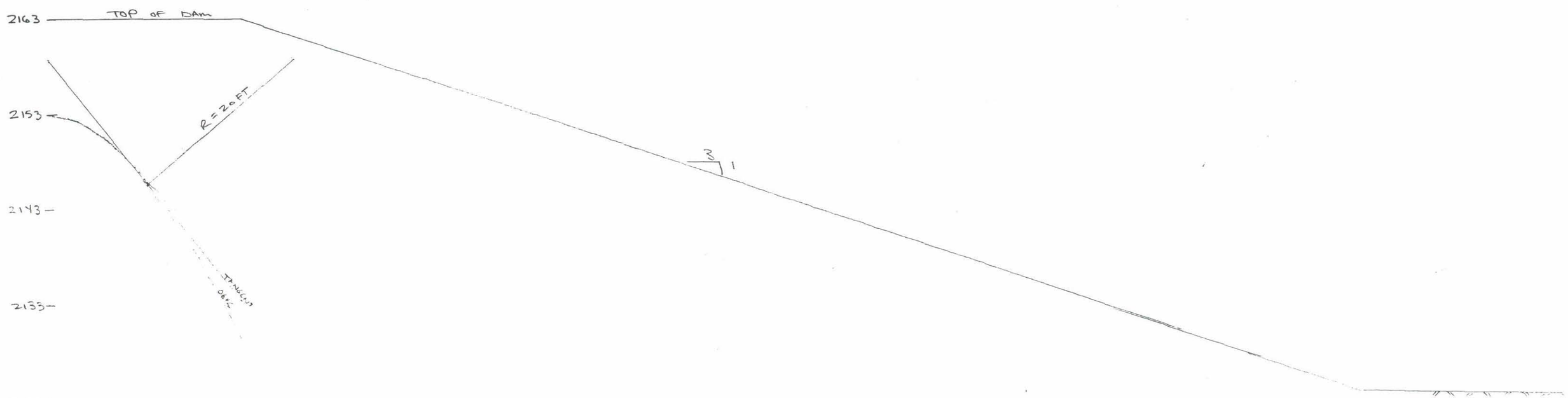
SUBJECT CASANDRO SPILLWAY CHUTE PROJECT NO. SWW3541 BY JBF DATE 5/94

SHEET NO. 30 OF

SCALE 1" = 10 FT



SUBJECT CASANDRO - SPILLWAY SCALE 1" = 10' PROJECT NO. BY DATE SHEET NO. OF



Sedimentation

MEMORANDUM CH2M HILL

TO: Michael Lopez/FCDMC

COPIES: Steve Walker
Tom Wolf
Dave Allard
Peter Binney/DEN
Roger Linquist/CVO
John Livingston/RDD
Kevin Bradford/RDD

FROM: Jon Fuller

DATE: March 30, 1994

SUBJECT: Casandro Wash - Sedimentation

PROJECT: SWW35441.HY.20

DRAFT

Introduction

This memorandum summarizes the results of the sedimentation investigation for the Casandro Wash Detention Dam to be located near Wickenberg, Arizona. This sedimentation investigation consisted of two elements: (1) estimation of sediment supply to the dam site, and (2) estimation of average annual and episodic sediment maintenance requirements. Design of sedimentation basins will be addressed separately.

Sediment Supply

Sediment deposited in the Casandro Dam impoundment area reduces the available storage volume for floodwater. The estimate of sediment supply will be used to estimate the additional storage volume required to meet the design requirements for floodwater storage and conveyance through the dam.

Data Requirements. Technical data required for estimating sediment supply was obtained from existing studies, regional geologic, land use and watershed mapping, HEC-1 hydrologic modeling of the watershed prepared for this project, and a sieve analysis of Casandro Wash bed sediments.

Methodology. Sediment supply was estimated using the following methodologies:

- PSIAC Method (Pacific Southwest InterAgency Committee). This procedure was developed for planning level analyses of sedimentation in

the southwest United States, and uses generalized watershed characteristics to predict sedimentation rates. The methodology is described in "*Design Manual for Engineering Analysis of Fluvial Systems*," Arizona Department of Water Resources, 1985.

- MUSLE (Modified Uniform Soil Loss Equation). MUSLE was developed by the U.S. Soil Conservation Service to predict rates of soil erosion, and is also commonly used to predict sediment yield in the arid southwest. MUSLE can be used to estimate sediment supplied from individual design storms, as well as average annual sediment production. MUSLE is described in "*Design Manual for Engineering Analysis of Fluvial Systems*," Arizona Department of Water Resources, 1985, with supplemental information available in "*Predicting Rainfall Erosion Loss - A Guide to Conservation Planning*," USDA Agricultural Handbook 537, 1978.

- C.T. Yang's Bedload Sediment Transport Function. C.T. Yang developed a sediment transport function which is commonly used to predict sediment movement rates in sand/gravel-bedded streams. Casandro Wash sediment load is mostly sand and gravel as indicated by sieve analysis of channel bed sediments from the project site. Yang's sediment equation is described in "*Unit Stream Power Equation for Gravel*," ASCE Journal of Hydraulic Engineering, Vol. 110, No. 12, December, 1984.

- U.S. Soil Conservation Service (SCS) Modeling for Sunset and Sunny Cove Dams. The SCS prepared a sedimentation investigation for two dams on watersheds similar to Casandro Wash, that are located within several miles of Casandro Wash. SCS estimates are based on sediment survey data and the "Range Method." SCS estimates are described in "*Watershed Work Plan: Wickenberg Watershed, Maricopa and Yavapai Counties, Arizona*," Soil Conservation Service, December 1974.

- FCDMC Sediment Maintenance Data. The FCDMC periodically removes sediment from Sunset and Sunnycove Dams in Wickenberg. Although no systematic sediment removal data is maintained, anecdotal information was used to roughly estimate potential sedimentation at Casandro Dam.

Results. Estimates of average annual sediment supply at Casandro Wash Dam from the sedimentation investigation are shown in Table 1. Estimates of sediment supply for specific recurrence interval design floods are shown in Table 2. It was assumed that the reservoir trapping efficiency was 100 percent due the high percentage of bed load transport and orifice-type outlet design.

Table 1 Casandro Wash Sediment Supply Estimates	
Methodology	**Average Annual Supply (AF/yr)**
PSIAC	0.3
MUSLE	0.6
SCS Studies	0.3
Yang Equation	0.4
FCDMC Maintenance	0.1 - 11.9

Table 2 Sediment Supply for Design Storms		
Recurrence Interval	**MUSLE**	**Yang Equation**
Q2	0.5	0.3
Q5	0.8	0.6
Q10	1.1	0.8
Q25	1.5	1.1
Q50	1.7	1.4
Q100	2.0	1.6

DRAFT

Discussion. Sediment supply estimates are relatively consistent between all methodologies used. Estimates based on anecdotal sediment maintenance information supplied by the FCDMC exceed the upper limit of sediment yields expected at the Casandro Wash site, but illustrate well the variability of sediment supply in an arid environment. It is likely the upper limit of sediment yield shown in Table 1 is skewed upward as a result of several large events occurring upstream of Sunset Dam during recent years; the long-term average is likely to be lower. It is also noted that estimated sediment supply does not increase dramatically with return period. This is probably due to the relatively short duration of the design flood, as well as the relatively intense design rainfall and steep channels which produce high velocity turbulent flow even for more frequent flood events.

Given the results reported above, sediment supply rates to be used for design of the detention dam are based on the average of the methods reported, and are summarized in Table 3. For the purposes of design of the reservoir and impoundment area, an additional 1.8 acre feet should be allowed for sediment storage.

Table 3
Design Sediment Volumes

Recurrence Interval	Sediment Volume
Average Annual	0.4 AF/yr
Q100	1.8 AF

DRAFT

Sediment Maintenance

Sediment maintenance requirements for the Casandro Wash Dam are directly related to the sediment supply rates. The average annual sediment yield of 0.4 AF/year can be used to predict annualized sediment maintenance needs. However, since annual sedimentation may be highly variable, as indicated by anecdotal information obtained for the nearby Sunset and Sunnycove Dams, actual sediment removal requirements may vary significantly in any given year. Therefore, monitoring of sediment accumulation should be included in the reservoir maintenance plan.

Sediment Summary Table

By: K. Bradford

Method	Basin Area (sq. mi.)	Unit Average Annual Sediment Yield (AF/sq.mi./year)	Average Annual Sediment Yield (AF/year)	Recurrence Interval	Sediment Volume (AF/year)
PSIAC	1.24	0.25	0.31	2-year	0.40
MUSLE	1.24	0.46	0.57	50-year	1.38
SCS Study	-	-	0.25	100-year	1.65
		Average =	0.38		

DRAFT

CH2M HILL

SUBJECT CASANDRO WASH
SEDIMENT TRANSPORT WASHLOAD

BY K. BRADFORD DATE 1-25-94
SHEET NO. 1 OF 6
PROJECT NO. SWW 3544.HY.20

PSIAC METHOD -

A. SURFACE GEOLOGY — RATING = 0 — NO BEDROCK

LITTLE exposed BEDROCK w/ (AT 20" DEEP IN UPPER WATERSHED, MAYBE <10% OF TOTAL AREA)

MOSTLY VERY GRAVELLY LOAM AND EXTREMELY GRAVELLY CLAY

SOME AREAS OF $CaCO_3$ HARDPAN, 6" THICK, @ 14" DEEP

B. SOILS — RATING = 5 — MED. TEXTURE/OCC. ROCK FRAG.

MOSTLY VERY GRAVELLY LOAM AND EXTREMELY GRAVELLY CLAY (SEE ABOVE)

SHRINK/SWELL IS MOSTLY LOW, EXCEPT IN EXTREME UPPER WATERSHED MOD. → HIGH

C. CLIMATE — RATING = 3 — COMBINATION OF BELOW

(5) INFREQUENT/RARE CONVECTIVE STORMS

(0) ARID CLIMATE

(0) SHORT DURATION STORMS, VERY INTENSE

D. RUNOFF — RATING = 3 — COMBINATION OF BELOW

(2) RARE RUNOFF EVENTS

(5) MODERATE PEAK FLOWS

E. TOPOGRAPHY — RATING = 10

(10) MODERATE DRAINAGE DENSITY

F. GROUND COVER — RATING = -5 — PARTIAL MODERATE VEGETATION

(-5) VERY VEGETATED

(0) SOME VEGETATION

(-5) ROCK FRAGMENTS MORE [illegible]

DRAFT

CH2M HILL

SUBJECT CASANDRO WASH
SEDIMENT TRANSPORT WASHLOAD

BY L. BRADFORD DATE 1-25-94
SHEET NO. 2 OF 6
PROJECT NO. SWW 35441.HT.20

G. LAND USE — RATING = -5 COMB. OF BELOW

(-10) NO/LITTLE CULTIVATION

(0) ORDINARY ROAD / OTHER CONSTRUCTION

H. UPLAND EROSION — RATING = 15 COMB. OF BELOW

(20) SOME RILL / GULLY EROSION EVIDENCED ON AERIAL PHOTOS (25-50%)

(10) POSSIBLE WIND EROSION W/ DEPOSITION IN CHANNEL

I. CHANNEL EROSION — RATING = 5 COMB. OF BELOW

(0) WIDE SHALLOW CHANNELS / SHORT FLOW DURATION

(5) OCCASIONALLY ERODED BED

SUMMARY

A	0
B	5
C	3
D	3
E	10
F	-5
G	-5
H	15
I	5
TOTAL:	31

=> CLASSIFICATION 1 (25-50) => 0.2-0.5 AF/mi²/yr

$\frac{6}{25} = \frac{x}{0.2}$ => x = 0.05

USE 0.25 AF/mi²/yr

[illegible] = 1.24 mi²

[illegible] = 0.31 AF/yr

DRAFT

FORM 3B

CH2M HILL

SUBJECT CASANDRO WASH
SEDIMENT TRANSPORT WASHLOAD

BY K. BRADFORD DATE 1-27-94
SHEET NO. 3 OF 6
PROJECT NO. 5000 3544.1.HY.20

MUSLE METHOD -

- USED MUSLE.XLS SPREADSHEET WITH SCS HANDBOOK #537 & ADWR DESIGN MANUAL FOR ENGINEERING ANALYSIS OF FLUVIAL SYSTEMS, APPENDIX B AS REFERENCES.

1. USE HEC-1 OUTPUT TO OBTAIN PEAK FLOWS & VOLUMES FOR Q_2, Q_5, Q_{10}, Q_{25}, Q_{50}, & Q_{100}
   - PUT FLOWS & VOLUMES INTO SPREADSHEET
   - USE $\alpha = 95$, $\beta = 0.56$ (ADWR, PG B-1) → SPREADSHEET GIVES L_w

2. USE SCS SOIL SURVEY MAPS TO DETERMINE SOIL TYPES & PROPERTIES WITHIN DRAINAGE BASIN:
   - TRANSPOSE BASIN BOUNDARY ON COPY OF SCS MAP.
   - SOIL TYPES ARE: #38, 73, 94
   - USE PLANIMETER TO DETERMINE % OF TOTAL AREA THAT EACH SOIL TYPE MAKES UP. RESULTS: #38 - 50%, #73 - 12%, #94 - 38%
   - USE SOIL SURVEY MANUAL TO DETERMINE SOIL PROPERTIES:

From DETAILED SOIL MAP UNITS:
#38 - 40% EBA, 25% CONTINENTAL, 20% CAVE, 15% OTHERS
#73 - 45% LEMMAN, 30% ROCK OUTCROP, 25% OTHERS
#94 - 50% NICKEL, 35% CAVE, 15% OTHERS

RESULTS: FROM METHOD, SOIL MAP UNITS, CLASSIFICATION OF SOILS, & TABLE 13

SOIL TYPE	SOIL GROUP	% OF EBA	% OF CONT.	% OF AREA	% SILTS	% SANDS	STRUCTURE	PERMEABILITY
EBA	40	50	50	50	30	20	PLATY	[illegible]
CONTINENTAL	[illegible]	[illegible]	[illegible]	[illegible]	65	35	PLATY	[illegible]
CAVE	20 / 35	50 / 35	[illegible]	[illegible]	[illegible]	[illegible]	PLATY	[illegible]
LEMMAN	45	5	[illegible]	[illegible]	35	40	PLATY	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	35	PLATY	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	PLATY	[illegible]

DRAFT

SUBJECT CASANDRO WASH
SEDIMENT TRANSPORT WASHLOAD

BY K. BRADFORD DATE 1-27-94
SHEET NO. 4 OF 6
PROJECT NO. SWW 35441.MT.00

- FROM FIG. 3, PG 11 OF SCS #573 USE NOMOGRAPH TO COME UP WITH K VALUES FOR EACH SOIL TYPE
- PLACE REQ'D INFO. INTO SPREADSHEET → AREA WEIGHTED K IS CALCULATED.

3. USED PHOTOGRAPHS TAKEN DURING FIELD SURVEY, AERIAL PHOTOS, QUAD SHEETS, & VERBAL ESTIMATES FROM J. FULLER TO ESTIMATE COVER TYPES
   - BROKE COVER TYPES INTO THREE MAIN CATEGORIES: GRASSLAND BRUSHLAND, URBAN, NONE
   - ESTIMATED FROM ABOVE SOURCES THAT: GRASSLAND - 10%, BRUSHLAND - 10%, URBAN - 20%, NONE - 60%
   - FOR FIG. 3.2 (ADWR, PG 3.4), ASSUMED GRASSLAND < 0.5m, BRUSHLAND = 1m, URBAN & NONE ∞
   - FOR FIG. 3.3 (ADWR, PG 3.5), ASSUMED GRASSLAND - 10%, BRUSHLAND - 5%, URBAN & NONE = 5
   - FOR FIG. 3.4 (ADWR, PG 3.6), USED "WEEDS", GRASSLAND - 100%, BRUSHLAND - 50%, URBAN - ≤10%, NONE - USE FACTOR OF 1.00
   - PLACE DATA IN SPREADSHEET → AREA WEIGHTED K IS CALC'D.

4. USED QUAD SHEETS & FIELD SURVEY PHOTOS TO DETERMINE AVERAGE SLOPES & SLOPE LENGTHS
   - ESTIMATED AN AVERAGE LENGTH FROM MOST DISTANT POINT TO STREAM BED FOR ENTIRE BASIN
   - ESTIMATED AN AVERAGE FALL FROM MOST DISTANT POINT TO STREAM BED FOR ENTIRE BASIN
   - USE AVERAGE SLOPE & AVG. SLOPE LENGTH IN FIGURE 4 (SCS #573) TO GET LS
   - PLACE INFO INTO SPREADSHEET

DRAFT

SUBJECT CASANDRO WASH
SEDIMENT TRANSPORT WASHLOAD

BY K. BRADFORD DATE 1-27-94
SHEET NO. 5 OF 6
PROJECT NO. SWRO 35AA1.44.20

5. SINCE NO CONSERVATION PRACTICES EXIST IN THE DRAINAGE BASIN AREA EROSION CONTROL PRACTICE FACTOR = 1.0
   - PLACE INTO SPREADSHEET

6. USING BASIN AREA (1.24 mi²) AND ASSUMING UNIT WEIGHT OF SOIL EQUAL TO 165.4 lbs/ft³, DETERMINE WEIGHTED UNIT AVERAGE ANNUAL SEDIMENT YIELD

DRAFT

SUBJECT CASANDRO WASH
SEDIMENT TRANSPORT WASHLOAD

BY K. BRADFORD DATE 1-27-94
SHEET NO. 6 OF 6
PROJECT NO. SWW 35441.HY.20

SOIL TYPES - FROM SCS SOIL SURVEY OF AGUILA-CAREFREE AREA

1.52 in² (50%) #38 - 40% EBA VERY GRAVELLY LOAM, 25% CONTINENTAL CLAY LOAM, 20% CAVE GRAVELLY LOAM, 15% OTHERS; MOSTLY LOW → MODERATE SHRINK/SWELL

.03
.98
1. in² (12%) #73 - 45% LEHMANS VERY GRAVELLY CLAY LOAM, 30% ROCK OUTCROP, 25% OTHERS MOSTLY LOW → HIGH SHRINK/SWELL

.34 in² (33%)
#94 - 50% NICKEL GRAVELLY SANDY LOAM, 35% CAVE GRAVELLY LOAM, 15% OTHERS LOW SHRINK/SWELL
3.99 in² (100%)

K			% BASIN	% SILTS & V.F.	% SANDS (0.1-2.0 mm)	STRU.	PERM
0.24	RESULTS:	EBA	VERY GRAV. LOAM/ VERY GRAV. CLAY	20%	30%	20%	4	5
0.69		CONT.	CLAY LOAM/CLAY	30%	65%	30%	4	5
0.39		CAVE	GRAV. LOAM	23%	45%	35%	4	3
0.34		LEHMANS	VERY GRAV. CLAY LOAM/GCL	5%	35%	40%	4	5
0.00		ROCK OUTCROP		4%	—	—	—	—
0.22		NICKEL	GRAV. SANDY LOAM	15%	75%	35%	4	4
0.17		OTHERS		13%	25%	50%	4	1
				100%				

~~[illegible]~~ 156

Q_{100} ? 1769 NEED HYDROGRAPH ?

V_{50} = 0.59 X_{soil} ? SEE MESQUITE

SCS AG. HANDBOOK #[illegible]

[illegible]				
[illegible]			700'	[illegible]
[illegible]			10'	[illegible]
[illegible]			0.043	[illegible]
[illegible]	4		0.29	[illegible]

DRAFT

FORM 3B

Sediment Yeild Worksheet
By
Modified Universal Soil Loss Equation Method

MODIFIED UNIVERSAL SOIL LOSS EQUATION (MUSLE), Ys = Rw * K * LS * C * P By: K. Bradford

A. Rw, STORM ENERGY RUNOFF FACTOR; Rw = a(V*q)^b

Drainage Area at CAS 240 = 1.24 sq. mi.

Recurrence Interval	Volume, V (ac-ft)	Flow Peak (cfs)	a	b	Rw
Q-2	43	506	95	0.56	25515
Q-5	68	819	95	0.56	43188
Q-10	86	1028	95	0.56	55945
Q-25	112	1346	95	0.56	75431
Q-50	129	1544	95	0.56	88165
Q-100	156	1769	95	0.56	105828

B. K, SOIL ERODIBILITY FACTOR; Figure 3, SCS Ag. Handbook # 537

Soil Group	% Silt & v.f.sand	% Sand	% Organic Material	Soil Structure	Permea-bility	K	% of Basin
Very Grav.-loam	30	20	0	platy	slow	0.24	20
Clay Loam	65	30	0	platy	slow	0.69	13
Gravelly-loam	45	35	0	platy	moderate	0.39	23
Gravelly-clay loam	35	40	0	platy	slow	0.34	5
Rock Outcrop	-	-	-	-	-	0.00	4
Gravelly-sandy loam	25	35	0	platy	m.slow	0.22	19
Others	25	50	0	platy	v.rapid	0.17	16
					Weighted K Factor:		0.31

C. C, COVER AND MANAGEMENT FACTOR; Figures 5-7, SCS Ag. Handbook #537

Soil Group	% of Basin	Canopy Factor	Mulch Factor	Root Factor	Composite C Factor	Weighted C Factor
Grassland	10	0.90	0.75	0.35	0.24	0.02
Brushland	10	0.92	0.90	0.35	0.29	0.03
Urban	20	1.00	0.99	0.45	0.45	0.09
None	60	1.00	1.00	1.00	1.00	0.60
				Composite Weighted C Factor=		0.742

D. LS, TOPOGRAPHIC FACTOR; LS = ((L/72.6)^n)*(0.65+0.0454*S+0.0065*S^2)

Slope Lengths: 50 - 1500 feet (Basin Average)
Slope Angles: 1 - 15 % (Basin Average)

Figure 3-2, SCS Ag. Handbook 537: LS= 0.2 - 0.4

LS = 0.30

E. P, EROSION CONTROL FACTOR

Rangeland, P = 1.00

DRAFT

Sediment Yeild Worksheet
By
Modified Universal Soil Loss Equation Method

F. RESULTS:

Recurrence Interval	Rw	K	LS	C	P	Ys (tons)	Unit Ys (tn/sq.mi)	Unit Annual Sediment Yeild (ac-ft/sq.mi/year)	
Q-2	25515	0.31	0.30	0.74	1.00	1779	1435	0.40	.50
Q-5	43188	0.31	0.30	0.74	1.00	3012	2429	0.67	.83
Q-10	55945	0.31	0.30	0.74	1.00	3901	3146	0.87	1.07
Q-25	75431	0.31	0.30	0.74	1.00	5260	4242	1.18	1.46
Q-50	88165	0.31	0.30	0.74	1.00	6148	4958	1.38	1.71
Q-100	105828	0.31	0.30	0.74	1.00	7380	5952	1.65	2.05

WEIGHTED AVERAGE ANNUAL SEDIMENT YIELD:		2039	tons/year
WEIGHTED UNIT AVERAGE ANNUAL SEDIMENT YIELD:		1645	tons/sq.mi/year
ASSUMED SOIL UNIT WEIGHT (lbs/cu ft):	165.4	0.46	ac-ft/sq.mi/year

DRAFT

Comparison to SCS Study:

The Soil Conservation Service performed sediment investigations on the Sunset and Sunnycove washes as part of the Wickenburg Watershed Workplan of December 1974. The following rationalization was used to confirm the applicability of comparing data from the SCS approach to the current estimates obtained from the PSIAC and MUSLE methods:

1. The two study areas are in close proximity to one another
    - Similar rainfall patterns
    - Similar topography
    - Similar ground cover and runoff characteristics

2. The study areas are approximately the same size and shape (1.24 versus 1.95 square miles)

The procedure for the SCS approach was to use ground cover survey data, topographic maps, visual inspections of the watersheds, and sediment surveys on two stock ponds. The range method was used to survey the two ponds. The original volume and the volume of sediment contained in each pond were calculated using the range-area method. Trap efficiencies were estimated using capacity-inflow curves and the total trapped sediment was adjusted accordingly. Annual sediment yields for each wash were computed by applying the unit annual sediment yield for the ponds to the drainage area of each wash. Adjustments were made to reflect any differences in ground cover and rainfall intensities.

Comparatively, the PSIAC and MUSLE methods rely on topographic and ground cover estimates. While neither equation allows for input of observed sediment depositions, each was derived from empirical data. It is important to note that sediment yields determined by the SCS were used simply as a check to confirm that the numbers obtained from PSIAC and MUSLE methods are of the correct order of magnitude.

DRAFT

SUBJECT _____ BY _____ DATE _____

SHEET NO. ____ OF ____

PROJECT NO. _____

Watershed Work Plan
Wickenburg Watershed
McKYC, AZ SCS 12/74

Notes of SCS Report
Sediment -

① severe erosion in places ≥ 3 AF/yr/mi² ≈
(not an average rate)

② Sunset / Sunny cove = 0.3 AF/yr 600 tons/yr
(p.11) in watershed (69 Acres evaluated)
D.A = 1250 acres

③ Cassandra Aver yield = 0.25 AF/yr (500 tons/yr)
(p.12)

p.63 & 64 ④ Methodology "Sed Survey" Sunny cove / Sunset
Range method on 2 ponds
trap efficiency is capacity-inflow ratio curve $\frac{.12\ AF}{.79\ m^2}$

Hydrology
since 1949 : 9 floods (by 12/74)

DRAFT

SUBJECT SUNSET/SUNNYCOVE WASH SEDIMENT TRANSPORT ESTIMATES

BY K. BRADFORD DATE 2-4-94

SHEET NO. 1 OF 2

PROJECT NO. SWW 3541.MY.20

- INFORMATION ON ACTUAL SEDIMENT REMOVAL BY FCDMC PERSONNEL WAS OBTAINED FROM PAUL DEPIRO / FCDMC

SUNSET - • CLEANED ABOUT ONCE EVERY OTHER YEAR
• 1 FOOT OF SEDIMENT REMOVED THROUGHOUT (PAUL'S ESTIMATE)
• AREA OF REMOVAL IS APPROX. 500' x 1000' (PAUL'S ESTIMATE)

VOLUME OF SEDIMENT = 1' x 500' x 1000' = 500,000 ft³
= 11.5 acre-ft

FREQUENCY = 2 years

AVERAGE SEDIMENT DEPOSIT PER YEAR = 11.5 ÷ 2 = 5.7 acre-ft/year

BASIN AREA = 0.60 mi² (FROM 1974 SCS REPORT)

UNIT AVERAGE ANNUAL SEDIMENT YIELD = $\frac{5.7}{0.60}$ = 9.6 acre-ft/mi²/year

FOR CASSANDRA = 11.9 AF/YR

SUNNYCOVE - • CLEANED ONCE IN LAST 10 YEARS
• PULLED 3' OUT OF BOTTOM END, HAD REDUCED TO 1' ABOUT 300' UPSTREAM (PAUL'S ESTIMATE)
• AREA OF REMOVAL IS APPROX. 500' x 80' (PAUL'S ESTIMATE)

VOLUME OF SEDIMENT = $\left[\frac{(3'+1')}{2} \times 300' \times 80'\right] + (1' \times 200' \times 80')$
= 64,000 ft³
= 1.47 acre-ft

DRAFT

CH2M HILL

SUBJECT SUNSET/SUNNYCOVER WASH
SEDIMENT TRANSPORT ESTIMATES

BY K. BRADFORD DATE 2-4-94
SHEET NO. 2 OF 2
PROJECT NO. SWW 35441.M4.20

FREQUENCY = 10 years

AVERAGE SEDIMENT DEPOSIT PER YEAR = 1.47 ÷ 10 = 0.147 acre·ft/year

BASIN AREA = 1.35 sq. mi. (FROM 1974 SCS REPORT)

UNIT AVERAGE ANNUAL SEDIMENT YIELD = 0.147 ÷ 1.35

= 0.11 acre·ft / mi² / year

.14

DRAFT

CH2M HILL *TELEPHONE CONVERSATION RECORD*

CALL TO PAUL DEPIRO / FCDMC

BOB PANESEWICZE / FCDMC 390-7803 (mobile)

CALL FROM K. BRADFORD

MESSAGE TAKEN BY

SUBJECT SEDIMENT REMOVAL NEAR WICKENBURG

PHONE NO. 506-1501

DATE 2-2-94

TIME 8:00 ☒ AM ☐ PM

PROJECT NO. SWW 3544.14.20

- HAVE TWO DAMS: SUNSET
  SUNNYCOVE
- SUNSET (BY TOWER FORT)
  - CLEAN OUT EVERY OTHER [illegible] HAVE
  - REMOVE [illegible] REMAINING
  - [illegible] UPSTREAM (FROM TOWER TO THE [illegible]) "A THOUSAND" FEET WIDE.
- SUNNYCOVE (NEAR CEMETERY)
  - CLEANED [illegible] YEARS → 2 OR 4 YRS. AGO
  - POLE [illegible] NEAR BOTTOM WHERE I "POKED" [illegible] BACK THE SED. DEPTH WAS [illegible]
  - TOTAL [illegible] UPSTREAM [illegible] WIDE.
  - FILLS [illegible]

DRAFT

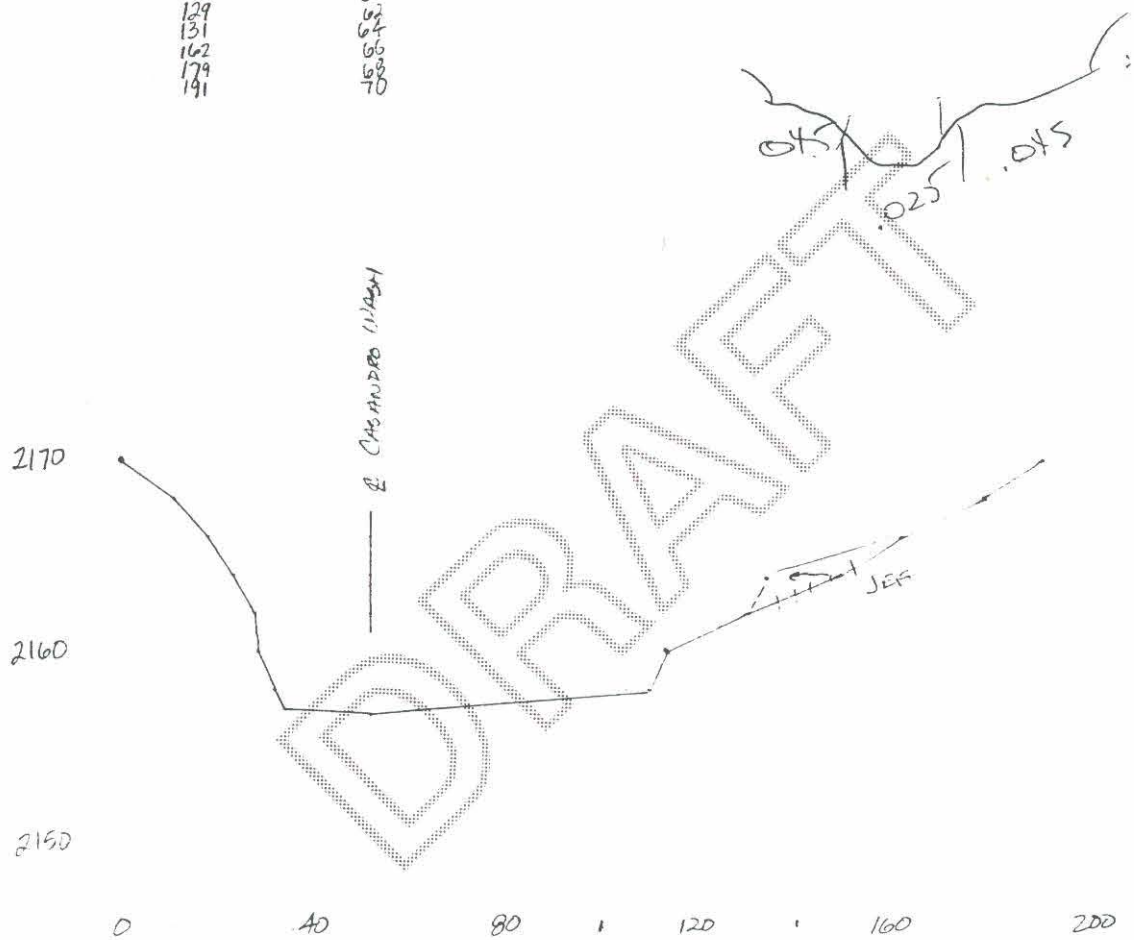
FORM

CH2M HILL SUBJECT CASANDRO WASH BY K. BRADFORD DATE 2-24-94

CHANNEL GEOMETRY FOR SEDIMENT TRANSPORT ANALYSIS PROJECT NO. 4WW3544.14.20 SHT 1 OF 1

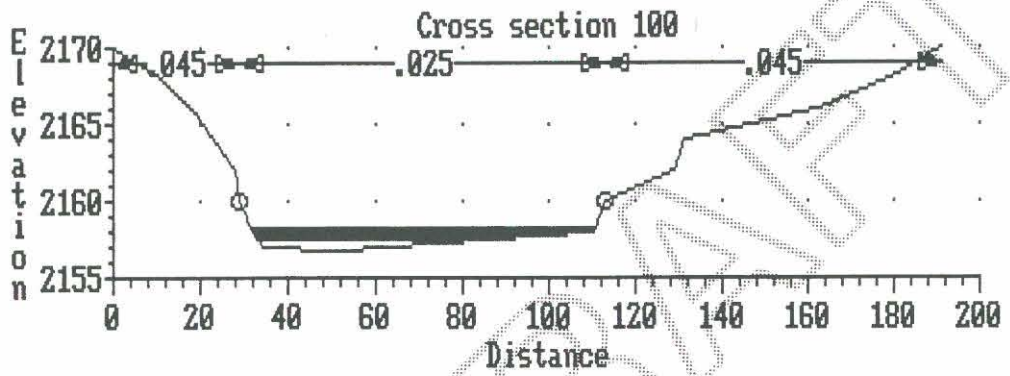
DIST	ELEV
0	2170
11	68
18	66
23	64
28	62
29	60
32	58
34	57
52	56.8
62	57
110	58
113	60
129	62
131	64
162	66
179	68
191	70

AVE. CHANNEL SLOPE = $\frac{41'}{168'}$ = 0.0238 ft/ft



DRAFT

$\frac{40}{15}$


Cross section 100
.045
.025
.045
Elevation
2170
2165
2160
2155
0
20
40
60
80
100
120
140
160
180
200
Distance

DRAFT

HEC2 S/N: 1916530021 HMVersion: 6.50 Data File: yangsecs.hc2

```
*****************************************
*  HEC-2 WATER SURFACE PROFILES         *
*                                       *
*  Version   4.6.2;  May 1991           *
*                                       *
*  RUN DATE     3MAR94    TIME    9:21:05 *
*****************************************
```

```
****************************************
*  U.S. ARMY CORPS OF ENGINEERS        *
*  HYDROLOGIC ENGINEERING CENTER       *
*  609 SECOND STREET, SUITE D          *
*  DAVIS, CALIFORNIA 95616-4687        *
*          (916) 756-1104              *
****************************************
```

```
X     X  XXXXXXX   XXXXX              XXXXX
X     X  X       X     X            X     X
X     X  X       X                        X
XXXXXXX  XXXX    X          XXXXX    XXXXX
X     X  X       X                  X
X     X  X       X     X            X
X     X  XXXXXXX   XXXXX            XXXXXXX
```

```
::::::::::::::::::::::::::::::::::::::::::::
::::::::::::::::::::::::::::::::::::::::::::
:::                                      :::
:::   FULL MICRO-COMPUTER IMPLEMENTATION  :::
:::                                      :::
::::::::::::::::::::::::::::::::::::::::::::
::::::::::::::::::::::::::::::::::::::::::::
```

```
============================
H A E S T A D   M E T H O D S
============================
```

37 Brookside Road * Waterbury, Connecticut 06708 * (203) 755-1666

DRAFT

THIS RUN EXECUTED 3MAR94 9:21:05

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

CASANDRO WASH - SEDIMENT TRANSPORT ANALYSIS
TYPICAL SECTION FOR USE WITH YANG 1984 SEDIMENT TRANSPORT EQUATION.
FOR Q = 125 cfs

ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
-10	2	0	1	0.0238					

VARIABLE CODES FOR SUMMARY PRINTOUT

43	8	14	26	5	25	4	21	22	33
67									

DRAFT

THIS RUN EXECUTED 3MAR94 9:21:09

****

C-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991

****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

S MARY PRINTOUT

Q	DEPTH	QCH	VCH	10*KS	AREA	TOPWID	STCHL	STCHR	K*CHSL	SHEAR
125.000	0.71	125.00	5.29	237.09	23.61	53.52	29.00	113.00	0.00	0.65
250.000	0.97	250.00	6.39	235.50	39.10	66.44	29.00	113.00	0.00	0.86
375.000	1.16	375.00	7.15	237.18	52.48	75.84	29.00	113.00	0.00	1.02
500.000	1.30	500.00	7.90	236.18	63.26	78.29	29.00	113.00	0.00	1.19
625.000	1.41	625.00	8.64	237.25	72.38	78.64	29.00	113.00	0.00	1.36
750.000	1.52	750.00	9.28	237.65	80.86	78.96	29.00	113.00	0.00	1.52
875.000	1.62	875.00	9.85	237.84	88.84	79.26	29.00	113.00	0.00	1.66
1000.000	1.72	1000.00	10.37	237.81	96.42	79.55	29.00	113.00	0.00	1.80
1125.000	1.81	1125.00	10.81	234.44	104.10	79.84	29.00	113.00	0.00	1.91
1250.000	1.90	1250.00	11.27	235.49	110.92	80.09	29.00	113.00	0.00	2.03
1375.000	1.98	1375.00	11.70	236.16	117.52	80.34	29.00	113.00	0.00	2.16
1500.000	2.06	1500.00	12.11	236.72	123.90	80.58	29.00	113.00	0.00	2.27

DRAFT

SUBJECT Sediment Sample Sieve Test Results BY D CMS DATE 2/8/90
Phone Call From WT Lab. SHEET 1 OF 1
PROJECT NO. SWW 35441.DT.20

Cansando Wash

Note Laboratory data sheet will be FAXed to us later today.

Sediment Sample

Sieve	mm	% Passing	
1/2"	12.7	100	0
3/8"	9.525	99	1
1/4"	6.35	95	4
4	6.35	90	5
8	3.175	71	19
10	2.54	65	6
16	1.5875	45	20
~~20~~ 30	0.847	26	19
40	0.635	18	8
50	0.508	13	5
100	0.254	6	7
200	0.127	3	3
	0.0235		3

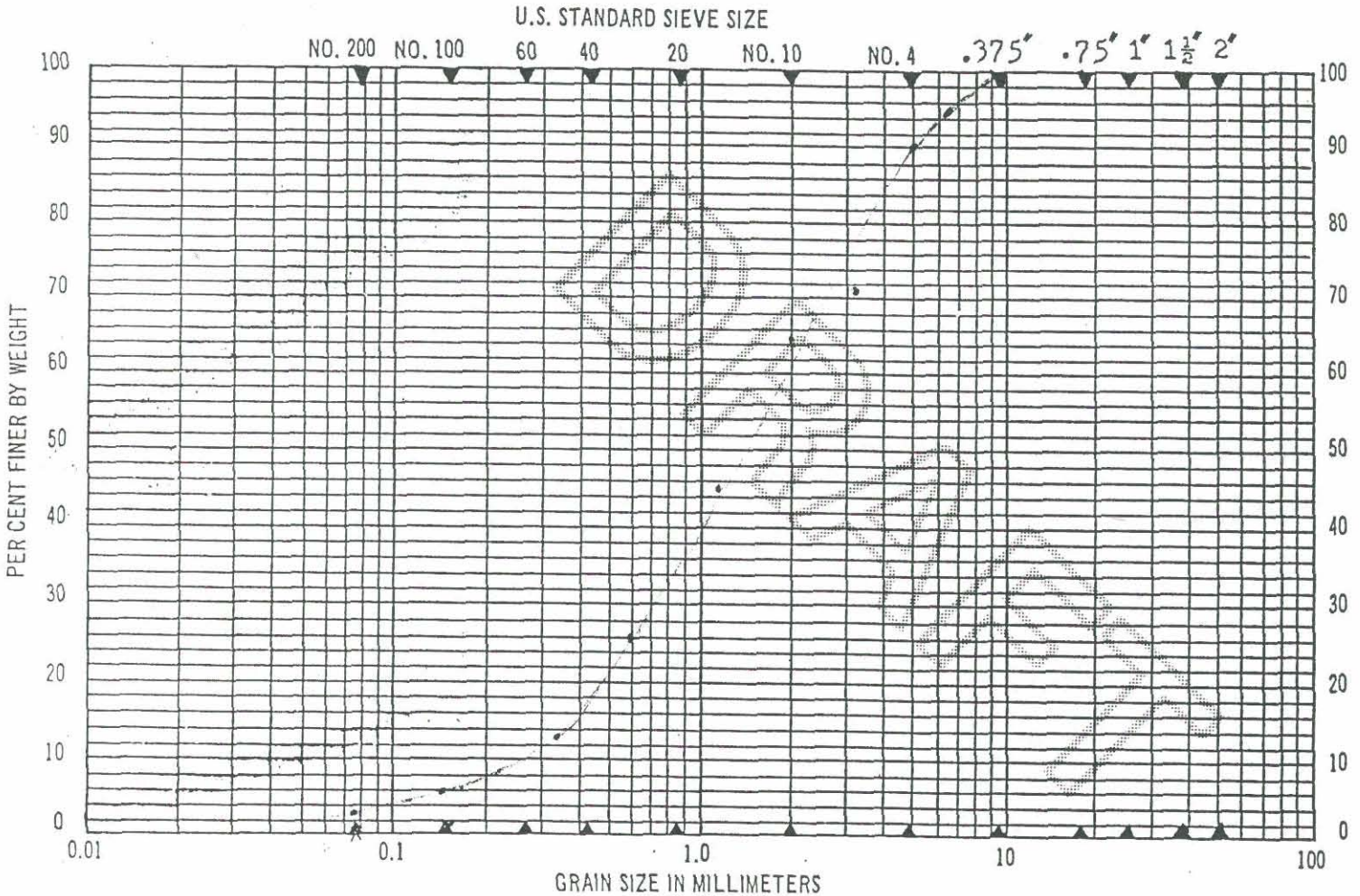
M3% FKA4 X159 X59

DRAFT

GRAIN-SIZE DISTRIBUTION
(UNIFIED SOIL CLASSIFICATION SYSTEM)

JOB NO. _____ BY _____ DATE _____

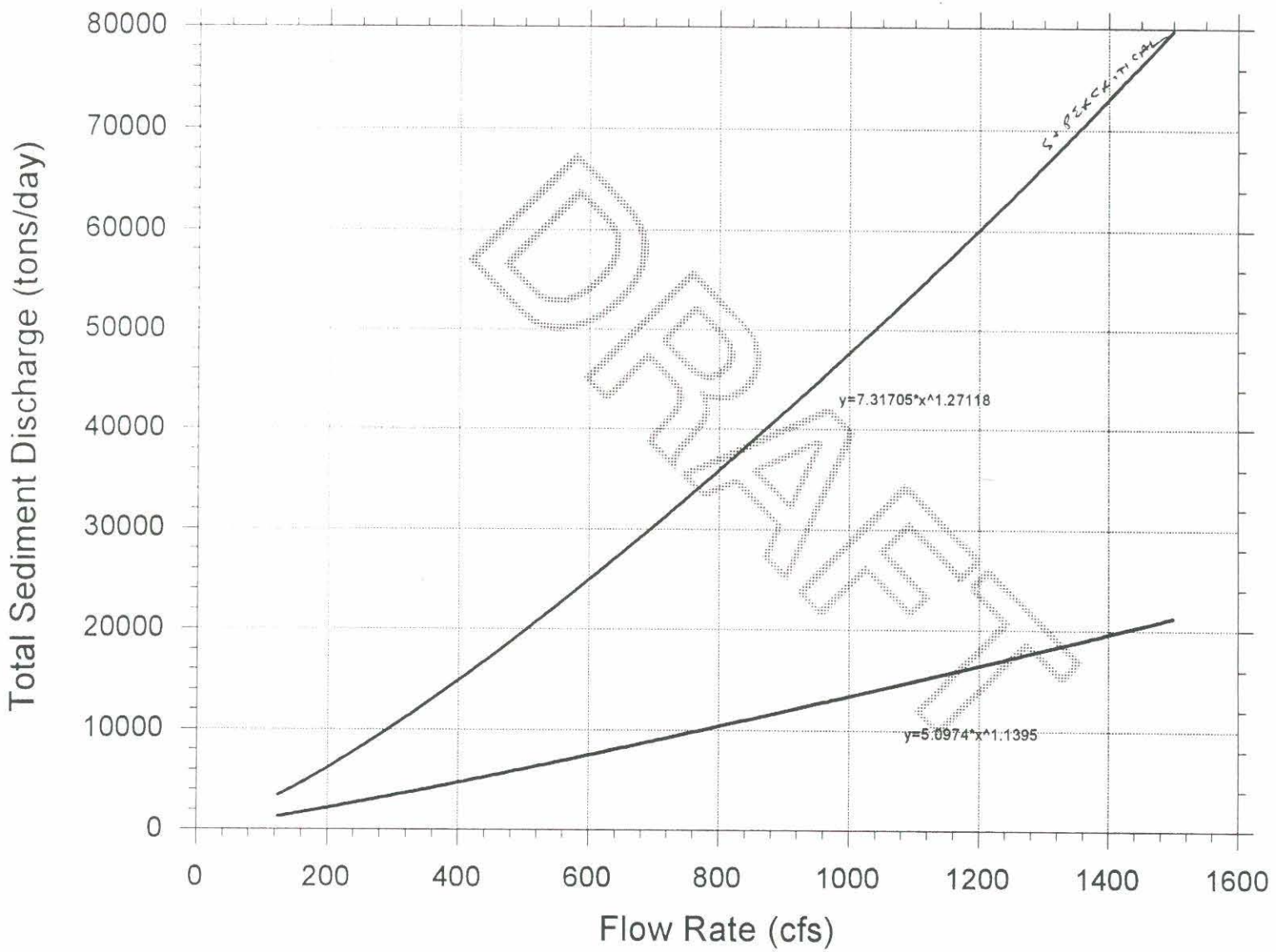
KEY	BORING	DEPTH	ELEV.	SOIL CLASSIFICATION



SILT OR CLAY	SAND			GRAVEL		*
	FINE	MEDIUM	COARSE	FINE	COARSE	

*COBBLES

Sediment Rating Curve
for
Casandro Wash



Q-2

HYDROGRAPH AT STATION ADD
SUM OF 2 HYDROGRAPHS

DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW
1		0000	1	0.	1		0615	76	25.	1		1230	151	0.	1		1845	226	0.
1		0005	2	0.	1		0620	77	23.	1		1235	152	0.	1		1850	227	0.
1		0010	3	0.	1		0625	78	21.	1		1240	153	0.	1		1855	228	0.
1		0015	4	1.	1		0630	79	19.	1		1245	154	0.	1		1900	229	0.
1		0020	5	2.	1		0635	80	16.	1		1250	155	0.	1		1905	230	0.
1		0025	6	2.	1		0640	81	14.	1		1255	156	0.	1		1910	231	0.
1		0030	7	3.	1		0645	82	12.	1		1300	157	0.	1		1915	232	0.
1		0035	8	4.	1		0650	83	11.	1		1305	158	0.	1		1920	233	0.
1		0040	9	5.	1		0655	84	9.	1		1310	159	0.	1		1925	234	0.
1		0045	10	6.	1		0700	85	8.	1		1315	160	0.	1		1930	235	0.
1		0050	11	7.	1		0705	86	6.	1		1320	161	0.	1		1935	236	0.
1		0055	12	7.	1		0710	87	5.	1		1325	162	0.	1		1940	237	0.
1		0100	13	8.	1		0715	88	5.	1		1330	163	0.	1		1945	238	0.
1		0105	14	9.	1		0720	89	4.	1		1335	164	0.	1		1950	239	0.
1		0110	15	9.	1		0725	90	3.	1		1340	165	0.	1		1955	240	0.
1		0115	16	10.	1		0730	91	3.	1		1345	166	0.	1		2000	241	0.
1		0120	17	10.	1		0735	92	2.	1		1350	167	0.	1		2005	242	0.
1		0125	18	11.	1		0740	93	2.	1		1355	168	0.	1		2010	243	0.
1		0130	19	11.	1		0745	94	2.	1		1400	169	0.	1		2015	244	0.
1		0135	20	11.	1		0750	95	1.	1		1405	170	0.	1		2020	245	0.
1		0140	21	12.	1		0755	96	1.	1		1410	171	0.	1		2025	246	0.
1		0145	22	12.	1		0800	97	1.	1		1415	172	0.	1		2030	247	0.
1		0150	23	12.	1		0805	98	1.	1		1420	173	0.	1		2035	248	0.
1		0155	24	12.	1		0810	99	1.	1		1425	174	0.	1		2040	249	0.
1		0200	25	12.	1		0815	100	0.	1		1430	175	0.	1		2045	250	0.
1		0205	26	12.	1		0820	101	0.	1		1435	176	0.	1		2050	251	0.
1		0210	27	12.	1		0825	102	0.	1		1440	177	0.	1		2055	252	0.
1		0215	28	12.	1		0830	103	0.	1		1445	178	0.	1		2100	253	0.
1		0220	29	12.	1		0835	104	0.	1		1450	179	0.	1		2105	254	0.
1		0225	30	12.	1		0840	105	0.	1		1455	180	0.	1		2110	255	0.
1		0230	31	12.	1		0845	106	0.	1		1500	181	0.	1		2115	256	0.
1		0235	32	13.	1		0850	107	0.	1		1505	182	0.	1		2120	257	0.
1		0240	33	13.	1		0855	108	0.	1		1510	183	0.	1		2125	258	0.
1		0245	34	14.	1		0900	109	0.	1		1515	184	0.	1		2130	259	0.
1		0250	35	14.	1		0905	110	0.	1		1520	185	0.	1		2135	260	0.
1		0255	36	15.	1		0910	111	0.	1		1525	186	0.	1		2140	261	0.
1		0300	37	16.	1		0915	112	0.	1		1530	187	0.	1		2145	262	0.
1		0305	38	17.	1		0920	113	0.	1		1535	188	0.	1		2150	263	0.
1		0310	39	18.	1		0925	114	0.	1		1540	189	0.	1		2155	264	0.
1		0315	40	20.	1		0930	115	0.	1		1545	190	0.	1		2200	265	0.
1		0320	41	23.	1		0935	116	0.	1		1550	191	0.	1		2205	266	0.
1		0325	42	26.	1		0940	117	0.	1		1555	192	0.	1		2210	267	0.
1		0330	43	32.	1		0945	118	0.	1		1600	193	0.	1		2215	268	0.
1		0335	44	43.	1		0950	119	0.	1		1605	194	0.	1		2220	269	0.
1		0340	45	61.	1		0955	120	0.	1		1610	195	0.	1		2225	270	0.
1		0345	46	85.	1		1000	121	0.	1		1615	196	0.	1		2230	271	0.
1		0350	47	120.	1		1005	122	0.	1		1620	197	0.	1		2235	272	0.
1		0355	48	184.	1		1010	123	0.	1		1625	198	0.	1		2240	273	0.
1		0400	49	276.	1		1015	124	0.	1		1630	199	0.	1		2245	274	0.
1		0405	50	383.	1		1020	125	0.	1		1635	200	0.	1		2250	275	0.

DRAFT

1	0410	51	469.	*	1	1025	126	0.	*	1	1640	201	0.	*	1	2255	276	0.
1	0415	52	506.	*	1	1030	127	0.	*	1	1645	202	0.	*	1	2300	277	0.
1	0420	53	502.	*	1	1035	128	0.	*	1	1650	203	0.	*	1	2305	278	0.
1	0425	54	468.	*	1	1040	129	0.	*	1	1655	204	0.	*	1	2310	279	0.
1	0430	55	420.	*	1	1045	130	0.	*	1	1700	205	0.	*	1	2315	280	0.
1	0435	56	366.	*	1	1050	131	0.	*	1	1705	206	0.	*	1	2320	281	0.
1	0440	57	315.	*	1	1055	132	0.	*	1	1710	207	0.	*	1	2325	282	0.
1	0445	58	272.	*	1	1100	133	0.	*	1	1715	208	0.	*	1	2330	283	0.
1	0450	59	233.	*	1	1105	134	0.	*	1	1720	209	0.	*	1	2335	284	0.
1	0455	60	198.	*	1	1110	135	0.	*	1	1725	210	0.	*	1	2340	285	0.
1	0500	61	170.	*	1	1115	136	0.	*	1	1730	211	0.	*	1	2345	286	0.
1	0505	62	146.	*	1	1120	137	0.	*	1	1735	212	0.	*	1	2350	287	0.
1	0510	63	124.	*	1	1125	138	0.	*	1	1740	213	0.	*	1	2355	288	0.
1	0515	64	106.	*	1	1130	139	0.	*	1	1745	214	0.	*	2	0000	289	0.
1	0520	65	90.	*	1	1135	140	0.	*	1	1750	215	0.	*	2	0005	290	0.
1	0525	66	79.	*	1	1140	141	0.	*	1	1755	216	0.	*	2	0010	291	0.
1	0530	67	70.	*	1	1145	142	0.	*	1	1800	217	0.	*	2	0015	292	0.
1	0535	68	61.	*	1	1150	143	0.	*	1	1805	218	0.	*	2	0020	293	0.
1	0540	69	54.	*	1	1155	144	0.	*	1	1810	219	0.	*	2	0025	294	0.
1	0545	70	47.	*	1	1200	145	0.	*	1	1815	220	0.	*	2	0030	295	0.
1	0550	71	42.	*	1	1205	146	0.	*	1	1820	221	0.	*	2	0035	296	0.
1	0555	72	37.	*	1	1210	147	0.	*	1	1825	222	0.	*	2	0040	297	0.
1	0600	73	33.	*	1	1215	148	0.	*	1	1830	223	0.	*	2	0045	298	0.
1	0605	74	30.	*	1	1220	149	0.	*	1	1835	224	0.	*	2	0050	299	0.
1	0610	75	27.	*	1	1225	150	0.	*	1	1840	225	0.	*	2	0055	300	0.
				*					*					*				

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PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	24.92-HR
506.	4.25	(CFS)	92.	23.	22.	22.
		(INCHES)	0.687	0.696	0.696	0.696
		(AC-FT)	45.	46.	46.	46.

CUMULATIVE AREA = 1.24 SQ MI

DRAFT

Q-5

HYDROGRAPH AT STATION ADD

SUM OF 2 HYDROGRAPHS

DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW
1		0000	1	0.	1		0615	76	33.	1		1230	151	0.	1		1845	226	0.
1		0005	2	0.	1		0620	77	28.	1		1235	152	0.	1		1850	227	0.
1		0010	3	0.	1		0625	78	26.	1		1240	153	0.	1		1855	228	0.
1		0015	4	1.	1		0630	79	23.	1		1245	154	0.	1		1900	229	0.
1		0020	5	2.	1		0635	80	21.	1		1250	155	0.	1		1905	230	0.
1		0025	6	3.	1		0640	81	18.	1		1255	156	0.	1		1910	231	0.
1		0030	7	4.	1		0645	82	16.	1		1300	157	0.	1		1915	232	0.
1		0035	8	5.	1		0650	83	14.	1		1305	158	0.	1		1920	233	0.
1		0040	9	7.	1		0655	84	12.	1		1310	159	0.	1		1925	234	0.
1		0045	10	8.	1		0700	85	10.	1		1315	160	0.	1		1930	235	0.
1		0050	11	9.	1		0705	86	8.	1		1320	161	0.	1		1935	236	0.
1		0055	12	10.	1		0710	87	7.	1		1325	162	0.	1		1940	237	0.
1		0100	13	11.	1		0715	88	6.	1		1330	163	0.	1		1945	238	0.
1		0105	14	12.	1		0720	89	5.	1		1335	164	0.	1		1950	239	0.
1		0110	15	13.	1		0725	90	4.	1		1340	165	0.	1		1955	240	0.
1		0115	16	13.	1		0730	91	4.	1		1345	166	0.	1		2000	241	0.
1		0120	17	14.	1		0735	92	3.	1		1350	167	0.	1		2005	242	0.
1		0125	18	14.	1		0740	93	2.	1		1355	168	0.	1		2010	243	0.
1		0130	19	15.	1		0745	94	2.	1		1400	169	0.	1		2015	244	0.
1		0135	20	15.	1		0750	95	2.	1		1405	170	0.	1		2020	245	0.
1		0140	21	15.	1		0755	96	1.	1		1410	171	0.	1		2025	246	0.
1		0145	22	16.	1		0800	97	1.	1		1415	172	0.	1		2030	247	0.
1		0150	23	16.	1		0805	98	1.	1		1420	173	0.	1		2035	248	0.
1		0155	24	16.	1		0810	99	1.	1		1425	174	0.	1		2040	249	0.
1		0200	25	16.	1		0815	100	1.	1		1430	175	0.	1		2045	250	0.
1		0205	26	16.	1		0820	101	1.	1		1435	176	0.	1		2050	251	0.
1		0210	27	16.	1		0825	102	0.	1		1440	177	0.	1		2055	252	0.
1		0215	28	16.	1		0830	103	0.	1		1445	178	0.	1		2100	253	0.
1		0220	29	16.	1		0835	104	0.	1		1450	179	0.	1		2105	254	0.
1		0225	30	16.	1		0840	105	0.	1		1455	180	0.	1		2110	255	0.
1		0230	31	17.	1		0845	106	0.	1		1500	181	0.	1		2115	256	0.
1		0235	32	17.	1		0850	107	0.	1		1505	182	0.	1		2120	257	0.
1		0240	33	18.	1		0855	108	0.	1		1510	183	0.	1		2125	258	0.
1		0245	34	18.	1		0900	109	0.	1		1515	184	0.	1		2130	259	0.
1		0250	35	19.	1		0905	110	0.	1		1520	185	0.	1		2135	260	0.
1		0255	36	20.	1		0910	111	0.	1		1525	186	0.	1		2140	261	0.
1		0300	37	21.	1		0915	112	0.	1		1530	187	0.	1		2145	262	0.
1		0305	38	23.	1		0920	113	0.	1		1535	188	0.	1		2150	263	0.
1		0310	39	25.	1		0925	114	0.	1		1540	189	0.	1		2155	264	0.
1		0315	40	27.	1		0930	115	0.	1		1545	190	0.	1		2200	265	0.
1		0320	41	30.	1		0935	116	0.	1		1550	191	0.	1		2205	266	0.
1		0325	42	37.	1		0940	117	0.	1		1555	192	0.	1		2210	267	0.
1		0330	43	48.	1		0945	118	0.	1		1600	193	0.	1		2215	268	0.
1		0335	44	66.	1		0950	119	0.	1		1605	194	0.	1		2220	269	0.
1		0340	45	96.	1		0955	120	0.	1		1610	195	0.	1		2225	270	0.
1		0345	46	143.	1		1000	121	0.	1		1615	196	0.	1		2230	271	0.
1		0350	47	216.	1		1005	122	0.	1		1620	197	0.	1		2235	272	0.
1		0355	48	327.	1		1010	123	0.	1		1625	198	0.	1		2240	273	0.
1		0400	49	479.	1		1015	124	0.	1		1630	199	0.	1		2245	274	0.
1		0405	50	645.	1		1020	125	0.	1		1635	200	0.	1		2250	275	0.

DRAFT

1	0410	51	768.	*	1	1025	126	0.	*	1	1640	201	0.	*	1	2255	276	0.
1	0415	52	819.	*	1	1030	127	0.	*	1	1645	202	0.	*	1	2300	277	0.
1	0420	53	803.	*	1	1035	128	0.	*	1	1650	203	0.	*	1	2305	278	0.
1	0425	54	745.	*	1	1040	129	0.	*	1	1655	204	0.	*	1	2310	279	0.
1	0430	55	662.	*	1	1045	130	0.	*	1	1700	205	0.	*	1	2315	280	0.
1	0435	56	576.	*	1	1050	131	0.	*	1	1705	206	0.	*	1	2320	281	0.
1	0440	57	493.	*	1	1055	132	0.	*	1	1710	207	0.	*	1	2325	282	0.
1	0445	58	421.	*	1	1100	133	0.	*	1	1715	208	0.	*	1	2330	283	0.
1	0450	59	357.	*	1	1105	134	0.	*	1	1720	209	0.	*	1	2335	284	0.
1	0455	60	303.	*	1	1110	135	0.	*	1	1725	210	0.	*	1	2340	285	0.
1	0500	61	258.	*	1	1115	136	0.	*	1	1730	211	0.	*	1	2345	286	0.
1	0505	62	218.	*	1	1120	137	0.	*	1	1735	212	0.	*	1	2350	287	0.
1	0510	63	184.	*	1	1125	138	0.	*	1	1740	213	0.	*	1	2355	288	0.
1	0515	64	158.	*	1	1130	139	0.	*	1	1745	214	0.	*	2	0000	289	0.
1	0520	65	135.	*	1	1135	140	0.	*	1	1750	215	0.	*	2	0005	290	0.
1	0525	66	115.	*	1	1140	141	0.	*	1	1755	216	0.	*	2	0010	291	0.
1	0530	67	99.	*	1	1145	142	0.	*	1	1800	217	0.	*	2	0015	292	0.
1	0535	68	86.	*	1	1150	143	0.	*	1	1805	218	0.	*	2	0020	293	0.
1	0540	69	77.	*	1	1155	144	0.	*	1	1810	219	0.	*	2	0025	294	0.
1	0545	70	68.	*	1	1200	145	0.	*	1	1815	220	0.	*	2	0030	295	0.
1	0550	71	60.	*	1	1205	146	0.	*	1	1820	221	0.	*	2	0035	296	0.
1	0555	72	53.	*	1	1210	147	0.	*	1	1825	222	0.	*	2	0040	297	0.
1	0600	73	47.	*	1	1215	148	0.	*	1	1830	223	0.	*	2	0045	298	0.
1	0605	74	42.	*	1	1220	149	0.	*	1	1835	224	0.	*	2	0050	299	0.
1	0610	75	37.	*	1	1225	150	0.	*	1	1840	225	0.	*	2	0055	300	0.
				*					*					*				

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PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	24.92-HR
819.	4.25	(CFS)	144.	36.	35.	35.
		(INCHES)	1.076	1.088	1.088	1.088
		(AC-FT)	71.	72.	72.	72.

CUMULATIVE AREA = 1.24 SQ MI

DRAFT

Q-10

HYDROGRAPH AT STATION ADD
SUM OF 2 HYDROGRAPHS

DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW
1		0000	1	0.	1		0615	76	39.	1		1230	151	0.	1		1845	226	0.
1		0005	2	0.	1		0620	77	34.	1		1235	152	0.	1		1850	227	0.
1		0010	3	1.	1		0625	78	28.	1		1240	153	0.	1		1855	228	0.
1		0015	4	1.	1		0630	79	26.	1		1245	154	0.	1		1900	229	0.
1		0020	5	2.	1		0635	80	23.	1		1250	155	0.	1		1905	230	0.
1		0025	6	4.	1		0640	81	20.	1		1255	156	0.	1		1910	231	0.
1		0030	7	5.	1		0645	82	18.	1		1300	157	0.	1		1915	232	0.
1		0035	8	6.	1		0650	83	15.	1		1305	158	0.	1		1920	233	0.
1		0040	9	8.	1		0655	84	13.	1		1310	159	0.	1		1925	234	0.
1		0045	10	9.	1		0700	85	11.	1		1315	160	0.	1		1930	235	0.
1		0050	11	10.	1		0705	86	10.	1		1320	161	0.	1		1935	236	0.
1		0055	12	12.	1		0710	87	8.	1		1325	162	0.	1		1940	237	0.
1		0100	13	13.	1		0715	88	7.	1		1330	163	0.	1		1945	238	0.
1		0105	14	14.	1		0720	89	6.	1		1335	164	0.	1		1950	239	0.
1		0110	15	15.	1		0725	90	5.	1		1340	165	0.	1		1955	240	0.
1		0115	16	16.	1		0730	91	4.	1		1345	166	0.	1		2000	241	0.
1		0120	17	16.	1		0735	92	3.	1		1350	167	0.	1		2005	242	0.
1		0125	18	17.	1		0740	93	3.	1		1355	168	0.	1		2010	243	0.
1		0130	19	17.	1		0745	94	2.	1		1400	169	0.	1		2015	244	0.
1		0135	20	18.	1		0750	95	2.	1		1405	170	0.	1		2020	245	0.
1		0140	21	18.	1		0755	96	2.	1		1410	171	0.	1		2025	246	0.
1		0145	22	19.	1		0800	97	1.	1		1415	172	0.	1		2030	247	0.
1		0150	23	19.	1		0805	98	1.	1		1420	173	0.	1		2035	248	0.
1		0155	24	19.	1		0810	99	1.	1		1425	174	0.	1		2040	249	0.
1		0200	25	19.	1		0815	100	1.	1		1430	175	0.	1		2045	250	0.
1		0205	26	19.	1		0820	101	1.	1		1435	176	0.	1		2050	251	0.
1		0210	27	19.	1		0825	102	0.	1		1440	177	0.	1		2055	252	0.
1		0215	28	19.	1		0830	103	0.	1		1445	178	0.	1		2100	253	0.
1		0220	29	19.	1		0835	104	0.	1		1450	179	0.	1		2105	254	0.
1		0225	30	19.	1		0840	105	0.	1		1455	180	0.	1		2110	255	0.
1		0230	31	20.	1		0845	106	0.	1		1500	181	0.	1		2115	256	0.
1		0235	32	20.	1		0850	107	0.	1		1505	182	0.	1		2120	257	0.
1		0240	33	21.	1		0855	108	0.	1		1510	183	0.	1		2125	258	0.
1		0245	34	22.	1		0900	109	0.	1		1515	184	0.	1		2130	259	0.
1		0250	35	23.	1		0905	110	0.	1		1520	185	0.	1		2135	260	0.
1		0255	36	24.	1		0910	111	0.	1		1525	186	0.	1		2140	261	0.
1		0300	37	25.	1		0915	112	0.	1		1530	187	0.	1		2145	262	0.
1		0305	38	27.	1		0920	113	0.	1		1535	188	0.	1		2150	263	0.
1		0310	39	29.	1		0925	114	0.	1		1540	189	0.	1		2155	264	0.
1		0315	40	32.	1		0930	115	0.	1		1545	190	0.	1		2200	265	0.
1		0320	41	38.	1		0935	116	0.	1		1550	191	0.	1		2205	266	0.
1		0325	42	47.	1		0940	117	0.	1		1555	192	0.	1		2210	267	0.
1		0330	43	60.	1		0945	118	0.	1		1600	193	0.	1		2215	268	0.
1		0335	44	81.	1		0950	119	0.	1		1605	194	0.	1		2220	269	0.
1		0340	45	121.	1		0955	120	0.	1		1610	195	0.	1		2225	270	0.
1		0345	46	190.	1		1000	121	0.	1		1615	196	0.	1		2230	271	0.
1		0350	47	287.	1		1005	122	0.	1		1620	197	0.	1		2235	272	0.
1		0355	48	432.	1		1010	123	0.	1		1625	198	0.	1		2240	273	0.
1		0400	49	625.	1		1015	124	0.	1		1630	199	0.	1		2245	274	0.
1		0405	50	830.	1		1020	125	0.	1		1635	200	0.	1		2250	275	0.

DRAFT

1	0410	51	977.	*	1	1025	126	0.	*	1	1640	201	0.	*	1	2255	276	0.
1	0415	52	1028.	*	1	1030	127	0.	*	1	1645	202	0.	*	1	2300	277	0.
1	0420	53	1008.	*	1	1035	128	0.	*	1	1650	203	0.	*	1	2305	278	0.
1	0425	54	938.	*	1	1040	129	0.	*	1	1655	204	0.	*	1	2310	279	0.
1	0430	55	835.	*	1	1045	130	0.	*	1	1700	205	0.	*	1	2315	280	0.
1	0435	56	721.	*	1	1050	131	0.	*	1	1705	206	0.	*	1	2320	281	0.
1	0440	57	615.	*	1	1055	132	0.	*	1	1710	207	0.	*	1	2325	282	0.
1	0445	58	522.	*	1	1100	133	0.	*	1	1715	208	0.	*	1	2330	283	0.
1	0450	59	442.	*	1	1105	134	0.	*	1	1720	209	0.	*	1	2335	284	0.
1	0455	60	375.	*	1	1110	135	0.	*	1	1725	210	0.	*	1	2340	285	0.
1	0500	61	316.	*	1	1115	136	0.	*	1	1730	211	0.	*	1	2345	286	0.
1	0505	62	268.	*	1	1120	137	0.	*	1	1735	212	0.	*	1	2350	287	0.
1	0510	63	227.	*	1	1125	138	0.	*	1	1740	213	0.	*	1	2355	288	0.
1	0515	64	191.	*	1	1130	139	0.	*	1	1745	214	0.	*	2	0000	289	0.
1	0520	65	164.	*	1	1135	140	0.	*	1	1750	215	0.	*	2	0005	290	0.
1	0525	66	141.	*	1	1140	141	0.	*	1	1755	216	0.	*	2	0010	291	0.
1	0530	67	121.	*	1	1145	142	0.	*	1	1800	217	0.	*	2	0015	292	0.
1	0535	68	104.	*	1	1150	143	0.	*	1	1805	218	0.	*	2	0020	293	0.
1	0540	69	90.	*	1	1155	144	0.	*	1	1810	219	0.	*	2	0025	294	0.
1	0545	70	81.	*	1	1200	145	0.	*	1	1815	220	0.	*	2	0030	295	0.
1	0550	71	72.	*	1	1205	146	0.	*	1	1820	221	0.	*	2	0035	296	0.
1	0555	72	64.	*	1	1210	147	0.	*	1	1825	222	0.	*	2	0040	297	0.
1	0600	73	57.	*	1	1215	148	0.	*	1	1830	223	0.	*	2	0045	298	0.
1	0605	74	51.	*	1	1220	149	0.	*	1	1835	224	0.	*	2	0050	299	0.
1	0610	75	45.	*	1	1225	150	0.	*	1	1840	225	0.	*	2	0055	300	0.
				*					*					*				

* **********

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	24.92-HR
1028.	4.25	(CFS)	180.	45.	44.	44.
		(INCHES)	1.347	1.361	1.361	1.361
		(AC-FT)	89.	90.	90.	90.

CUMULATIVE AREA = 1.24 SQ MI

DRAFT

Q-25

HYDROGRAPH AT STATION ADD
SUM OF 2 HYDROGRAPHS

DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW
1		0000	1	0.	1		0615	76	49.	1		1230	151	0.	1		1845	226	0.
1		0005	2	0.	1		0620	77	42.	1		1235	152	0.	1		1850	227	0.
1		0010	3	1.	1		0625	78	36.	1		1240	153	0.	1		1855	228	0.
1		0015	4	2.	1		0630	79	30.	1		1245	154	0.	1		1900	229	0.
1		0020	5	3.	1		0635	80	26.	1		1250	155	0.	1		1905	230	0.
1		0025	6	5.	1		0640	81	23.	1		1255	156	0.	1		1910	231	0.
1		0030	7	6.	1		0645	82	20.	1		1300	157	0.	1		1915	232	0.
1		0035	8	8.	1		0650	83	18.	1		1305	158	0.	1		1920	233	0.
1		0040	9	10.	1		0655	84	15.	1		1310	159	0.	1		1925	234	0.
1		0045	10	11.	1		0700	85	13.	1		1315	160	0.	1		1930	235	0.
1		0050	11	13.	1		0705	86	11.	1		1320	161	0.	1		1935	236	0.
1		0055	12	14.	1		0710	87	9.	1		1325	162	0.	1		1940	237	0.
1		0100	13	16.	1		0715	88	8.	1		1330	163	0.	1		1945	238	0.
1		0105	14	17.	1		0720	89	7.	1		1335	164	0.	1		1950	239	0.
1		0110	15	18.	1		0725	90	6.	1		1340	165	0.	1		1955	240	0.
1		0115	16	19.	1		0730	91	5.	1		1345	166	0.	1		2000	241	0.
1		0120	17	20.	1		0735	92	4.	1		1350	167	0.	1		2005	242	0.
1		0125	18	21.	1		0740	93	3.	1		1355	168	0.	1		2010	243	0.
1		0130	19	21.	1		0745	94	3.	1		1400	169	0.	1		2015	244	0.
1		0135	20	22.	1		0750	95	2.	1		1405	170	0.	1		2020	245	0.
1		0140	21	22.	1		0755	96	2.	1		1410	171	0.	1		2025	246	0.
1		0145	22	23.	1		0800	97	2.	1		1415	172	0.	1		2030	247	0.
1		0150	23	23.	1		0805	98	1.	1		1420	173	0.	1		2035	248	0.
1		0155	24	23.	1		0810	99	1.	1		1425	174	0.	1		2040	249	0.
1		0200	25	23.	1		0815	100	1.	1		1430	175	0.	1		2045	250	0.
1		0205	26	23.	1		0820	101	1.	1		1435	176	0.	1		2050	251	0.
1		0210	27	23.	1		0825	102	1.	1		1440	177	0.	1		2055	252	0.
1		0215	28	24.	1		0830	103	0.	1		1445	178	0.	1		2100	253	0.
1		0220	29	24.	1		0835	104	0.	1		1450	179	0.	1		2105	254	0.
1		0225	30	24.	1		0840	105	0.	1		1455	180	0.	1		2110	255	0.
1		0230	31	24.	1		0845	106	0.	1		1500	181	0.	1		2115	256	0.
1		0235	32	25.	1		0850	107	0.	1		1505	182	0.	1		2120	257	0.
1		0240	33	26.	1		0855	108	0.	1		1510	183	0.	1		2125	258	0.
1		0245	34	27.	1		0900	109	0.	1		1515	184	0.	1		2130	259	0.
1		0250	35	28.	1		0905	110	0.	1		1520	185	0.	1		2135	260	0.
1		0255	36	29.	1		0910	111	0.	1		1525	186	0.	1		2140	261	0.
1		0300	37	31.	1		0915	112	0.	1		1530	187	0.	1		2145	262	0.
1		0305	38	34.	1		0920	113	0.	1		1535	188	0.	1		2150	263	0.
1		0310	39	38.	1		0925	114	0.	1		1540	189	0.	1		2155	264	0.
1		0315	40	43.	1		0930	115	0.	1		1545	190	0.	1		2200	265	0.
1		0320	41	50.	1		0935	116	0.	1		1550	191	0.	1		2205	266	0.
1		0325	42	63.	1		0940	117	0.	1		1555	192	0.	1		2210	267	0.
1		0330	43	83.	1		0945	118	0.	1		1600	193	0.	1		2215	268	0.
1		0335	44	114.	1		0950	119	0.	1		1605	194	0.	1		2220	269	0.
1		0340	45	175.	1		0955	120	0.	1		1610	195	0.	1		2225	270	0.
1		0345	46	269.	1		1000	121	0.	1		1615	196	0.	1		2230	271	0.
1		0350	47	406.	1		1005	122	0.	1		1620	197	0.	1		2235	272	0.
1		0355	48	601.	1		1010	123	0.	1		1625	198	0.	1		2240	273	0.
1		0400	49	853.	1		1015	124	0.	1		1630	199	0.	1		2245	274	0.
1		0405	50	1106.	1		1020	125	0.	1		1635	200	0.	1		2250	275	0.

DRAFT

1	0410	51	1275.	*	1	1025	126	0.	*	1	1640	201	0.	*	1	2255	276	0.
1	0415	52	1346.	*	1	1030	127	0.	*	1	1645	202	0.	*	1	2300	277	0.
1	0420	53	1318.	*	1	1035	128	0.	*	1	1650	203	0.	*	1	2305	278	0.
1	0425	54	1224.	*	1	1040	129	0.	*	1	1655	204	0.	*	1	2310	279	0.
1	0430	55	1095.	*	1	1045	130	0.	*	1	1700	205	0.	*	1	2315	280	0.
1	0435	56	953.	*	1	1050	131	0.	*	1	1705	206	0.	*	1	2320	281	0.
1	0440	57	812.	*	1	1055	132	0.	*	1	1710	207	0.	*	1	2325	282	0.
1	0445	58	682.	*	1	1100	133	0.	*	1	1715	208	0.	*	1	2330	283	0.
1	0450	59	576.	*	1	1105	134	0.	*	1	1720	209	0.	*	1	2335	284	0.
1	0455	60	484.	*	1	1110	135	0.	*	1	1725	210	0.	*	1	2340	285	0.
1	0500	61	409.	*	1	1115	136	0.	*	1	1730	211	0.	*	1	2345	286	0.
1	0505	62	344.	*	1	1120	137	0.	*	1	1735	212	0.	*	1	2350	287	0.
1	0510	63	290.	*	1	1125	138	0.	*	1	1740	213	0.	*	1	2355	288	0.
1	0515	64	246.	*	1	1130	139	0.	*	1	1745	214	0.	*	2	0000	289	0.
1	0520	65	207.	*	1	1135	140	0.	*	1	1750	215	0.	*	2	0005	290	0.
1	0525	66	177.	*	1	1140	141	0.	*	1	1755	216	0.	*	2	0010	291	0.
1	0530	67	153.	*	1	1145	142	0.	*	1	1800	217	0.	*	2	0015	292	0.
1	0535	68	133.	*	1	1150	143	0.	*	1	1805	218	0.	*	2	0020	293	0.
1	0540	69	115.	*	1	1155	144	0.	*	1	1810	219	0.	*	2	0025	294	0.
1	0545	70	100.	*	1	1200	145	0.	*	1	1815	220	0.	*	2	0030	295	0.
1	0550	71	88.	*	1	1205	146	0.	*	1	1820	221	0.	*	2	0035	296	0.
1	0555	72	79.	*	1	1210	147	0.	*	1	1825	222	0.	*	2	0040	297	0.
1	0600	73	71.	*	1	1215	148	0.	*	1	1830	223	0.	*	2	0045	298	0.
1	0605	74	63.	*	1	1220	149	0.	*	1	1835	224	0.	*	2	0050	299	0.
1	0610	75	56.	*	1	1225	150	0.	*	1	1840	225	0.	*	2	0055	300	0.
				*					*					*				

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PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	24.92-HR
1346.	4.25	(CFS)	236.	59.	57.	57.
		(INCHES)	1.767	1.783	1.783	1.783
		(AC-FT)	117.	118.	118.	118.

CUMULATIVE AREA = 1.24 SQ MI

DRAFT

Q-50

HYDROGRAPH AT STATION ADD
SUM OF 2 HYDROGRAPHS

DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW
1		0000	1	0.	1		0615	76	55.	1		1230	151	0.	1		1845	226	0.
1		0005	2	0.	1		0620	77	47.	1		1235	152	0.	1		1850	227	0.
1		0010	3	1.	1		0625	78	40.	1		1240	153	0.	1		1855	228	0.
1		0015	4	2.	1		0630	79	33.	1		1245	154	0.	1		1900	229	0.
1		0020	5	3.	1		0635	80	28.	1		1250	155	0.	1		1905	230	0.
1		0025	6	5.	1		0640	81	25.	1		1255	156	0.	1		1910	231	0.
1		0030	7	7.	1		0645	82	22.	1		1300	157	0.	1		1915	232	0.
1		0035	8	9.	1		0650	83	19.	1		1305	158	0.	1		1920	233	0.
1		0040	9	11.	1		0655	84	16.	1		1310	159	0.	1		1925	234	0.
1		0045	10	13.	1		0700	85	14.	1		1315	160	0.	1		1930	235	0.
1		0050	11	14.	1		0705	86	12.	1		1320	161	0.	1		1935	236	0.
1		0055	12	16.	1		0710	87	10.	1		1325	162	0.	1		1940	237	0.
1		0100	13	18.	1		0715	88	9.	1		1330	163	0.	1		1945	238	0.
1		0105	14	19.	1		0720	89	7.	1		1335	164	0.	1		1950	239	0.
1		0110	15	20.	1		0725	90	6.	1		1340	165	0.	1		1955	240	0.
1		0115	16	21.	1		0730	91	5.	1		1345	166	0.	1		2000	241	0.
1		0120	17	22.	1		0735	92	4.	1		1350	167	0.	1		2005	242	0.
1		0125	18	23.	1		0740	93	4.	1		1355	168	0.	1		2010	243	0.
1		0130	19	24.	1		0745	94	3.	1		1400	169	0.	1		2015	244	0.
1		0135	20	24.	1		0750	95	3.	1		1405	170	0.	1		2020	245	0.
1		0140	21	25.	1		0755	96	2.	1		1410	171	0.	1		2025	246	0.
1		0145	22	25.	1		0800	97	2.	1		1415	172	0.	1		2030	247	0.
1		0150	23	26.	1		0805	98	1.	1		1420	173	0.	1		2035	248	0.
1		0155	24	26.	1		0810	99	1.	1		1425	174	0.	1		2040	249	0.
1		0200	25	26.	1		0815	100	1.	1		1430	175	0.	1		2045	250	0.
1		0205	26	26.	1		0820	101	1.	1		1435	176	0.	1		2050	251	0.
1		0210	27	26.	1		0825	102	1.	1		1440	177	0.	1		2055	252	0.
1		0215	28	26.	1		0830	103	1.	1		1445	178	0.	1		2100	253	0.
1		0220	29	26.	1		0835	104	0.	1		1450	179	0.	1		2105	254	0.
1		0225	30	27.	1		0840	105	0.	1		1455	180	0.	1		2110	255	0.
1		0230	31	27.	1		0845	106	0.	1		1500	181	0.	1		2115	256	0.
1		0235	32	28.	1		0850	107	0.	1		1505	182	0.	1		2120	257	0.
1		0240	33	29.	1		0855	108	0.	1		1510	183	0.	1		2125	258	0.
1		0245	34	30.	1		0900	109	0.	1		1515	184	0.	1		2130	259	0.
1		0250	35	31.	1		0905	110	0.	1		1520	185	0.	1		2135	260	0.
1		0255	36	33.	1		0910	111	0.	1		1525	186	0.	1		2140	261	0.
1		0300	37	36.	1		0915	112	0.	1		1530	187	0.	1		2145	262	0.
1		0305	38	39.	1		0920	113	0.	1		1535	188	0.	1		2150	263	0.
1		0310	39	43.	1		0925	114	0.	1		1540	189	0.	1		2155	264	0.
1		0315	40	49.	1		0930	115	0.	1		1545	190	0.	1		2200	265	0.
1		0320	41	57.	1		0935	116	0.	1		1550	191	0.	1		2205	266	0.
1		0325	42	74.	1		0940	117	0.	1		1555	192	0.	1		2210	267	0.
1		0330	43	98.	1		0945	118	0.	1		1600	193	0.	1		2215	268	0.
1		0335	44	139.	1		0950	119	0.	1		1605	194	0.	1		2220	269	0.
1		0340	45	216.	1		0955	120	0.	1		1610	195	0.	1		2225	270	0.
1		0345	46	330.	1		1000	121	0.	1		1615	196	0.	1		2230	271	0.
1		0350	47	491.	1		1005	122	0.	1		1620	197	0.	1		2235	272	0.
1		0355	48	715.	1		1010	123	0.	1		1625	198	0.	1		2240	273	0.
1		0400	49	999.	1		1015	124	0.	1		1630	199	0.	1		2245	274	0.
1		0405	50	1272.	1		1020	125	0.	1		1635	200	0.	1		2250	275	0.

DRAFT

1	0410	51	1471.	*	1	1025	126	0.	*	1	1640	201	0.	*	1	2255	276	0.
1	0415	52	1544.	*	1	1030	127	0.	*	1	1645	202	0.	*	1	2300	277	0.
1	0420	53	1511.	*	1	1035	128	0.	*	1	1650	203	0.	*	1	2305	278	0.
1	0425	54	1404.	*	1	1040	129	0.	*	1	1655	204	0.	*	1	2310	279	0.
1	0430	55	1252.	*	1	1045	130	0.	*	1	1700	205	0.	*	1	2315	280	0.
1	0435	56	1089.	*	1	1050	131	0.	*	1	1705	206	0.	*	1	2320	281	0.
1	0440	57	934.	*	1	1055	132	0.	*	1	1710	207	0.	*	1	2325	282	0.
1	0445	58	787.	*	1	1100	133	0.	*	1	1715	208	0.	*	1	2330	283	0.
1	0450	59	658.	*	1	1105	134	0.	*	1	1720	209	0.	*	1	2335	284	0.
1	0455	60	555.	*	1	1110	135	0.	*	1	1725	210	0.	*	1	2340	285	0.
1	0500	61	465.	*	1	1115	136	0.	*	1	1730	211	0.	*	1	2345	286	0.
1	0505	62	393.	*	1	1120	137	0.	*	1	1735	212	0.	*	1	2350	287	0.
1	0510	63	329.	*	1	1125	138	0.	*	1	1740	213	0.	*	1	2355	288	0.
1	0515	64	278.	*	1	1130	139	0.	*	1	1745	214	0.	*	2	0000	289	0.
1	0520	65	236.	*	1	1135	140	0.	*	1	1750	215	0.	*	2	0005	290	0.
1	0525	66	200.	*	1	1140	141	0.	*	1	1755	216	0.	*	2	0010	291	0.
1	0530	67	172.	*	1	1145	142	0.	*	1	1800	217	0.	*	2	0015	292	0.
1	0535	68	150.	*	1	1150	143	0.	*	1	1805	218	0.	*	2	0020	293	0.
1	0540	69	130.	*	1	1155	144	0.	*	1	1810	219	0.	*	2	0025	294	0.
1	0545	70	113.	*	1	1200	145	0.	*	1	1815	220	0.	*	2	0030	295	0.
1	0550	71	99.	*	1	1205	146	0.	*	1	1820	221	0.	*	2	0035	296	0.
1	0555	72	88.	*	1	1210	147	0.	*	1	1825	222	0.	*	2	0040	297	0.
1	0600	73	79.	*	1	1215	148	0.	*	1	1830	223	0.	*	2	0045	298	0.
1	0605	74	71.	*	1	1220	149	0.	*	1	1835	224	0.	*	2	0050	299	0.
1	0610	75	63.	*	1	1225	150	0.	*	1	1840	225	0.	*	2	0055	300	0.
				*					*					*				

****

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	24.92-HR
1544.	4.25	(CFS)	271.	68.	66.	66.
		(INCHES)	2.033	2.051	2.051	2.051
		(AC-FT)	134.	136.	136.	136.

CUMULATIVE AREA = 1.24 SQ MI

DRAFT

Q-100

HYDROGRAPH AT STATION ADD
SUM OF 2 HYDROGRAPHS

DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW	DA	MON	HRMN	ORD	FLOW
1		0000	1	0.	1		0615	76	62.	1		1230	151	0.	1		1845	226	0.
1		0005	2	0.	1		0620	77	53.	1		1235	152	0.	1		1850	227	0.
1		0010	3	1.	1		0625	78	45.	1		1240	153	0.	1		1855	228	0.
1		0015	4	2.	1		0630	79	37.	1		1245	154	0.	1		1900	229	0.
1		0020	5	4.	1		0635	80	31.	1		1250	155	0.	1		1905	230	0.
1		0025	6	6.	1		0640	81	26.	1		1255	156	0.	1		1910	231	0.
1		0030	7	8.	1		0645	82	23.	1		1300	157	0.	1		1915	232	0.
1		0035	8	10.	1		0650	83	20.	1		1305	158	0.	1		1920	233	0.
1		0040	9	12.	1		0655	84	18.	1		1310	159	0.	1		1925	234	0.
1		0045	10	14.	1		0700	85	15.	1		1315	160	0.	1		1930	235	0.
1		0050	11	16.	1		0705	86	13.	1		1320	161	0.	1		1935	236	0.
1		0055	12	18.	1		0710	87	11.	1		1325	162	0.	1		1940	237	0.
1		0100	13	20.	1		0715	88	10.	1		1330	163	0.	1		1945	238	0.
1		0105	14	21.	1		0720	89	8.	1		1335	164	0.	1		1950	239	0.
1		0110	15	23.	1		0725	90	7.	1		1340	165	0.	1		1955	240	0.
1		0115	16	24.	1		0730	91	6.	1		1345	166	0.	1		2000	241	0.
1		0120	17	25.	1		0735	92	5.	1		1350	167	0.	1		2005	242	0.
1		0125	18	26.	1		0740	93	4.	1		1355	168	0.	1		2010	243	0.
1		0130	19	26.	1		0745	94	3.	1		1400	169	0.	1		2015	244	0.
1		0135	20	27.	1		0750	95	3.	1		1405	170	0.	1		2020	245	0.
1		0140	21	28.	1		0755	96	2.	1		1410	171	0.	1		2025	246	0.
1		0145	22	28.	1		0800	97	2.	1		1415	172	0.	1		2030	247	0.
1		0150	23	29.	1		0805	98	2.	1		1420	173	0.	1		2035	248	0.
1		0155	24	29.	1		0810	99	1.	1		1425	174	0.	1		2040	249	0.
1		0200	25	29.	1		0815	100	1.	1		1430	175	0.	1		2045	250	0.
1		0205	26	29.	1		0820	101	1.	1		1435	176	0.	1		2050	251	0.
1		0210	27	29.	1		0825	102	1.	1		1440	177	0.	1		2055	252	0.
1		0215	28	29.	1		0830	103	1.	1		1445	178	0.	1		2100	253	0.
1		0220	29	29.	1		0835	104	0.	1		1450	179	0.	1		2105	254	0.
1		0225	30	30.	1		0840	105	0.	1		1455	180	0.	1		2110	255	0.
1		0230	31	30.	1		0845	106	0.	1		1500	181	0.	1		2115	256	0.
1		0235	32	31.	1		0850	107	0.	1		1505	182	0.	1		2120	257	0.
1		0240	33	33.	1		0855	108	0.	1		1510	183	0.	1		2125	258	0.
1		0245	34	34.	1		0900	109	0.	1		1515	184	0.	1		2130	259	0.
1		0250	35	36.	1		0905	110	0.	1		1520	185	0.	1		2135	260	0.
1		0255	36	38.	1		0910	111	0.	1		1525	186	0.	1		2140	261	0.
1		0300	37	41.	1		0915	112	0.	1		1530	187	0.	1		2145	262	0.
1		0305	38	44.	1		0920	113	0.	1		1535	188	0.	1		2150	263	0.
1		0310	39	49.	1		0925	114	0.	1		1540	189	0.	1		2155	264	0.
1		0315	40	54.	1		0930	115	0.	1		1545	190	0.	1		2200	265	0.
1		0320	41	65.	1		0935	116	0.	1		1550	191	0.	1		2205	266	0.
1		0325	42	86.	1		0940	117	0.	1		1555	192	0.	1		2210	267	0.
1		0330	43	118.	1		0945	118	0.	1		1600	193	0.	1		2215	268	0.
1		0335	44	174.	1		0950	119	0.	1		1605	194	0.	1		2220	269	0.
1		0340	45	265.	1		0955	120	0.	1		1610	195	0.	1		2225	270	0.
1		0345	46	402.	1		1000	121	0.	1		1615	196	0.	1		2230	271	0.
1		0350	47	590.	1		1005	122	0.	1		1620	197	0.	1		2235	272	0.
1		0355	48	845.	1		1010	123	0.	1		1625	198	0.	1		2240	273	0.
1		0400	49	1157.	1		1015	124	0.	1		1630	199	0.	1		2245	274	0.
1		0405	50	1463.	1		1020	125	0.	1		1635	200	0.	1		2250	275	0.

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1	0410	51	1685.	*	1	1025	126	0.	*	1	1640	201	0.	*	1	2255	276	0.
1	0415	52	1769.	*	1	1030	127	0.	*	1	1645	202	0.	*	1	2300	277	0.
1	0420	53	1723.	*	1	1035	128	0.	*	1	1650	203	0.	*	1	2305	278	0.
1	0425	54	1594.	*	1	1040	129	0.	*	1	1655	204	0.	*	1	2310	279	0.
1	0430	55	1425.	*	1	1045	130	0.	*	1	1700	205	0.	*	1	2315	280	0.
1	0435	56	1241.	*	1	1050	131	0.	*	1	1705	206	0.	*	1	2320	281	0.
1	0440	57	1066.	*	1	1055	132	0.	*	1	1710	207	0.	*	1	2325	282	0.
1	0445	58	907.	*	1	1100	133	0.	*	1	1715	208	0.	*	1	2330	283	0.
1	0450	59	762.	*	1	1105	134	0.	*	1	1720	209	0.	*	1	2335	284	0.
1	0455	60	637.	*	1	1110	135	0.	*	1	1725	210	0.	*	1	2340	285	0.
1	0500	61	536.	*	1	1115	136	0.	*	1	1730	211	0.	*	1	2345	286	0.
1	0505	62	449.	*	1	1120	137	0.	*	1	1735	212	0.	*	1	2350	287	0.
1	0510	63	378.	*	1	1125	138	0.	*	1	1740	213	0.	*	1	2355	288	0.
1	0515	64	317.	*	1	1130	139	0.	*	1	1745	214	0.	*	2	0000	289	0.
1	0520	65	269.	*	1	1135	140	0.	*	1	1750	215	0.	*	2	0005	290	0.
1	0525	66	229.	*	1	1140	141	0.	*	1	1755	216	0.	*	2	0010	291	0.
1	0530	67	195.	*	1	1145	142	0.	*	1	1800	217	0.	*	2	0015	292	0.
1	0535	68	169.	*	1	1150	143	0.	*	1	1805	218	0.	*	2	0020	293	0.
1	0540	69	148.	*	1	1155	144	0.	*	1	1810	219	0.	*	2	0025	294	0.
1	0545	70	129.	*	1	1200	145	0.	*	1	1815	220	0.	*	2	0030	295	0.
1	0550	71	112.	*	1	1205	146	0.	*	1	1820	221	0.	*	2	0035	296	0.
1	0555	72	98.	*	1	1210	147	0.	*	1	1825	222	0.	*	2	0040	297	0.
1	0600	73	88.	*	1	1215	148	0.	*	1	1830	223	0.	*	2	0045	298	0.
1	0605	74	79.	*	1	1220	149	0.	*	1	1835	224	0.	*	2	0050	299	0.
1	0610	75	70.	*	1	1225	150	0.	*	1	1840	225	0.	*	2	0055	300	0.
				*					*					*				

* **********

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	24.92-HR
1769.	4.25	(CFS)	312.	79.	76.	76.
		(INCHES)	2.336	2.355	2.355	2.355
		(AC-FT)	154.	156.	156.	156.

CUMULATIVE AREA = 1.24 SQ MI

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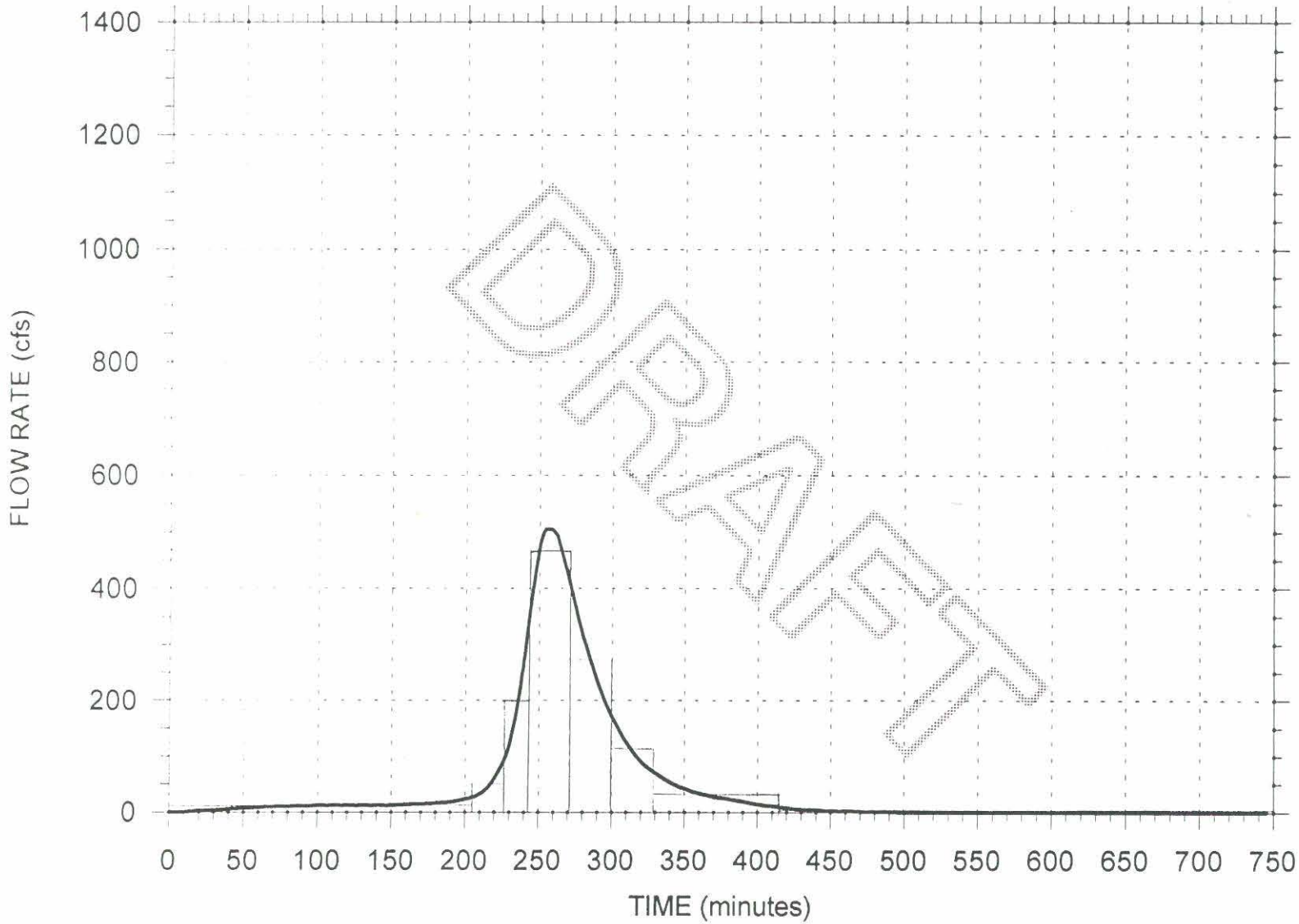
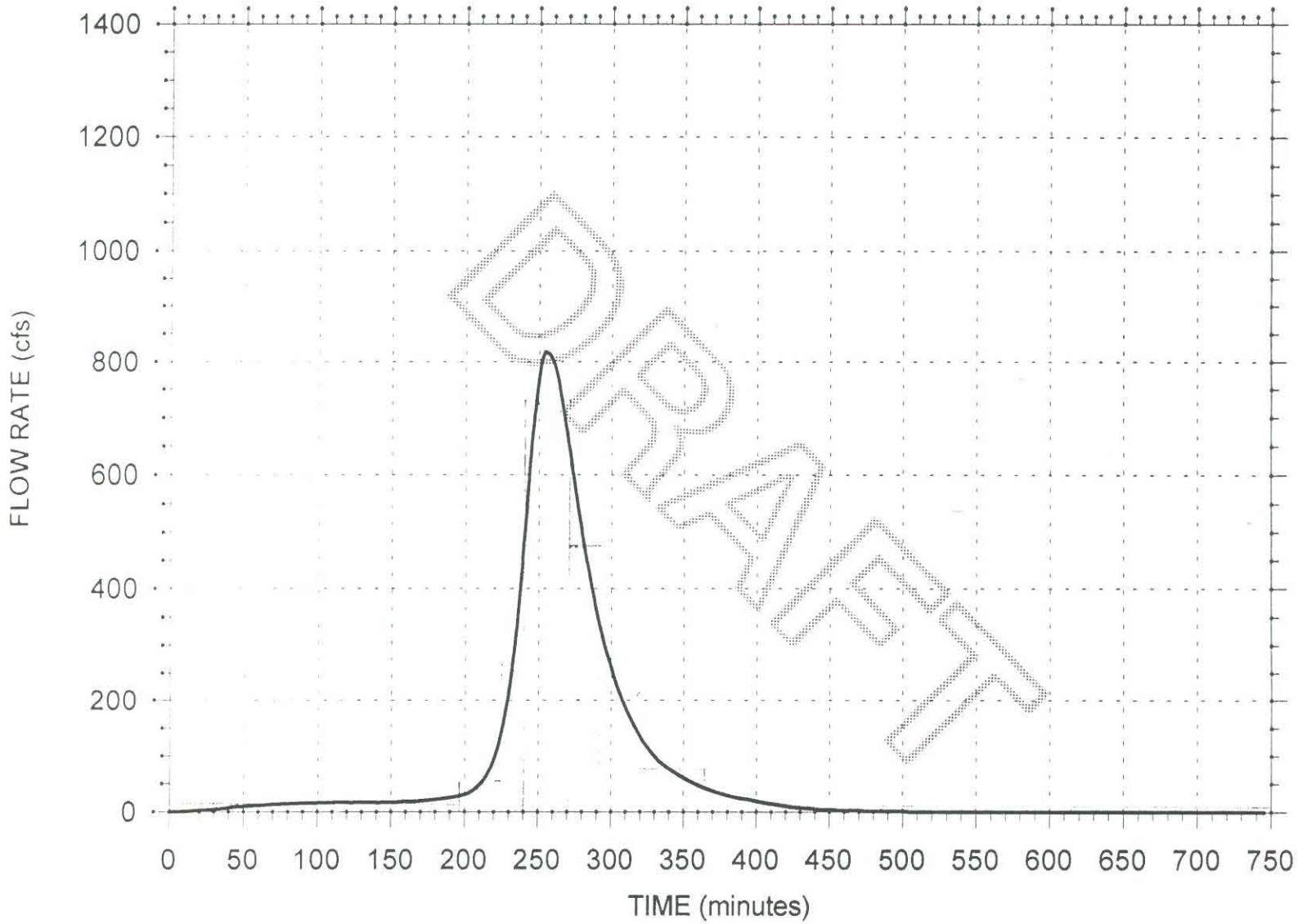
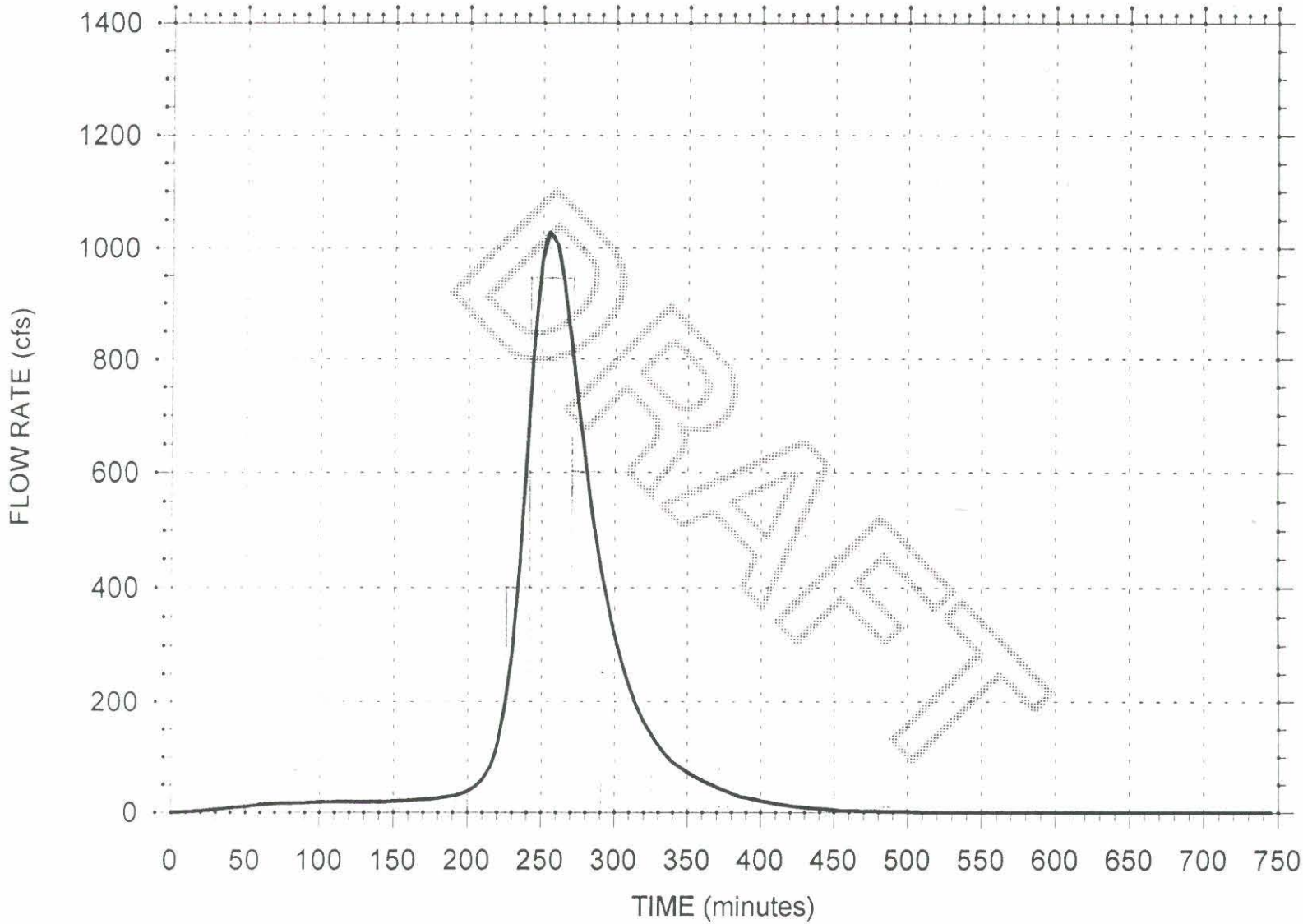
Casandro Wash 2-year Flood Hydrograph



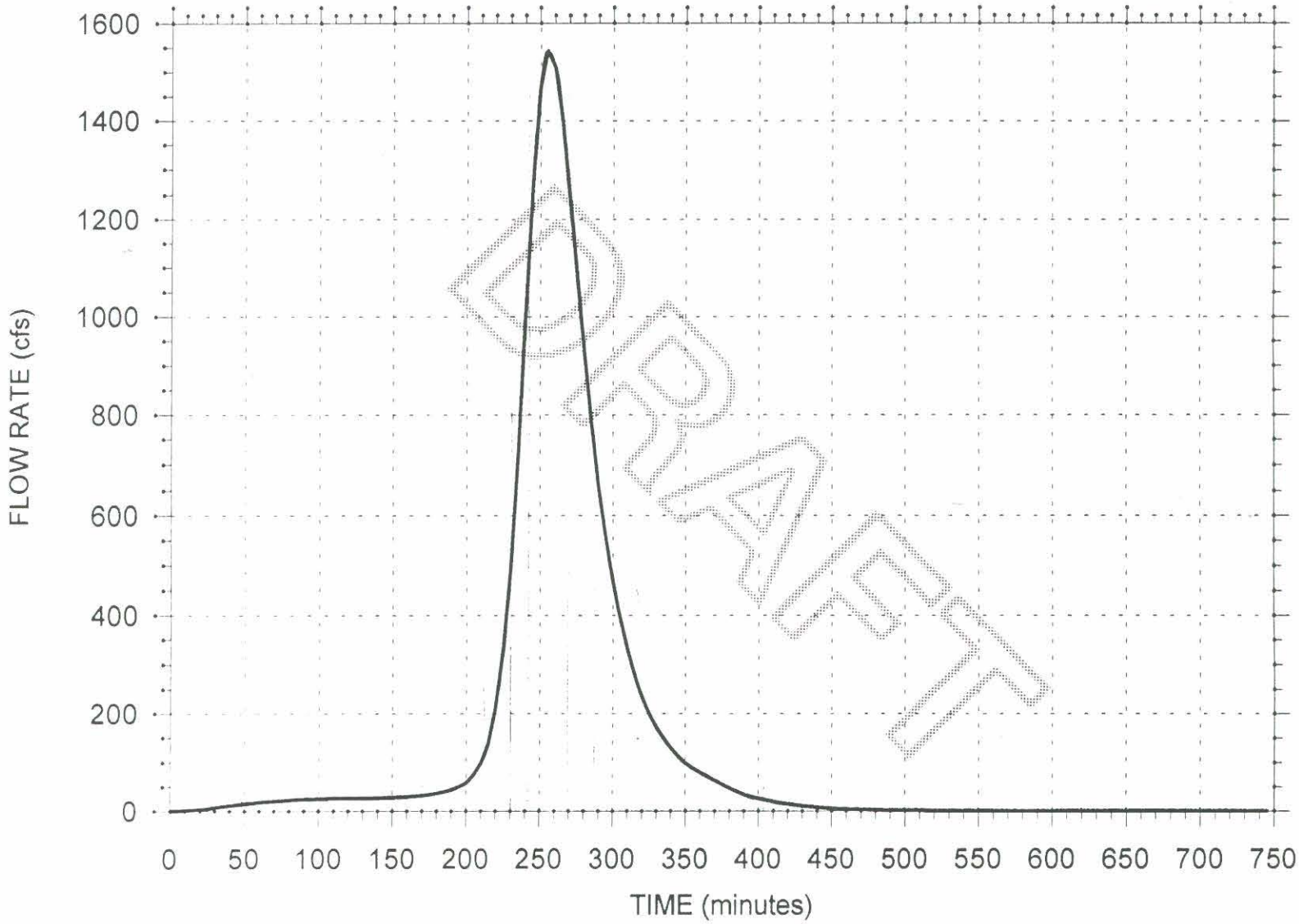
Casandro Wash 5-year Flood Hydrograph



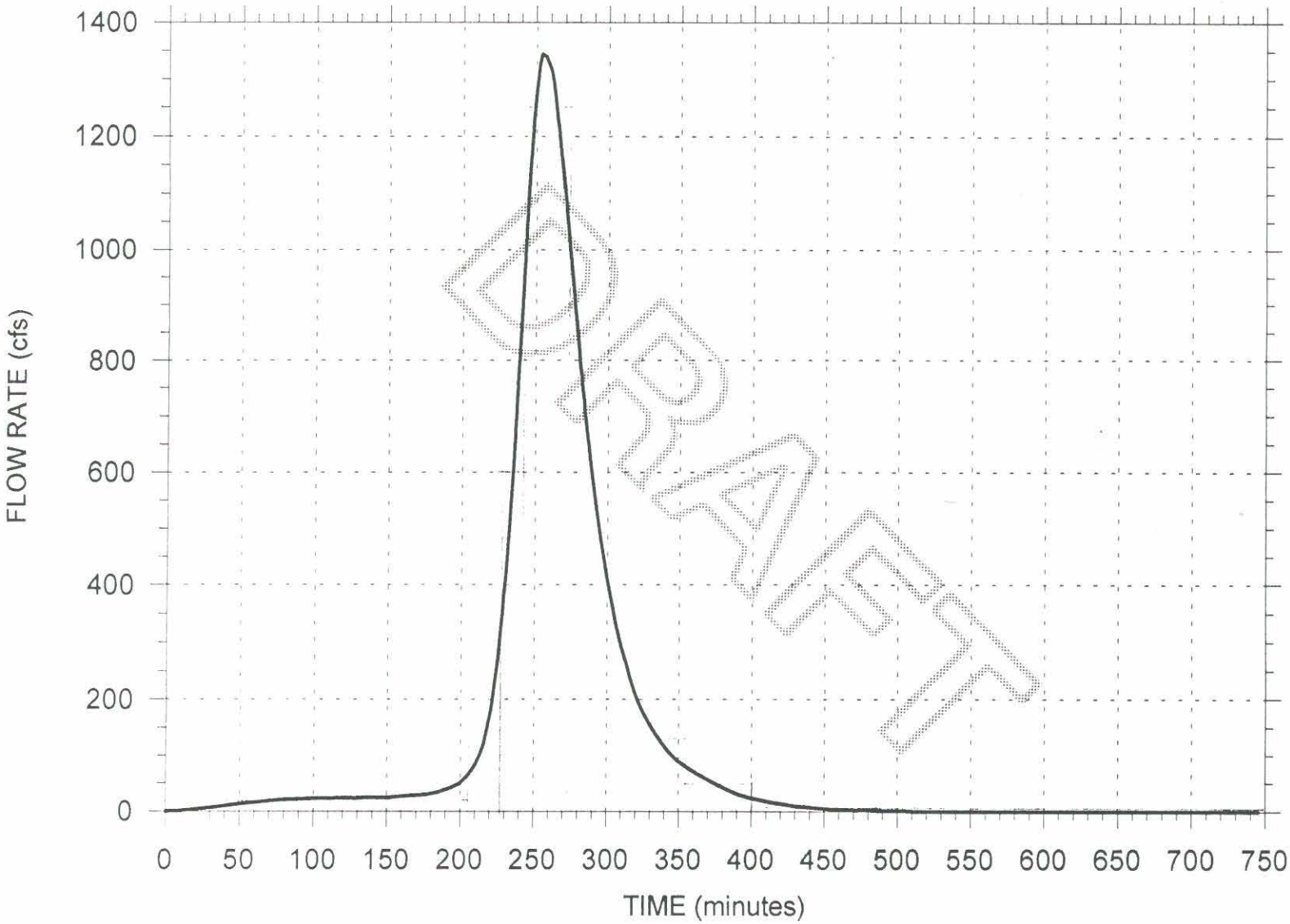
Casandro Wash 10-year Flood Hydograph



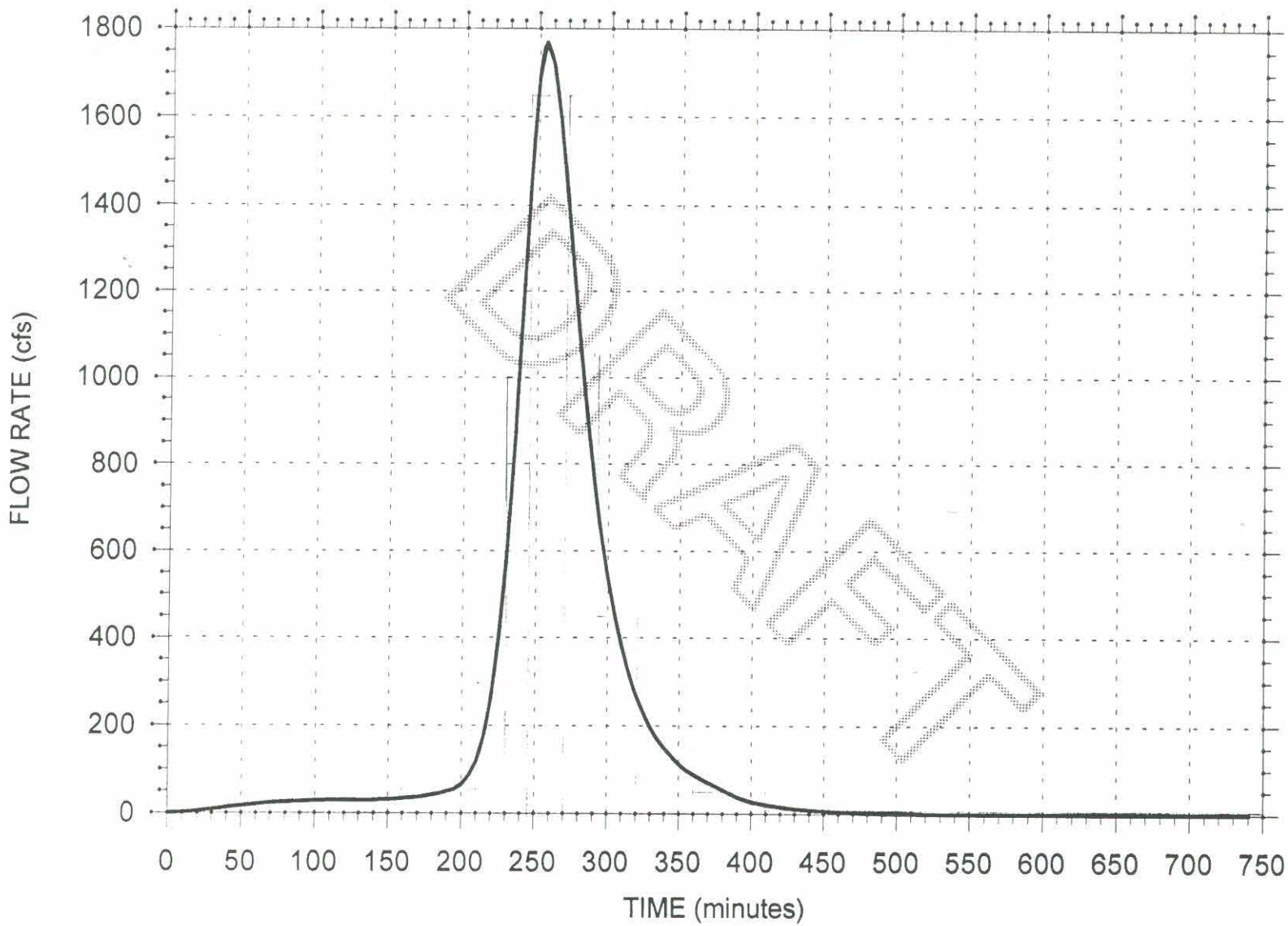
Casandro Wash 50-year Flood Hydrograph



Casandro Wash 25-year Flood Hydrograph



Casandro Wash 100-year Flood Hydrograph



HYDROGRAPH APPROXIMATION DATA:

2-YEAR FLOOD HYDROGRAPH

Q (cfs)	DURATION (min)
10	205
50	20
200	15
465	20
275	25
110	30
35	85
5	335

5-YEAR FLOOD HYDROGRAPH

Q (cfs)	DURATION (min.)
10	95
45	25
265	15
730	30
475	20
220	20
80	45
5	395

10-YEAR FLOOD HYDROGRAPH

Q (cfs)	DURATION (min)
20	200
[illegible]	35
205	5
[illegible]	30
600	[illegible]
[illegible]	[illegible]
[illegible]	
5	395

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25-YEAR FLOOD HYDROGRAPH

Q(cfs)	DURATION (cfs)
15	205
145	20
600	15
1250	30
750	20
350	25
130	35
50	45
5	350

50-YEAR FLOOD HYDROGRAPH

Q(cfs)	DURATION (min)
20	170
50	40
250	15
800	10
1450	30
1000	15
450	30
150	45
50	40
3	345

100-YEAR FLOOD HYDROGRAPH

Q(cfs)	DURATION (min)
15	160
50	50
200	30
1000	15
450	15
1000	20
450	30
150	40
45	40
3	340

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Casandro Wash Sediment Yield - Transport Function Method
Yang's 1984 Dimensionless Unit Stream Power Formula

Bed Sediment Data

	d85 (in)	d50 (in)	d65 (in)	d15 (in)	d90 (in)
From WT Lab	0.16	0.05	0.08	0.02	0.20

Hydraulic Constants

Dynamic Viscosity (68 F) =	2E-05	lb-s/ft^2
Water Temperature=	68	F
Manning's n =	0.035	
Kinematic Viscosity(68 F)=	1E-05	ft^2/s
dm =	0.06	in
Density of Water =	1.9	lb-s^2/ft^4
Specific Wt Sediment =	165.4	lb/ft^3
Specific Wt Water =	62.4	lb/ft^3

Hydraulic Parameters from HEC-2 Output

Q	DEPTH	QCH	VCH	10K*S	AREA	TOPWID	STCHL	STCHR	K*CHSL	SHEAR	CHANNEL AREA	WET PERIM CHANNEL
125	0.71	125	5.29	237.09	24	53.5	29	113	0.00	0.65	31	-
250	0.97	250	6.39	235.50	39	66.4	29	113	0.00	0.86	53	-
375	1.16	375	7.15	237.18	52	75.8	29	113	0.00	1.02	69	-
500	1.30	500	7.90	236.18	63	78.3	29	113	0.00	1.19	84	-
625	1.41	625	8.64	237.25	72	78.6	29	113	0.00	1.36	98	-
750	1.52	750	9.28	237.65	81	79.0	29	113	0.00	1.52	112	-
875	1.62	875	9.85	237.84	89	79.3	29	113	0.00	1.66	123	-
1000	1.72	1000	10.37	237.81	96	79.6	29	113	0.00	1.80	136	-
1125	1.81	1125	10.81	234.44	104	79.8	29	113	0.00	1.91	146	-
1250	1.90	1250	11.27	235.49	111	80.1	29	113	0.00	2.03	158	-
1375	1.98	1375	11.70	236.16	118	80.3	29	113	0.00	2.16	168	-
1500	2.06	1500	12.11	236.72	124	80.6	29	113	0.00	2.27	179	-

Bed Sediment Distribution

dm (mm)	0.13	0.25	0.51	0.85	1.59	2.54	3.18	5.00	6.35	9.53
%	6	7	13	19	20	6	19	5	4	1
w (ft/s)	0.24	0.34	0.49	0.63	0.86	1.09	1.22	1.52	1.72	2.10
wd/v	9	27	75	161	414	839	1172	2316	3315	6090

Computed Hydraulic Variables for Yang's Dimensionless Unit Stream Power Equation

Q	Hydr. Rad (ft)	Shear Vel, U* (ft/s)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	TOTAL SEDIMENT DISCHARGE (tons/day)
125	0.73	0.744	10939	6976	4791	3814	3060	1724	762	725	641	351	3418
250	0.97	0.857	26858	16872	11439	9072	7279	3936	1503	1634	1633	1415	8142
375	1.14	0.933	45786	28457	19109	15086	12057	6351	2177	2487	2591	2544	13549
500	1.33	1.005	67277	41415	27645	21744	17319	8912	2722	3214	3440	3638	19511
625	1.51	1.075	92366	56318	37336	29234	23174	11685	3203	3872	4220	4684	26246
750	1.68	1.135	118953	72001	47473	37035	29240	14514	3627	4451	4908	5614	33268
875	1.84	1.187	146910	88395	58013	45114	35494	17399	4009	4974	5531	6460	40555
1000	1.99	1.233	176032	105387	68891	53426	41904	20327	4354	5448	6096	7232	48062
1125	2.14	1.270	202391	120907	78923	61151	47919	23063	4609	5807	6530	7837	54959
1250	2.27	1.311	234613	139507	90706	70086	54744	26138	4926	6238	7043	8536	63082
1375	2.39	1.349	267613	158492	102698	79161	61657	29234	5217	6636	7516	9183	71343
1500	2.52	1.385	301655	178002	114976	88427	68694	32368	5489	7008	7959	9789	79798

DRAFT

Casandro Wash Sediment Yield - Transport Function Method
Yang's 1984 Dimensionless Unit Stream Power Formula

Bed Sediment Data

	d85 (in)	d50 (in)	d65 (in)	d15 (in)	d90 (in)
From WT Lab	0.16	0.05	0.08	0.02	0.20

Hydraulic Constants

Dynamic Viscosity (68 F) =	2E-05	lb-s/ft^2
Water Temperature=	68	F
Manning's n =	0.035	
Kinematic Viscosity(68 F)=	1E-05	ft^2/s
dm =	0.06	in
Density of Water =	1.9	lb-s^2/ft^4
Specific Wt Sediment =	165.4	lb/ft^3
Specific Wt Water =	62.4	lb/ft^3

Hydraulic Parameters from HEC-2 Output

Q	DEPTH	QCH	VCH	10K*S	AREA	TOPWID	STCHL	STCHR	K*CHSL	SHEAR	CHANNEL AREA	WET PERIM CHANNEL
125	0.83	125	4.08	115.38	31	59.7	29	113	0.00	0.37	31	-
250	1.16	250	4.76	105.41	52	75.8	29	113	0.00	0.46	53	-
375	1.37	375	5.41	98.45	69	78.5	29	113	0.00	0.54	69	-
500	1.56	500	5.93	91.92	84	79.1	29	113	0.00	0.61	84	-
625	1.74	625	6.38	88.01	98	79.6	29	113	0.00	0.68	98	-
750	1.91	750	6.70	82.39	112	80.1	29	113	0.00	0.72	112	-
875	2.05	875	7.10	81.81	123	80.6	29	113	0.00	0.78	123	-
1000	2.20	1000	7.37	78.44	136	81.0	29	113	0.00	0.82	136	-
1125	2.34	1125	7.69	77.70	146	81.4	29	113	0.00	0.87	146	-
1250	2.48	1250	7.92	75.29	158	81.8	29	113	0.00	0.91	158	-
1375	2.60	1375	8.18	74.19	168	82.2	29	113	0.00	0.95	168	-
1500	2.73	1500	8.40	72.76	179	82.6	29	113	0.00	0.98	179	-

Bed Sediment Distribution

dm (mm)	0.13	0.25	0.51	0.85	1.59	2.54	3.18	5.00	6.35	9.53
%	6	7	13	19	20	6	19	5	4	1
w (ft/s)	0.24	0.34	0.49	0.63	0.86	1.09	1.22	1.52	1.72	2.10
wd/v	9	27	75	161	414	839	1172	2316	3315	6090

Computed Hydraulic Variables for Yang's Dimensionless Unit Stream Power Equation

Q	Hydr. Rad (ft)	Shear Vel, U* (ft/s)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	Sed. Conc. (tn/dy)	TOTAL SEDIMENT DISCHARGE (tons/day)
125	0.84	0.560	3207	2295	1771	1508	1298	713	223	141	70	0	1224
250	1.14	0.621	7072	5060	3908	3364	2959	1627	476	418	331	89	2740
375	1.45	0.678	11511	8225	6348	5495	4889	2662	695	708	654	406	4471
500	1.75	0.720	15827	11324	8758	7618	6833	3686	855	938	927	740	6170
625	2.02	0.757	20519	14673	11349	9893	8911	4769	1002	1150	1182	1071	7988
750	2.28	0.779	24105	17314	13457	11787	10689	5694	1088	1284	1350	1306	9465
875	2.51	0.812	29873	21368	16546	14474	13115	6939	1235	1494	1602	1647	11618
1000	2.73	0.831	33903	24304	18869	16549	15052	7938	1314	1615	1754	1866	13239
1125	2.94	0.857	39617	28328	21944	19231	17483	9176	1430	1785	1962	2154	15375
1250	3.14	0.873	43849	31401	24368	21394	19497	10209	1500	1893	2097	2350	17061
1375	3.33	0.892	49173	35179	27281	23951	21835	11397	1589	2024	2259	2584	19080
1500	3.52	0.908	54013	38667	29982	26341	24040	12519	1662	2134	2397	2783	20955

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Casandro Wash Sediment Yield - Transport Function Method
Yang's 1984 Dimensionless Unit Stream Power Formula - Supercritical

Sediment Rating Curve Equation: y=7.31705*x^1.27118
Average Annual Yield (ac-ft) = 0.38

2-Year Flood

Flow Rate (cfs)	Duration (minutes)	Sediment Rate (tons/day)	Sediment Yield (tons)	Volume (ac-ft)
10	205	137	19	0.01
50	20	1057	15	0.01
200	15	6157	64	0.03
465	20	17995	250	0.11
275	25	9229	160	0.07
110	30	2879	60	0.03
35	85	672	40	0.02
5	335	57	13	0.01
		Total Yield:	621	0.29

5-Year Flood

Flow Rate (cfs)	Duration (minutes)	Sediment Rate (tons/day)	Sediment Yield (tons)	Volume (ac-ft)
10	195	137	19	0.01
45	25	924	16	0.01
265	15	8805	92	0.04
730	30	31925	665	0.31
475	20	18488	257	0.12
220	20	6950	97	0.04
80	45	1921	60	0.03
5	385	57	15	0.01
		Total Yield:	1220	0.56

10-Year Flood

Flow Rate (cfs)	Duration (minutes)	Sediment Rate (tons/day)	Sediment Yield (tons)	Volume (ac-ft)
20	200	330	46	0.02
75	25	1770	31	0.01
400	15	14860	155	0.07
950	30	44623	930	0.43
600	20	24881	346	0.16
250	35	8176	199	0.09
75	45	1770	55	0.03
5	380	57	15	0.01
		Total Yield:	1775	0.82

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Casandro Wash Sediment Yield - Transport Function Method
Yang's 1984 Dimensionless Unit Stream Power Formula - Supercritical

25-Year Flood

Flow Rate (cfs)	Duration (minutes)	Sediment Rate (tons/day)	Sediment Yield (tons)	Volume (ac-ft)
15	205	229	33	0.01
145	20	4091	57	0.03
600	15	24881	259	0.12
1250	30	63251	1318	0.61
750	20	33041	459	0.21
350	25	12540	218	0.10
130	35	3561	87	0.04
50	45	1057	33	0.02
5	350	57	14	0.01
		Total Yield:	2476	1.14

50-Year Flood

Flow Rate (cfs)	Duration (minutes)	Sediment Rate (tons/day)	Sediment Yield (tons)	Volume (ac-ft)
20	170	330	39	0.02
50	40	1057	29	0.01
250	15	8176	85	0.04
800	10	35866	249	0.11
1450	30	76384	1591	0.73
1000	15	47630	496	0.23
450	30	17260	360	0.17
150	45	4271	133	0.06
50	40	1057	29	0.01
3	345	30	7	0.00
		Total Yield:	3020	1.39

100-Year Flood

Flow Rate (cfs)	Duration (minutes)	Sediment Rate (tons/day)	Sediment Yield (tons)	Volume (ac-ft)
15	160	229	25	0.01
50	50	1057	37	0.02
300	20	10309	143	0.07
1000	15	47630	496	0.23
1650	25	90020	1563	0.72
1050	20	50677	704	0.32
450	30	17260	360	0.17
150	40	4271	119	0.05
45	50	924	32	0.01
3	340	30	7	0.00
		Total Yield:	3485	1.60

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$$(VOL_s)_m = 0.01\ (VOL_s)_{100} + 0.01\ \left(\frac{(VOL_s)_{100} + (VOL_s)_{50}}{2}\right) \qquad (3.2)$$

$$+ 0.02\ \left(\frac{(VOL_s)_{50} + (VOL_s)_{25}}{2}\right) + 0.06\ \left(\frac{(VOL_s)_{25} + (VOL_s)_{10}}{2}\right)$$

$$+ 0.1\ \left(\frac{(VOL_s)_{10} + (VOL_s)_5}{2}\right) + 0.3\ \left(\frac{(VOL_s)_5 + (VOL_s)_2}{2}\right)$$

$$+ 0.5\ \left(\frac{(VOL_s)_2 + 0}{2}\right)$$

As a check on this calculation, it is useful to apply the weighting relationship (Equation 3.2) with the corresponding water discharge hydrographs and compare the calculated value to the mean annual water delivery as determined from stream gaging data. In an arid or semi-arid area, differences in these two estimates of long-term mean annual water yield may reflect numerical errors resulting from the trapezoidal rule approximation. Alternatively, it may reflect an inadequate record length of measured data or inadequate hydrological analysis in developing return period hydrographs. In a more humid environment, these same factors may be responsible for differences between measured and calculated water yield. Additionally, differences could result from base flows that are not adequately accounted for in the flood-based incremental probability calculation. For arid and semi-arid application, assuming adequate record length and hydrology, a correction factor for application to the probability weighted sediment delivery can be defined as

$$K = \left(\frac{VOL_{meas}}{VOL_{inc}}\right)^2$$

where VOL_{inc} is mean annual water volume calculated from Equation 3.2, and VOL_{meas} is the mean annual water volume determined from gaging station data. The square of the ratio is taken since the relationship between water and sediment discharge is proportional to water discharge to the power of 1.5 to 2.0. Under the assumption of adequate record length and hydrology, the correction for numerical errors in evaluation of water yield should be relatively small, say no more than 10 to 20 percent. The maximum value for K would then be about 1.5. As a rule of thumb, this value should be assumed if

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Probable Maximum Flood

MEMORANDUM

CH2M HILL

TO: Steve Walker/PHX

COPIES: Michael Lopez/FCDMC
Sandy Story/FCDMC
Peter Binney/DEN
Roger Lindquist/CVO
John Livingston/RDD

FROM: Jon Fuller/PHX

DATE: January 26, 1994

SUBJECT: Casandro Wash Probable Maximum Flood Determination

PROJECT: SWW35441.HY.10

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Introduction

This memorandum summarizes emergency spillway design criteria for the Casandro Wash Detention Dam, as specified in Arizona Department of Water Resources (ADWR) report *"Guidelines for the Determination of Spillway Capacity Requirements"* dated May, 1991 (hereafter, "the ADWR Manual"). The memorandum also summarizes the procedures used and the modeling results for the probable maximum flood (PMF) at the proposed dam site.

Hazard Classification

In Arizona, spillway design criteria, as outlined in the ADWR Manual, are a function of the hazard classification of the dam. Hazard classification is based on factors such as the height of the dam, storage capacity, existing and probable future downstream development, uses of the reservoir, operational procedures, the type of dam, the type of spillway, the site and foundation geology, the size, slope and material composition and configuration of the downstream channel and the distance of the dam from the nearest downstream development. The Casandro Wash Dam will have a spillway crest height of about 25 feet (total dam height of about 30 feet), a maximum storage capacity of about 150 acre feet (below the spillway), will have increased future residential development downstream, will be used for flood control purposes only, will be uncontrolled, and will probably be earthen with an overflow emergency spillway.

The Casandro Wash Dam will be classified as a small, significant to high hazard dam by ADWR due to more than a small number of habitable structures downstream and the potential for appreciable economic losses downstream. Table 1 of the ADWR Manual

(attached) classifies these characteristics as high hazard. The dam is classified as high hazard for urban development, and significant hazard for economic loss. Dam size is a function of its height and capacity. The proposed dam's height is between 25 and 39 feet, and its proposed capacity is between 15 and 499 acre feet. These characteristics give the proposed structure a cumulative rating factor of 1. According to Table 2 of the ADWR Manual, "small" dams have a cumulative rating between 0 and 2.

Spillway Design Criteria

The spillway design flood recommended by ADWR for the proposed Casandro Wash Dam is the half probable maximum flood (0.5_PMF), given the hazard and size classification. Small dams in the high hazard class are to have a spillway that passes the 0.5_PMF; small dams in the significant hazard class are to have a spillway that passes the 100-year to 0.5_PMF, as indicated on Table 3 of the ADWR Manual (attached).

Total freeboard, or the distance between the top of the dam and the spillway crest, is determined by the type of dam, the maximum water surface during discharge of the design flow (0.5_PMF), wave height and runup, and economic factors. The minimum permissible total freeboard for the spillway will be 4 feet according to the ADWR Manual.

Residual freeboard, or the distance between the maximum water surface during passage of the inflow design flood and the top of the dam, must be a minimum of three feet, except when the inflow design flood is the 0.5_PMF or greater. For cases when the inflow design flood is 0.5_PMF or greater, the residual freeboard may be reduced.

Probable Maximum Flood Estimate

The 0.5_PMF and full PMF (PMF) were estimated using procedures outlined in Hydrometerological Report 49 (HMR 49; *Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages*, US Army Corps of Engineers, September 1997). The HEC-1 hydrologic model used to estimate the PMF and 0.5_PMF was developed by the FCDMC for the Casandro Wash as part of the Wickenburg Area Drainage Master Study (ADMS) and updated by CH2M HILL for this project. The HEC-1 model is described in detail elsewhere (See memorandum to Michael Lopez/FCDMC from Jon Fuller/CH2M HILL dated January 26, 1994).

Probable maximum precipitation (PMP) for a "local" storm was determined from HMR 49, as documented in computation sheets attached to this memorandum. The PMP

analysis featured the following:

- 1-hour PMP of 11.5 inches
- No elevation adjustment (site < 5,000 feet)
- 6-hour to 1-hour ratio of 1.32
- Aerial reduction of 0.25-, 0.5-, 0.75-hour PMP values (area = 1.24)
- No aerial reduction adjustment for 1-hour to 6-hour durations
- Alternative incremental PMP distribution developed by USACOE (EM#1110-2-1411)
- No aerial distribution of the PMP storm

Application of the PMP depth and distribution to the HEC1 watershed model for Casandro Wash resulted in a PMF estimate of 10,941 cfs (HEC-1 file "CASFPMFE.HC1"). The 0.5_PMF was determined by ratioing the full PMF hydrograph ordinates from the HEC1 model using a JR record, resulting in a 0.5_PMF estimate of 5,404 cfs (HEC-1 file "CASHPMFE.HC1"). Computation sheets for determination of PMF and 0.5_PMF are attached to this memorandum.

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Summary

For the Casandro Wash project, the 0.5_PMF of 5,404 is recommended for design purposes. Freeboard is likely to be controlled by residual freeboard requirement of 3 feet above the maximum 0.5_PMF water surface elevation (WSEL). The Casandro Wash Dam is a high hazard, small dam.

Table 1.
Casandro Wash Spillway Design Criteria

Spillway Capacity	0.5_PMF
Freeboard	4 ft (spillway to top of dam) or 3 ft above 0.5_PMF WSEL
0.5_PMF	5,404 cfs

Jon Fuller

STATE OF ARIZONA

DEPARTMENT OF WATER RESOURCES

ENGINEERING DIVISION/SAFETY OF DAMS SECTION

DRAFT

GUIDELINES FOR THE DETERMINATION OF SPILLWAY CAPACITY REQUIREMENTS

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PREPARED BY

DAN ROGER LAWRENCE, CHIEF

ENGINEERING DIVISION/SAFETY OF DAMS SECTION

MAY 1991

TABLE 1. DOWNSTREAM HAZARD POTENTIAL CLASSIFICATION

CATEGORY	URBAN DEVELOPMENT	ECONOMIC LOSS
Low	No permanent structure for human habitation.	Minimal (*undeveloped to occasional* structures or agriculture).
Significant	No urban development and no more than a small number of habitable structures.*	Appreciable (notable agriculture, industry or other structures).
High	Urban development with more than a small number of habitable structures.*	Excessive (extensive community, industry, agriculture).

* Because this definition does not cite a *specific number of lives that could be lost, some difficulty has* been experienced in determining whether dams should be categorized as having "significant" or "high" downstream hazard potential. The issue is clarified by emphasizing that the downstream hazard potential classification should be based on the density of downstream development containing habitable structures. For example, dams located upstream of isolated farmhouses would be classified as having significant downstream hazard potential, and those located upstream of several houses or a residential development would be classified as having a high downstream hazard potential.

SIZE CLASSIFICATION

Dams are classified into small, medium and large sizes. A *numerical rating procedure*, based on the descriptive characteristics of height and reservoir capacity has been developed to determine the dam size classification.

Height is measured from the lowest elevation of the *outside limit of the dam* (usually the downstream toe) to the spillway crest, or top of spillway gates if so equipped. For dams with no spillway, the height is measured to the crest of the dam.

Reservoir capacity, in acre-feet, is measured to the spillway crest, or top of the spillway gates if so equipped. For dams with no spillway, capacity is measured to the dam crest.

The categories and corresponding rating factors are shown in Table 2.

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TABLE 2. SIZE CLASSIFICATION RATING CATEGORIES

Height (feet)	Rating Factor	Capacity (acre-feet)	Rating Factor
6-24	0	15-499	0
25-39	1	500-999	1
40-59	2	1,000-2,999	2
60-79	3	3,000-9,999	3
80-99	4	10,000-24,999	4
100+	5	25,000+	5

A numerical rating is computed for each dam by adding the corresponding rating factors for each of the two categories. For example, a dam that is 65 feet in height and has a reservoir capacity of 22,000 acre-feet would have a rating of (3+4=7). Small dams have a rating in the range 0-2, medium dams in the range of 3-7 and large dams, 8 or greater.

⁻EQUIRED HYDROLOGIC CRITERIA

.ı evaluation of the performance and capacity of an existing spillway or a hydrologic design study for a ɔillway at a proposed dam is required to determine the ɔility of the structure to safely pass a flood whose magnitude is established on the basis of the size and downstream hazard potential classifications assigned to ıe dam.

The Inflow Design Flood (IDF) for a specific spillway is determined by the runoff hydrograph selected primarily n the basis of the size and hazard classifications assigned to the dam. As there are many factors to consider in the selection of the magnitude of this flood, it is not the purpose of these guidelines to require a specific flood frequency, volume or rainfall depth for each classification. However, Table 3 does provide ranges of flood magnitudes from which the Inflow Design Flood may be selected on the basis of the designated hazard potential and size classifications. These ranges of flood magnitudes generally define the limits acceptable to the Department of Water Resources for use as the basis for sizing the spillway.

TABLE 3. RECOMMENDED SPILLWAY DESIGN FLOODS

HAZARD CLASS	SIZE CLASSIFICATION	INFLOW DESIGN FLOOD MAGNITUDE
Low	Small	100-year
	Medium	100-year to 0.5 PMF
	Large	0.5 PMF
Significant	Small	100-year to 0.5 PMF
	Medium	0.5 PMF
	Large	0.5 PMF to PMF
High	Small	0.5 PMF
	Medium	0.5 PMF to PMF
	Large	PMF

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The flood magnitudes shown in Table 3 are derived from rainfall depths for various durations and severities of storms. Both general frontal and thunderstorm type storms should be studied with due consideration given tropical storm potential and orographic influences that may greatly increase rainfall amounts.

Recorded rainfall and flood flows in Arizona are rather sparse, and the period of record is usually short. Consequently, rainfall data are usually obtained from data published by the National Weather Service as listed in the References. Synthetic flood hydrographs are then developed by modeling the watershed's rainfall/runoff response and employing the unit hydrograph approach.

The peak inflow rate usually has a greater influence than the runoff volume on the spillway capacity requirement for a dam with a small reservoir storage that is subject to storm inflow from a large watershed. In this case, the Inflow Design Flood (IDF) peak flow is essentially equal to the peak outflow rate. Conversely, a reservoir that is relatively large compared to contributing watershed will usually attenuate the IDF peak; in this case, the spillway peak discharge may be considerably less than the IDF peak.

A spillway capacity less than outlined above will be acceptable for: (1) all new dams, (2) existing dams which are being enlarged or improved, and (3) dams being reevaluated for safety, where the owner (or the owner's engineer) can demonstrate to the Department that the incremental damages due to failure of the dam are insignificant and will not cause loss of life. The analysis shall be based upon the dam failure caused by a flood which just exceeds the routing capacity of the reservoir. The result shall be compared to the pre-failure conditions such as the spillway discharge and any reasonable rainfall runoff occurring between the dam site and the point(s) of interest below the dam. The burden of proof rests with the owner.

RESERVOIR ROUTING REQUIREMENTS

The adequacy of the spillway for an existing dam is normally determined by routing the Inflow Design Flood through the reservoir and spillway. Flood routings for spillway capacity determinations will normally be required to commence with the reservoir storage level at the spillway crest elevation. Infrequent exception would be: (1) normal conservation storage level is below the spillway crest of a reservoir without a flood storage pool, (2) the normal upper surface of the conservation pool is limited to a level that is coincident with the bottom level of the flood control pool allocation or (3) the reservoir is used exclusively for flood control and would normally be empty. Deviations from the normal starting level of routing at the spillway crest elevation must be considered on the basis of risk and reservoir operating procedure.

FREEBOARD REQUIREMENTS

Total freeboard (the distance between the top of the dam and the spillway crest) is determined by the type of dam, the maximum water surface during discharge of the Inflow Design Flood, maximum anticipated wave height and runup, and by economic factors. The minimum permissible total freeboard shall be four feet.

Residual freeboard (the distance between the maximum water surface and the top of the dam) depends on dam type, wave height and runup, the slope and finish of the upper part of the upstream face, and the Inflow Design Flood. Generally, the minimum permissible residual freeboard for an earthfill or rockfill dam shall be the greater of either the sum of wave height and runup or three feet. This requirement may be reduced in those cases where the Inflow Design Flood is the 0.5 PMF or greater.

The minimum residual freeboard for a concrete dam of any type without either a parapet wall or protection against overpour shall be the same as that of an earthfill or rockfill dam. Concrete dams provided with parapet walls exceeding the minimum residual freeboard height, or concrete dams provided with adequate splash impact protection at the toe need no other residual freeboard requirements except those which the owner may wish to provide.

DEFINITIONS

The following definitions may be helpful to those concerned with the design of an emergency spillway. The terminology is largely based on data published by Federal agencies.

100-Year Flood - The flood runoff whose magnitude is expected to be equaled or exceeded, on the average, once in 100 years. Stated another way, it is a flood that has a one percent chance of being equaled or exceeded in any one year.

Concrete Dam - Any dam constructed of concrete. Some examples are: arch, gravity, arch-gravity, slab and buttress, multiple arch. A dam having only a concrete facing should not be referred to as a concrete dam.

Drainage Area - The area that drains naturally to a particular point on a river or stream.

Earth Dam (Earthfill Dam) - An embankment dam in which more than 50% of the total volume is formed of compacted fine-grained material obtained from a borrow area.

Embankment Dam (Fill Dam) - Any dam constructed of excavated materials.

Fetch - The straight line distance between a dam and the farthest reservoir shore. The fetch is one of the factors used in calculating wave heights in a reservoir.

Flood - The runoff from rainfall or snowmelt of significant magnitude and often related to a theoretical frequency of occurrence. Flood is inflow to the water control structure.

Flood Routing - The determination of the attenuating effects of storage on a flood passing through a valley, channel, or reservoir.

Hydrograph - A graphical representation of discharge, stage, or other hydraulic property with respect to time for a particular point on a stream. (At times the term is applied to the phenomenon the graphical representation describes: hence a flood hydrograph is the passage of flood discharge past the observation point).

Inflow Design Flood (IDF) - The reservoir flood inflow whose magnitude has been selected for design requirements based on the size and assigned hazard classification of the dam. The magnitude of the IDF may range from the 100-year flood to the PMF.

Masonry Dam - Any dam constructed mainly of stone, brick, or concrete blocks that may or may not be joined with mortar. A dam having only a masonry facing should not be referred to as a masonry dam.

CH2M HILL

SUBJECT _____

CASSANDRA PMP

BY JEF DATE 1/21

SHEET NO. 1 OF ____

PROJECT NO. SNW3541.HY

LOCAL STORM ESTIMATE

- USE HMR 49 (COE, 1979) - Chap 6, p 148 PROCEDURES

① FIND 1-HR PMP - figure 4.5 (p 115)

LAT 33° 58'

LONG 112° 46'

1-HR PMP = 11.5"

② ELEVATION ≤ 5000' - NO ADJUSTMENT FOR ELEVATION

③ 6/1 HR RATIO = 1.32 → 1.3" (Fig 4.7 (p 115)

1.30 3

1.40 1.5 $\frac{3}{1.5} = \frac{x}{0.1}$ x = 0.021 (+ 1.30)

④ PERCENT DURATIONAL VARIATION Table 4.4 (p 120)

DURATION = 6 HR → 130 %

⑤ PMP 1 HR = 11.5" (Table 4.4)

¼	½	¾	1	2	3	4	5	6
8.5	10.2	10.9	11.5	13.1	13.9	14.4	14.7	15.0

⑥ AREAL REDUCTION Fig 4.9 (p 123)

.98	.99	.99	1	1	1	1	1	1
8.3	10.1	10.8	11.5	13.1	13.9	14.4	14.7	15.0

⑦ AREAL REDUCTION

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CH2M HILL

SUBJECT CASANDRO - PMP BY RF DATE 2/1

SHEET ___ OF ___

PROJECT NO. SWW3541.HV

CODING OF HEC 1 PI RECORDS

STORM IN 1-HR INCREMENTS

HR	1 HR INC.	15-MIN INC.
1	0.3	.075 .075 .075 .075
2	0.5	.125 .125 .125 .125
3	1.6	.4 .4 .4 .4
4	11.5	8.4 1.7 0.7 0.7
5	0.8	.2 .2 .2 .2
6	0.3	.075 .075 .075 .075

USE 15-MIN INCREMENTS FOR 1-HR PMP PER TABLE

Split hours 1-3, 5, 6 into even increments for PI Record per FCDMC Instructions

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SHEET 2

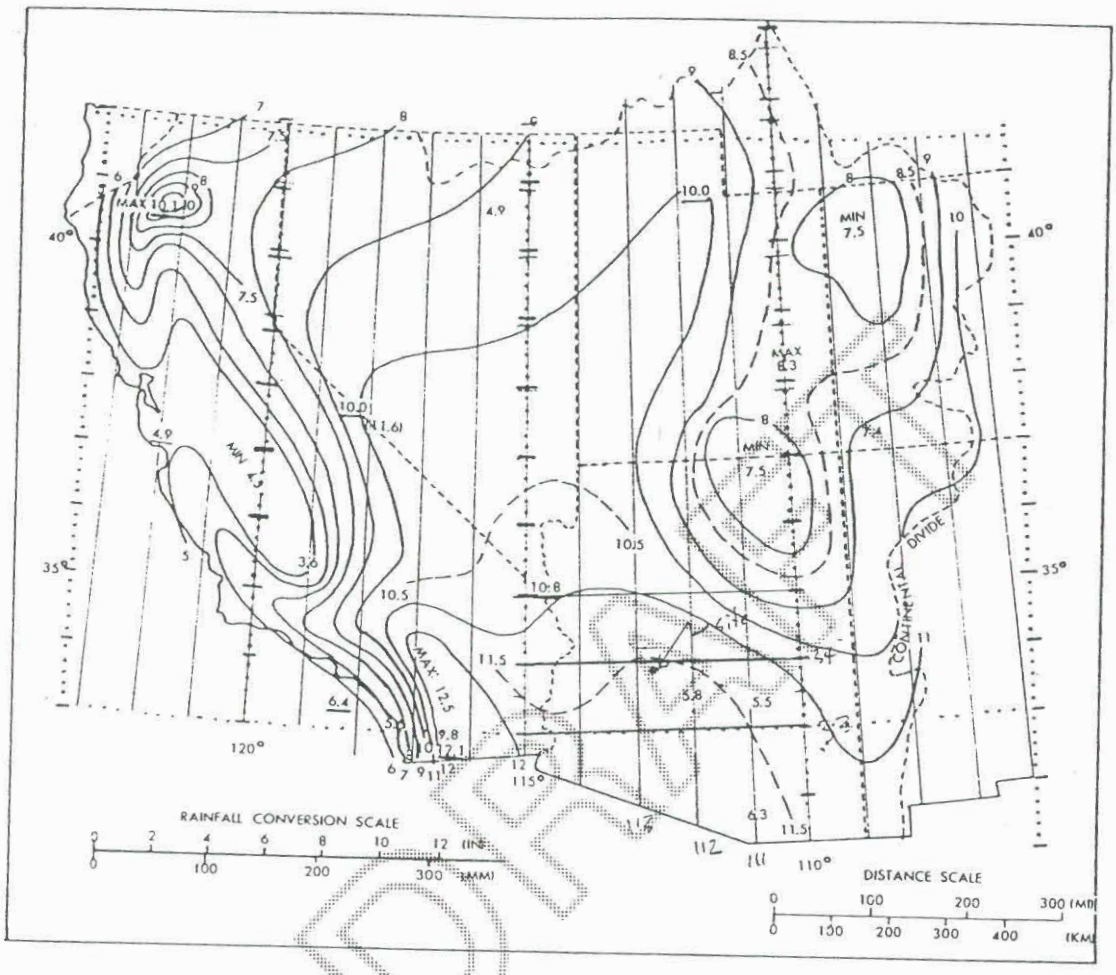

Figure 4.5--Local-storm PMP for 1 mi^2 (2.6 km^2) 1 hr. Directly applicable for locations between sea level and 5000 ft (1524 m). Elevation adjustment must be applied for locations above 5000 ft.

events. In contrast to figure 4.4, figure 4.5 maintains a maximum between these two locations. There is no known meteorological basis for a different solution. The analysis suggests that in the northern portion of the region maximum PMP occurs between the Sierra Nevada on the west and the Wasatch range on the east.

A discrete maximum (> 10 inches, 254 mm) occurs at the north end of the Sacramento Valley in northern California because the northward-flowing moist air is increasingly channeled and forced upslope. Support for this PMP center comes from the Newton, Kennett, and Red Bluff storms (fig. 4.1). Although the analysis in this region appears to be an extension of the broad maximum through the center of the Southwestern Region, it does not indicate the direction of moist inflow. The pattern has evolved primarily as a result of attempts to tie plotted maxima into a reasonable picture while considering inflow directions, terrain effects, and moisture potential.

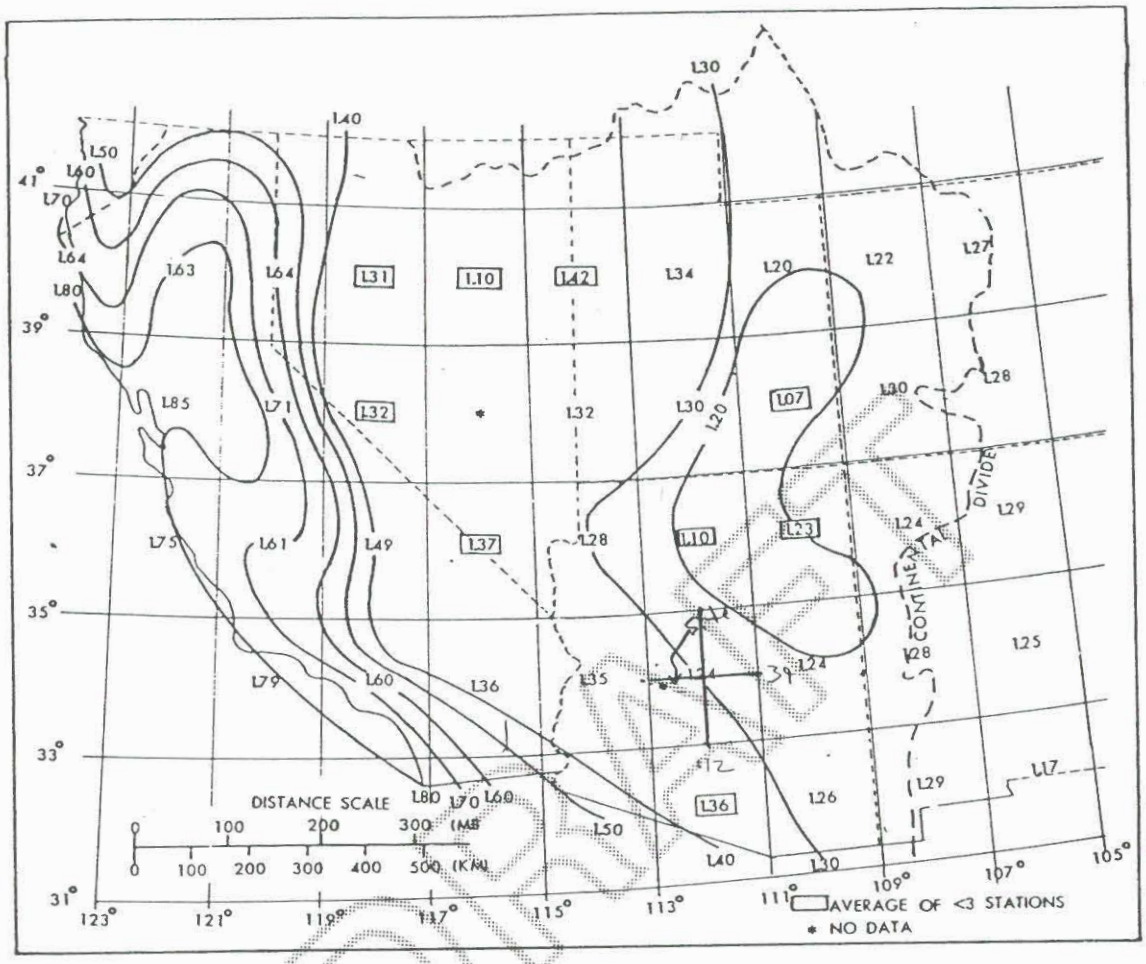

Figure 4.7.--Analysis of 6/1-hr ratios of averaged maximum station data (plotted at midpoints of a 2° latitude-longitude grid).

establish the basic depth-duration curve, then structure a variable set of depth-duration curves to cover the range of 6/1-hr ratios that are needed.

Three sets of data were considered for obtaining a base relation (see table 4.3 for depth-duration data):

a. An average of depth-duration relations from each of 17 greatest 3-hr rains from summer storms (1940-49) in Utah (U. S. Weather Bureau 1951b) and in unpublished tabulations for Nevada and Arizona (1940-63). The 3-hr amounts ranged from 1 to 3 inches (25 to 76 mm) in these events.

b. An average depth-duration relation from 14 of the most extreme short-duration storms listed in Storm Rainfall (U. S. Army, Corps of Engineers 1945-). These storms come from Eastern and Central States and have 3-hr amounts of 5 to 22 inches (127 to 559 mm).

SHEET 4

ratios than storms with high 3/1-hr ratios. The geographical distribution of 15-min to 1-hr ratios also were inversely correlated with magnitudes of the 6/1-hr ratios of figure 4.7. For example, Los Angeles and San Diego (high 6/1-hr ratios) have low 15-min to 1-hr ratios (approximately 0.60) whereas the 15-min to 1-hr ratios in Arizona and Utah (low 6/1-hr ratios) were generally higher (approximately 0.75).

Depth-duration relations for durations less than 1 hour were then smoothed to provide a family of curves consistent with the relations determined for 1 to 6 hours, as shown in figure 4.3. Adjustment was necessary to some of the curves to provide smoother relations through the common point at 1 hour.

We believe we were justified in reducing the number of the curves shown in figure 4.3 for durations less than 1 hour, letting one curve apply to a range of 6/1-hr ratios. The corresponding curves have been indicated by letter designators, A-D, on figure 4.3. As an example, for any 6-hr amount between 115% and 135% of 1-hr, 1-mi^2 (2.6-km^2) PMP, the associated values for durations less than 1 hour are obtained from the curve designated as "B".

Table 4.4 lists durational variations in percent of 1-hr PMP for selected 6/1-hr rain ratios. These values were interpolated from figure 4.3.

To determine 6-hr PMP for a basin, use figure 4.3 (or table 4.4) and the geographical distribution of 6/1-hr ratios given in figure 4.7.

Table 4.4.--Durational variation of 1-mi^2 (2.6-km^2) local-storm PMP in percent of 1-hr PMP (see figure 4.3)

6/1-hr ratio	Duration (hr) 1/4	1/2	3/4	1	2	3	4	5	6
1.1	86	93	97	100	107	109	110	110	110
~~1.2~~	~~74~~	~~89~~	~~95~~	~~100~~	~~110~~	~~115~~	~~118~~	~~119~~	~~120~~
CASSANDRA → 1.3	74	89	95	100	114	121	125	128	130
~~1.4~~	~~63~~	~~83~~	~~93~~	~~100~~	~~118~~	~~126~~	~~132~~	~~137~~	~~140~~
1.5	63	83	93	100	121	132	140	145	150
1.6	43	70	87	100	124	138	147	154	160
1.8	43	70	87	100	130	149	161	171	180
2.0	43	70	87	100	137	161	175	188	200

4.5 Depth-Area Relation

We have thus far developed local-storm PMP for an area of 1 mi^2 (2.6 km^2). To apply PMP to a basin, we need to determine how 1-mi^2 (2.6-km^2) PMP should decrease with increasing area. We have adopted depth-area relations based on rainfalls in the Southwest and from consideration of a model thunderstorm.

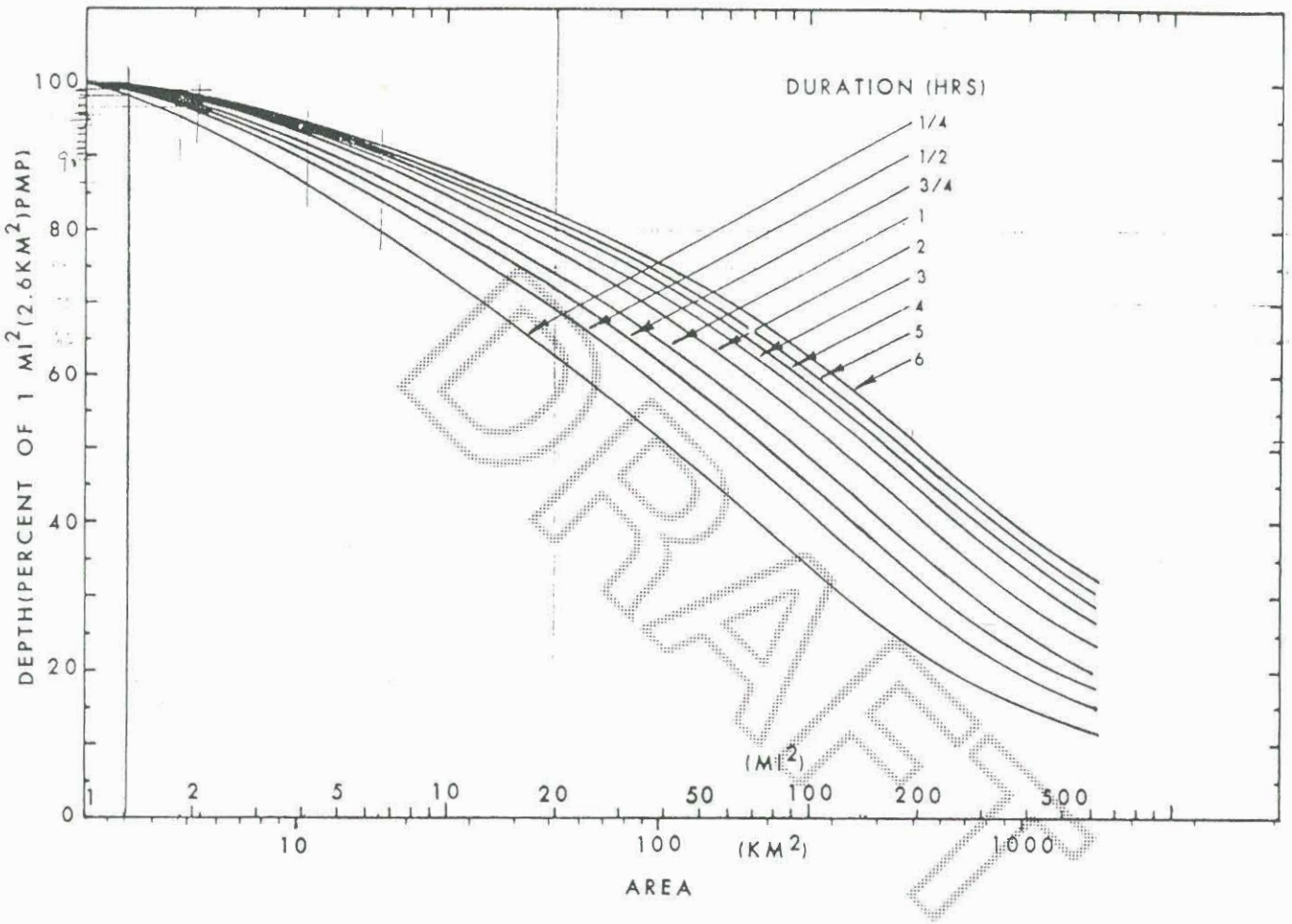

Figure 4.9.--Adopted depth-area relations for local-storm PMP.

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SUBJECT CASANDRO - PMP (LOCAL)

BY JRF DATE 1/24

SHEET NO. 6 OF

PROJECT NO. 5MW35441.HY

(8) INCREMENTAL PMP

1/4	1/2	3/4	1	2	3	4	5	6
8.4	1.7	0.7	0.7					
			11.5	1.6	0.8	0.5	0.3	0.3

(9) PMP DISTRIBUTION - Table 4.7 p.126

↳ 6 HR STORM

	HMR #5	EM MD-2-1411
1	0.3	0.3
2	0.8	0.5
3	11.5	1.6
4	1.6	11.5
5	0.5	0.5
6	0.3	0.3

(10) ~~ACCUM~~ DISTRIBUTE STORM WITH BASIN

D.A. = 1.24 " 81% WITHIN 1 mi² ∴ USE MAXIMUM PMP (NO REDUCTION) - CONSERVATIVE ASSUMPTION

(11) Q_{PMF} = 8097 8435 cfs — CASFPMF.HC1

8164 → w/ 15-MIN INCREMENTS = ~~[illegible]~~ 11093 — CASFPMFE.HC1

(12) ½ PMF - Ratio hydrograph ordinates using JR record w/ JR.2 = 0.5 (÷ flow ordinates by 2)

CASHPMFE.HC1

Q½PMF = 4073

15 MIN INCREMENTS → 5481 ← USE FOR DESIGN

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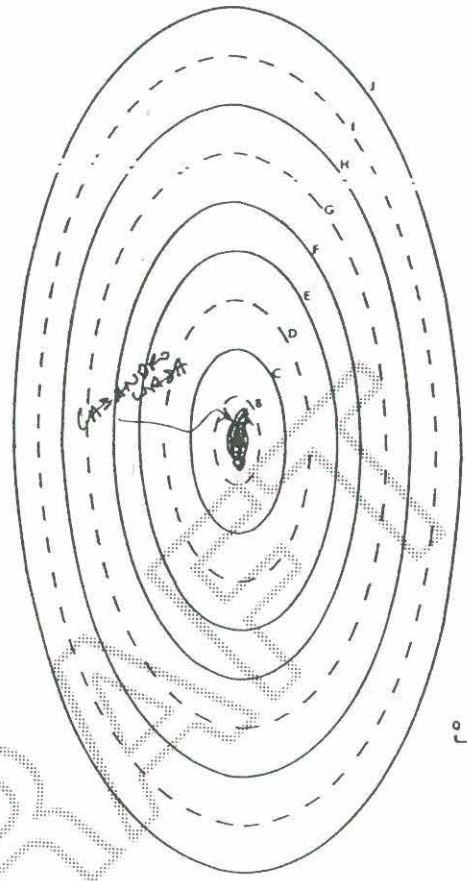
SAZET 7



ISOHYET	INCLOSED AREA (SQ.MI.)	(KM^2)
A	1	2.6
B	5	13
C	25	65
D	55	142
E	95	246
F	150	388
G	220	570
H	300	777
I	385	997
J	500	1295

Figure 4.10.--Idealized local-storm isohyetal pattern.

storm period. The sequence of hourly incremental PMP for the Southwest 6-hr thunderstorm in accord with this study is presented in column 2 of table 4.7. A small variation from this sequence is given in Engineering Manual 1110-2-1411 (U. S. Army, Corps of Engineers 1965). The latter, listed in column 3 of table 4.7, places greater incremental amounts somewhat more toward the end of the 6-hr storm period. In application, the choice of either of these distributions is left to the user since one may prove to be more critical in a specific case than the other.

Table 4.7.--Time sequence for hourly incremental PMP in 6-hr storm

Increment	HMR No. 5[1]	EM1110-2-1411[2]
	Sequence Position	
Largest hourly amount	Third	Fourth
2nd largest	Fourth	Third
3rd largest	Second	Fifth
4th largest	Fifth	Second
5th largest	First	Last
least	Last	First

[1] U. S. Weather Bureau 1947.
[2] U. S. Corps of Engineers 1952.

Watershed Reduced
to 1:500,000

DRAFT

9 FC 39

Hydrology

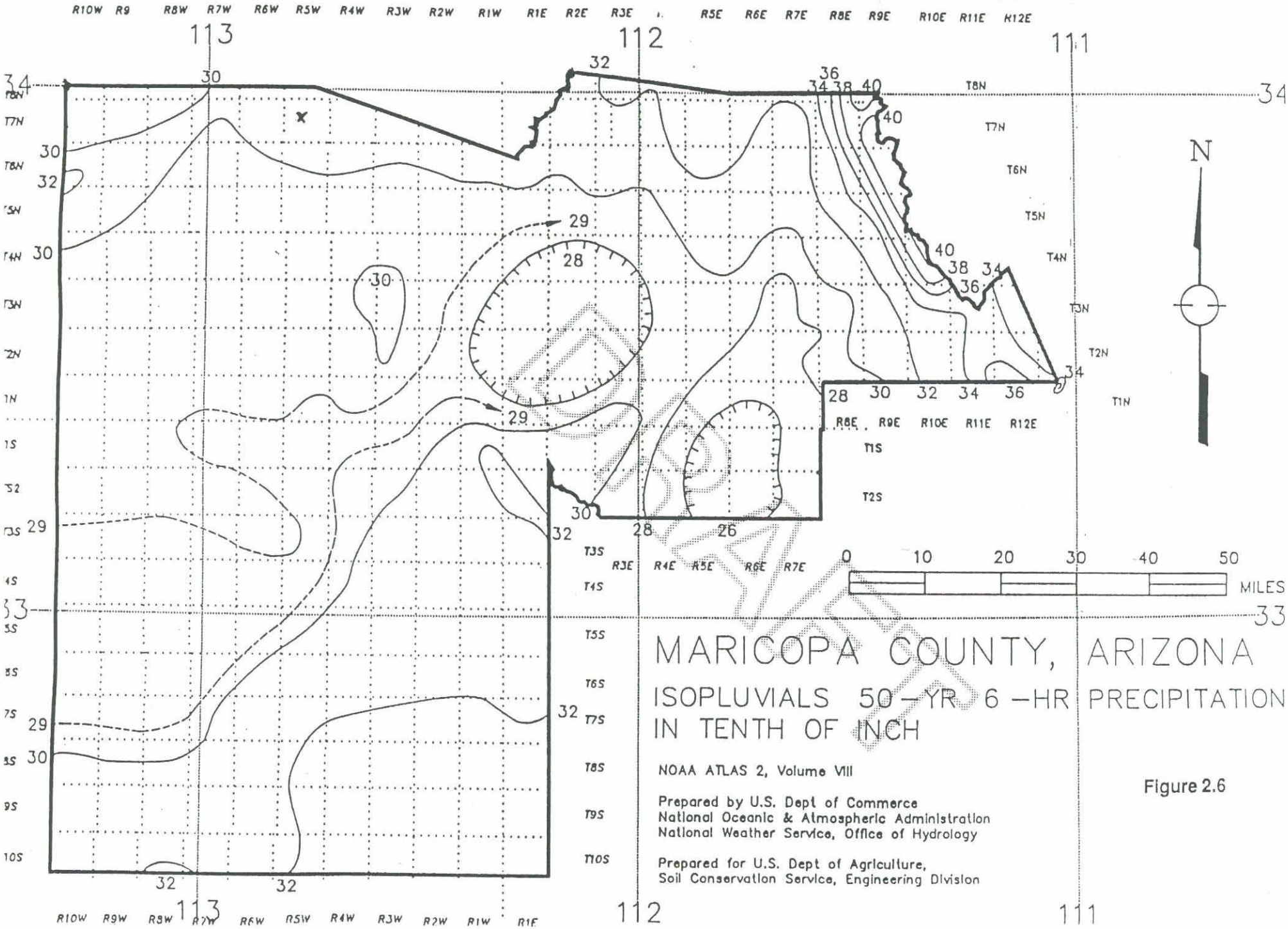
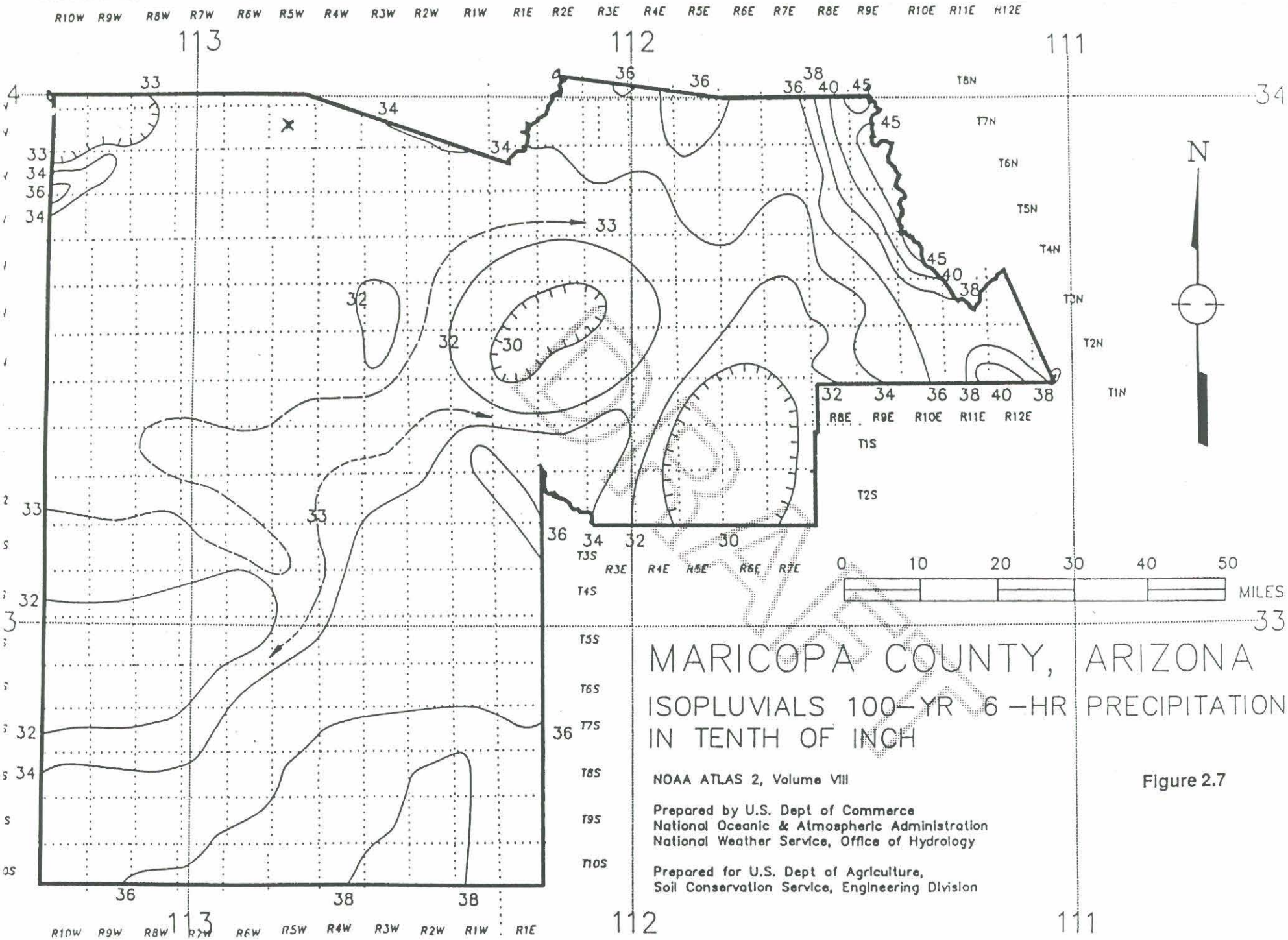

MARICOPA COUNTY, ARIZONA
ISOPLUVIALS 50-YR 6-HR PRECIPITATION
IN TENTH OF INCH
NOAA ATLAS 2, Volume VIII
Prepared by U.S. Dept of Commerce
National Oceanic & Atmospheric Administration
National Weather Service, Office of Hydrology
Prepared for U.S. Dept of Agriculture,
Soil Conservation Service, Engineering Division
N
0 10 20 30 40 50
MILES
R10W R9 R8W R7W R6W R5W R4W R3W R2W R1W R1E R2E R3E R4E R5E R6E R7E R8E R9E R10E R11E R12E
T8N T7N T6N T5N T4N T3N T2N T1N T1S T2S T3S T4S T5S T6S T7S T8S T9S T10S
113
112
111
33
34

Figure 2.6



MARICOPA COUNTY, ARIZONA

ISOPLUVIALS 100-YR 6-HR PRECIPITATION IN TENTH OF INCH

NOAA ATLAS 2, Volume VIII

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National Weather Service, Office of Hydrology

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Figure 2.7

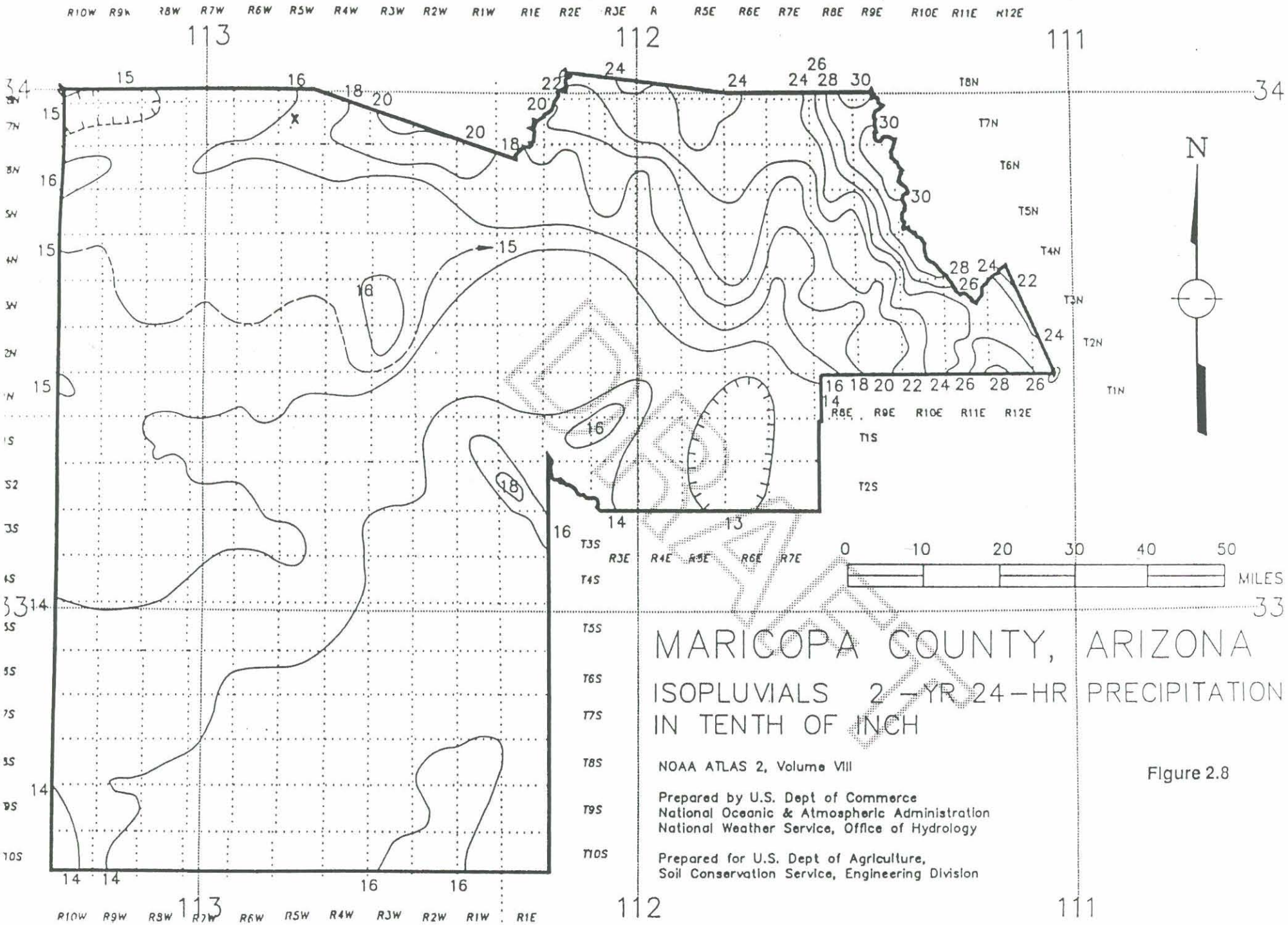

MARICOPA COUNTY, ARIZONA
ISOPLUVIALS 2-YR 24-HR PRECIPITATION
IN TENTH OF INCH
NOAA ATLAS 2, Volume VIII
Prepared by U.S. Dept of Commerce
National Oceanic & Atmospheric Administration
National Weather Service, Office of Hydrology
Prepared for U.S. Dept of Agriculture,
Soil Conservation Service, Engineering Division
N
MILES
0 10 20 30 40 50
R10W R9W R8W R7W R6W R5W R4W R3W R2W R1W R1E R2E R3E R4E R5E R6E R7E R8E R9E R10E R11E R12E
T8N T7N T6N T5N T4N T3N T2N T1N T1S T2S T3S T4S T5S T6S T7S T8S T9S T10S
113 112 111
34 33

Figure 2.8

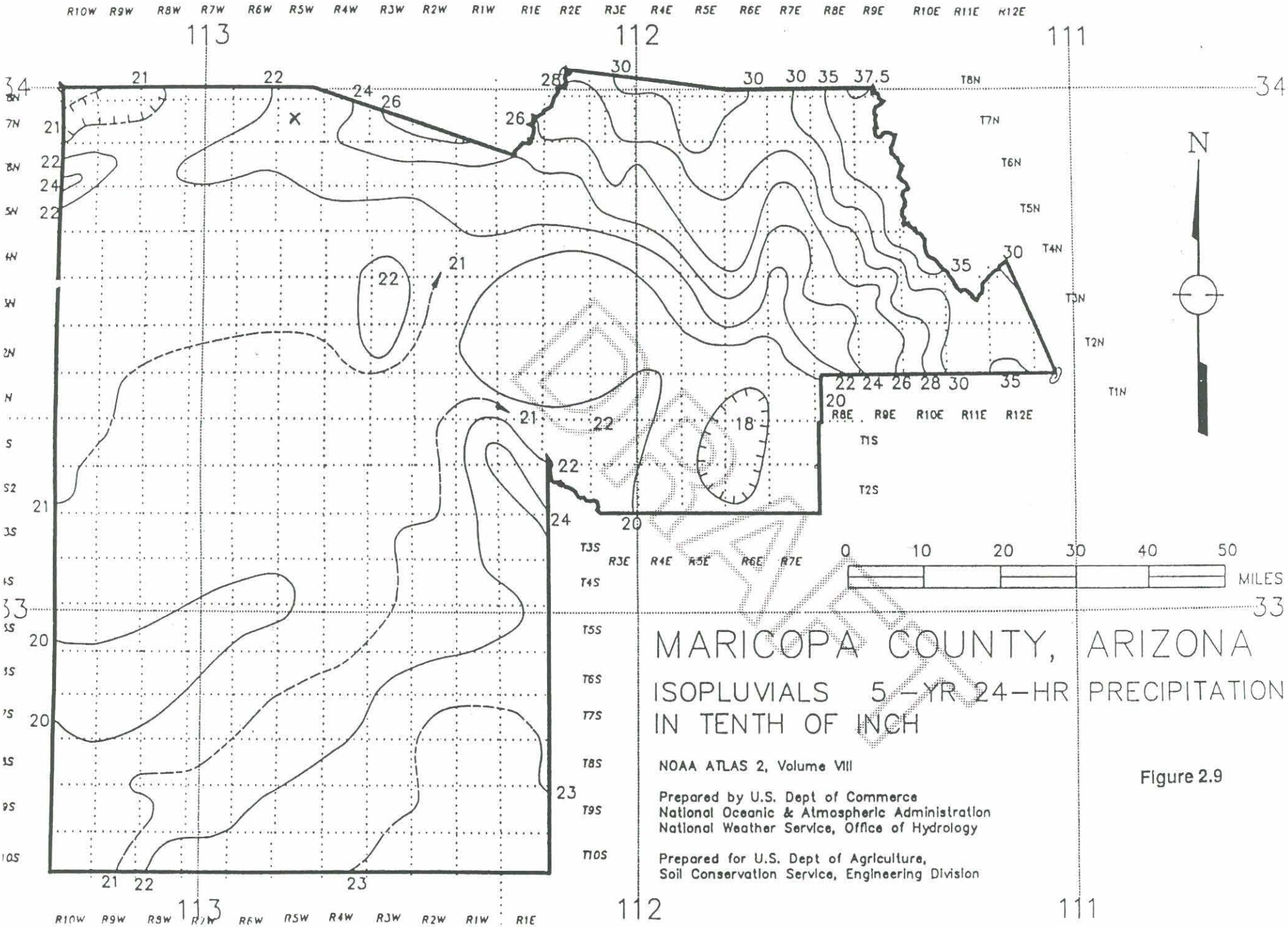
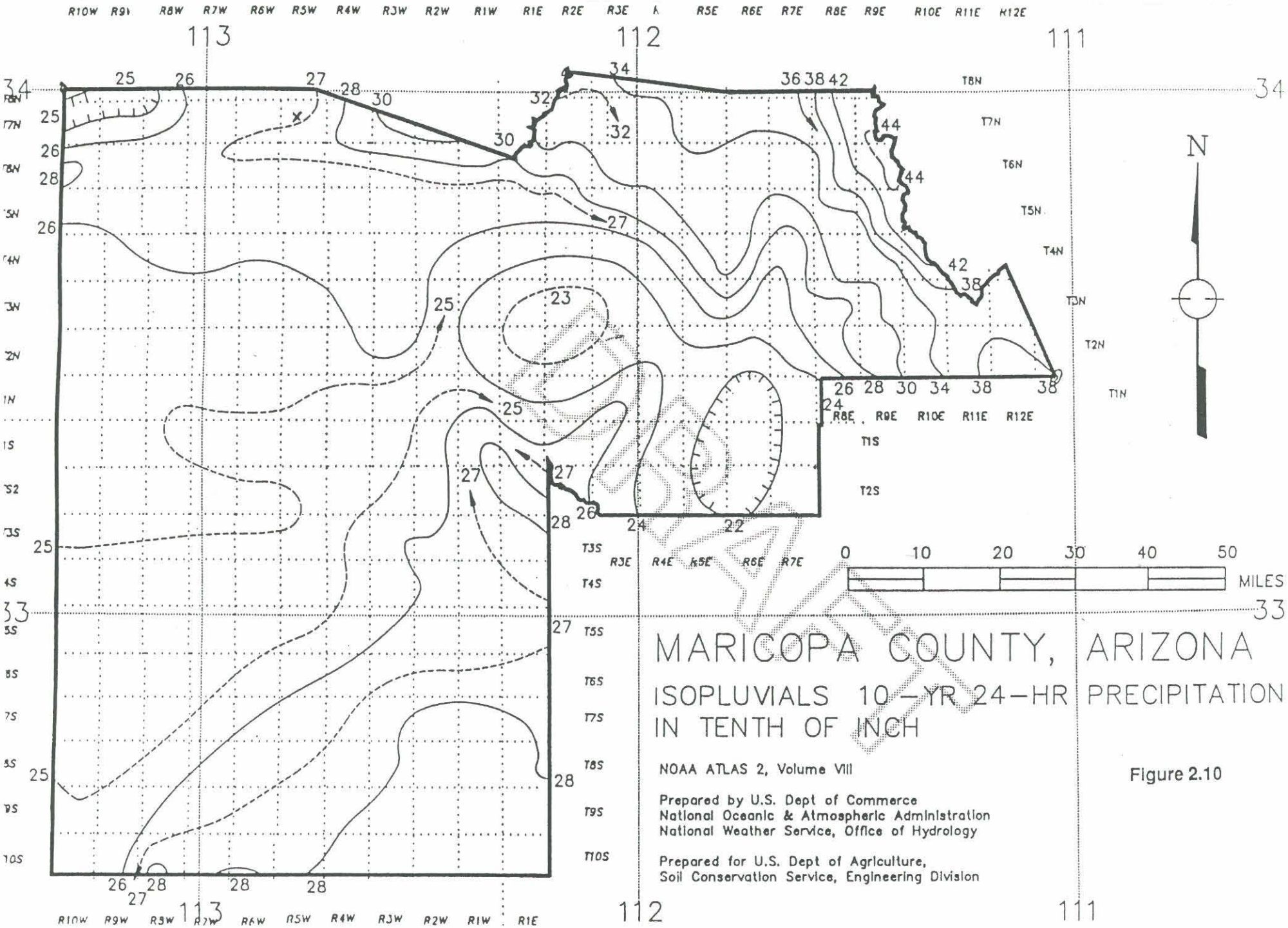

MARICOPA COUNTY, ARIZONA
ISOPLUVIALS 5-YR 24-HR PRECIPITATION
IN TENTH OF INCH
NOAA ATLAS 2, Volume VIII
Prepared by U.S. Dept of Commerce
National Oceanic & Atmospheric Administration
National Weather Service, Office of Hydrology
Prepared for U.S. Dept of Agriculture,
Soil Conservation Service, Engineering Division
N
MILES
0 10 20 30 40 50
R10W R9W R8W R7W R6W R5W R4W R3W R2W R1W R1E R2E R3E R4E R5E R6E R7E R8E R9E R10E R11E R12E
113
112
111
34
33
T8N
T7N
T6N
T5N
T4N
T3N
T2N
T1N
T1S
T2S
T3S
T4S
T5S
T6S
T7S
T8S
T9S
T10S

Figure 2.9


MARICOPA COUNTY, ARIZONA
ISOPLUVIALS 10-YR 24-HR PRECIPITATION
IN TENTH OF INCH
NOAA ATLAS 2, Volume VIII
Prepared by U.S. Dept of Commerce
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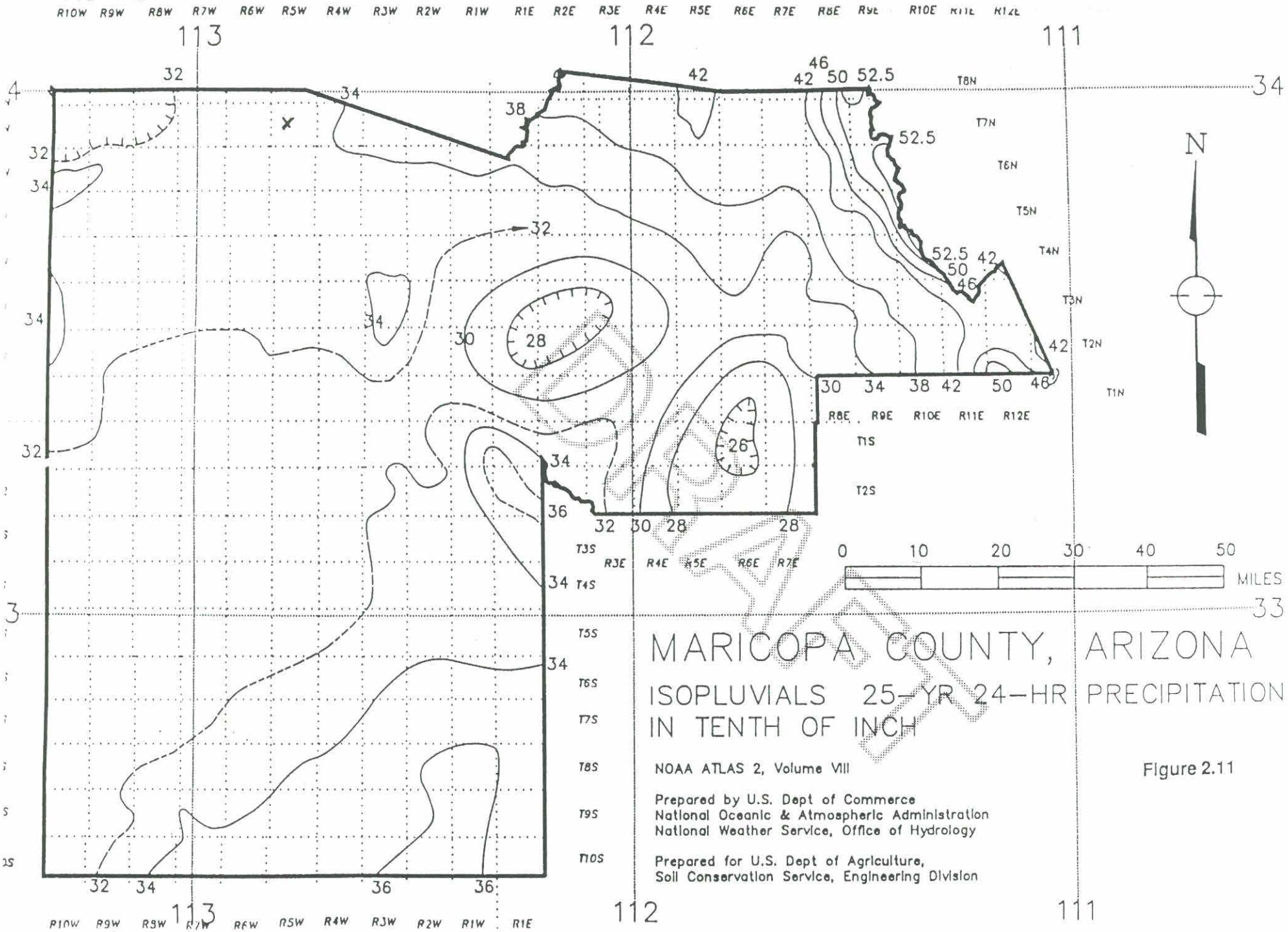
Soil Conservation Service, Engineering Division
N
0 10 20 30 40 50
MILES
R10W R9W R8W R7W R6W R5W R4W R3W R2W R1W R1E R2E R3E R4E R5E R6E R7E R8E R9E R10E R11E R12E
T8N T7N T6N T5N T4N T3N T2N T1N T1S T2S T3S T4S T5S T6S T7S T8S T9S T10S
113 112 111
34 33

Figure 2.10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113
112
111
34
33
T8N
T7N
T6N
T5N
T4N
T3N
T2N
T1N
T1S
T2S
T3S
T4S
T5S
T6S
T7S
T8S
T9S
T10S
N
0 10 20 30 40 50
MILES
MARICOPA COUNTY, ARIZONA
ISOPLUVIALS 25-YR 24-HR PRECIPITATION
IN TENTH OF INCH
NOAA ATLAS 2, Volume VIII
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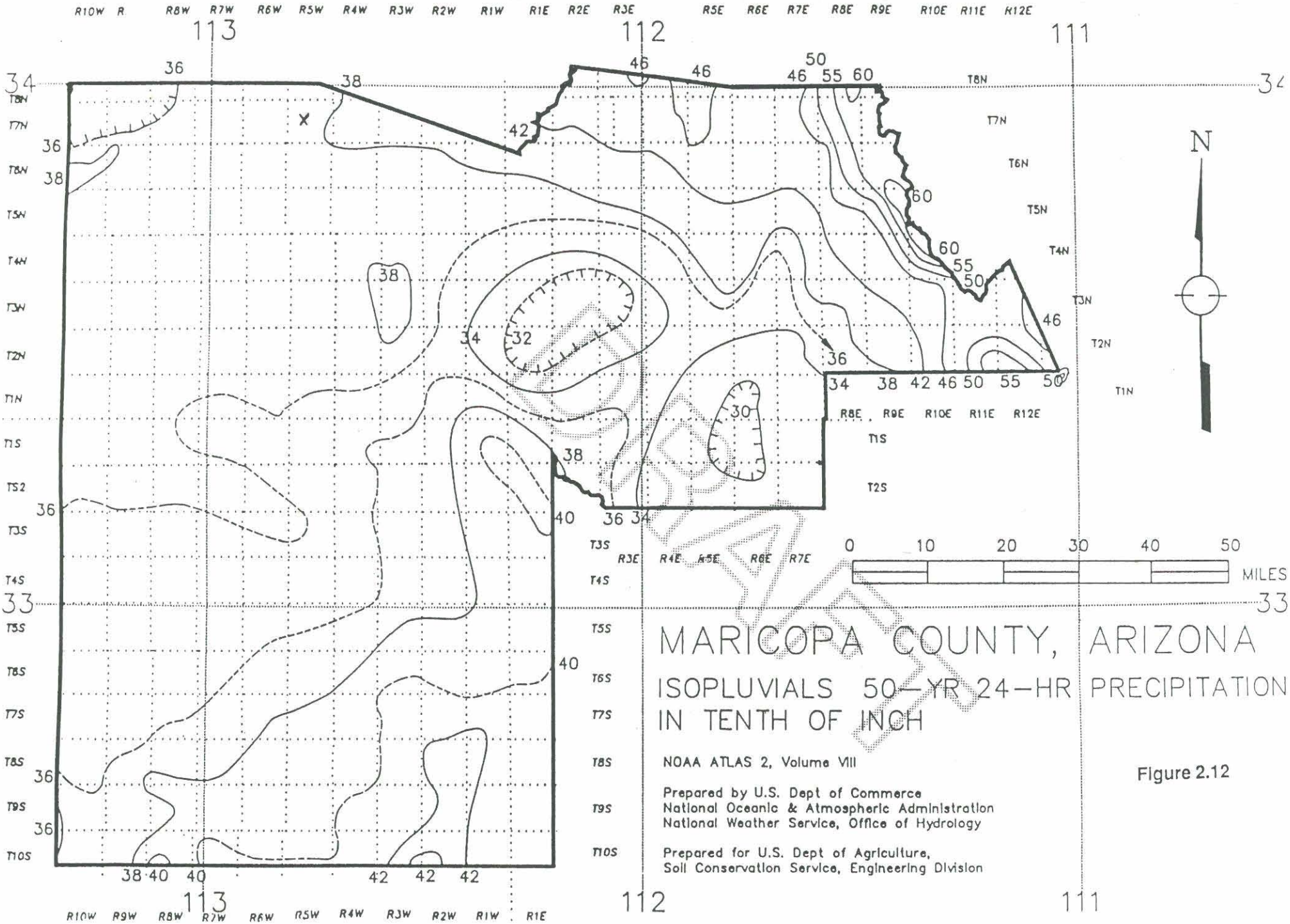
Figure 2.11


MARICOPA COUNTY, ARIZONA
ISOPLUVIALS 50-YR 24-HR PRECIPITATION
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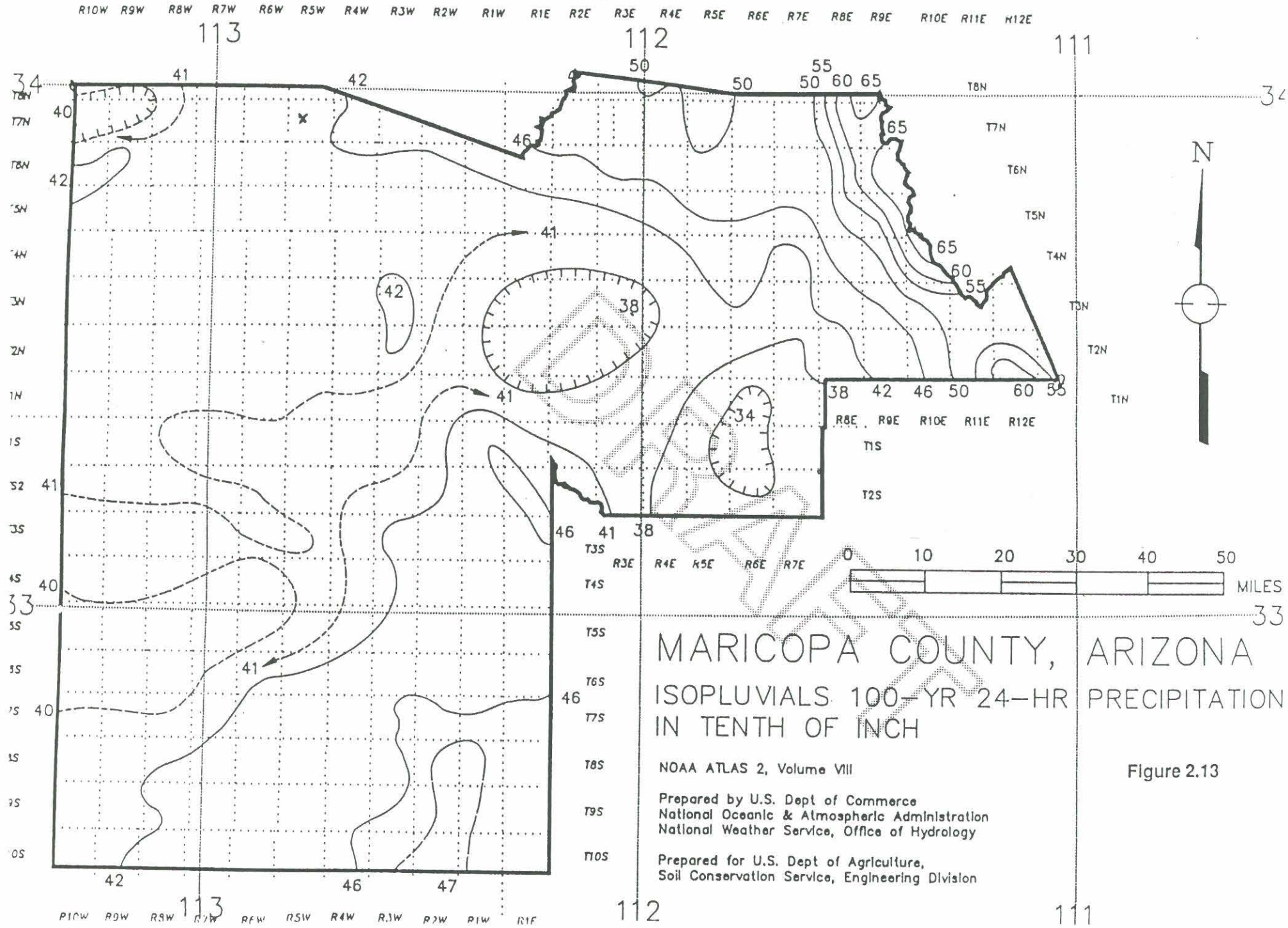
N
0 10 20 30 40 50
MILES
R10W R9W R8W R7W R6W R5W R4W R3W R2W R1W R1E R2E R3E R4E R5E R6E R7E R8E R9E R10E R11E R12E
T8N T7N T6N T5N T4N T3N T2N T1N T1S T2S T3S T4S T5S T6S T7S T8S T9S T10S
113 112 111
34 33

Figure 2.12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113
112
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T6N
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T2N
T1N
T1S
T2S
T3S
T4S
T5S
T6S
T7S
T8S
T9S
T10S
N
0 10 20 30 40 50
MILES
MARICOPA COUNTY, ARIZONA
ISOPLUVIALS 100-YR 24-HR PRECIPITATION
IN TENTH OF INCH
NOAA ATLAS 2, Volume VIII
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Figure 2.13

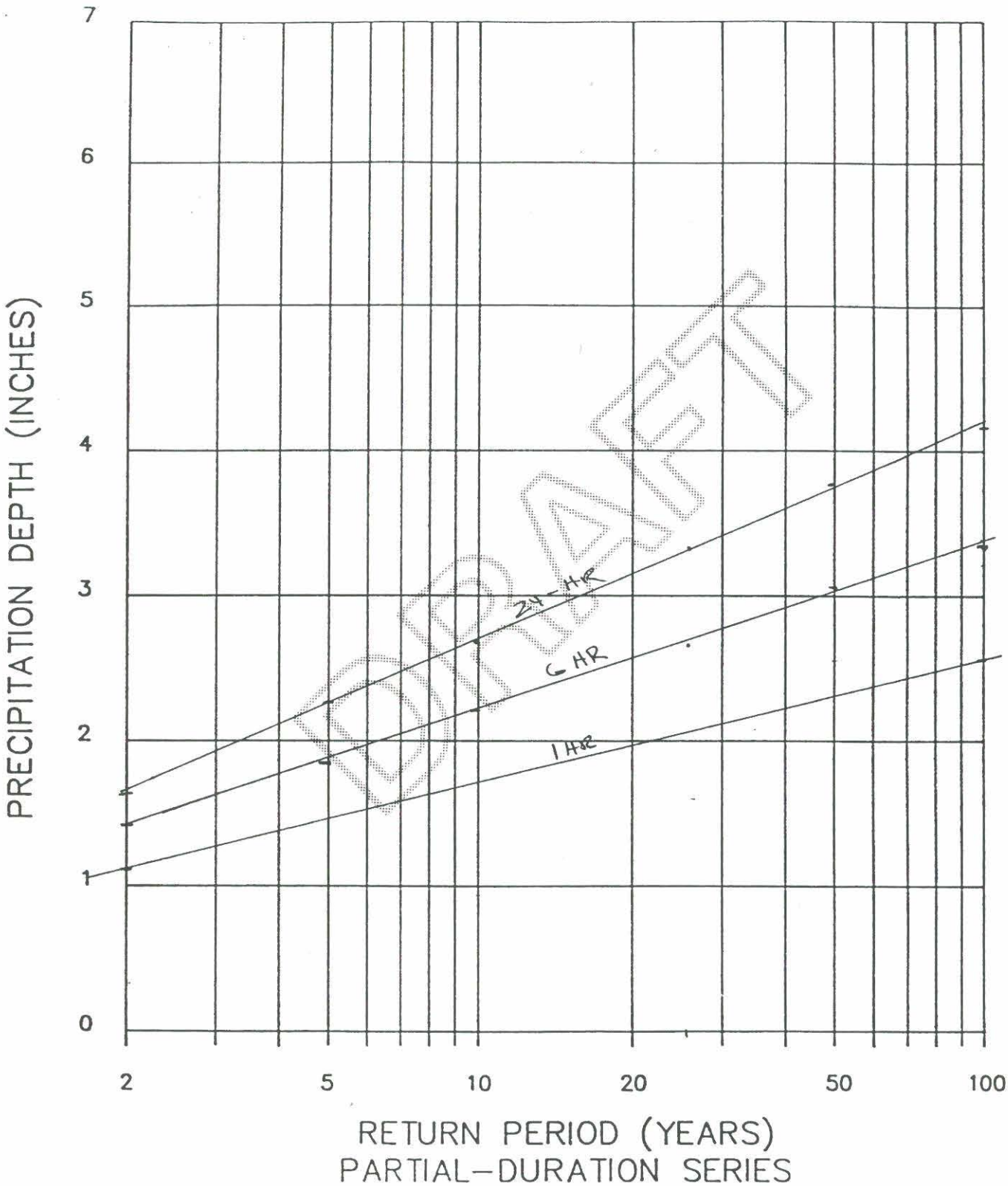

Figure 2.14
Precipitation Depth versus Return Period for Partial-Duration Series

SUBJECT CASANDRO HYDRAL

BY JRF DATE 1/18

SHEET NO. ___ OF ___

PROJECT NO. ___

(3) DEPTH-AREA REDUCTION - Table 2.2 p 2-20

D.A. = 1.24

→ DARF = .985 — SEE MCUHP1 OUTPUT

ADJUSTED RAINFALL DEPTHS - GAR

P_2 = 1.39

P_{10} = 2.20

P_{100} = 3.35

(4) DESIGN STORM

PATTERN 1.53 → 1.5

Use: Figure 2.17 p 2.26

Table 2.3 p 2-25

CHECKED CALCULATIONS USING DISTRICTS' PREFRE.EXE PROGRAM

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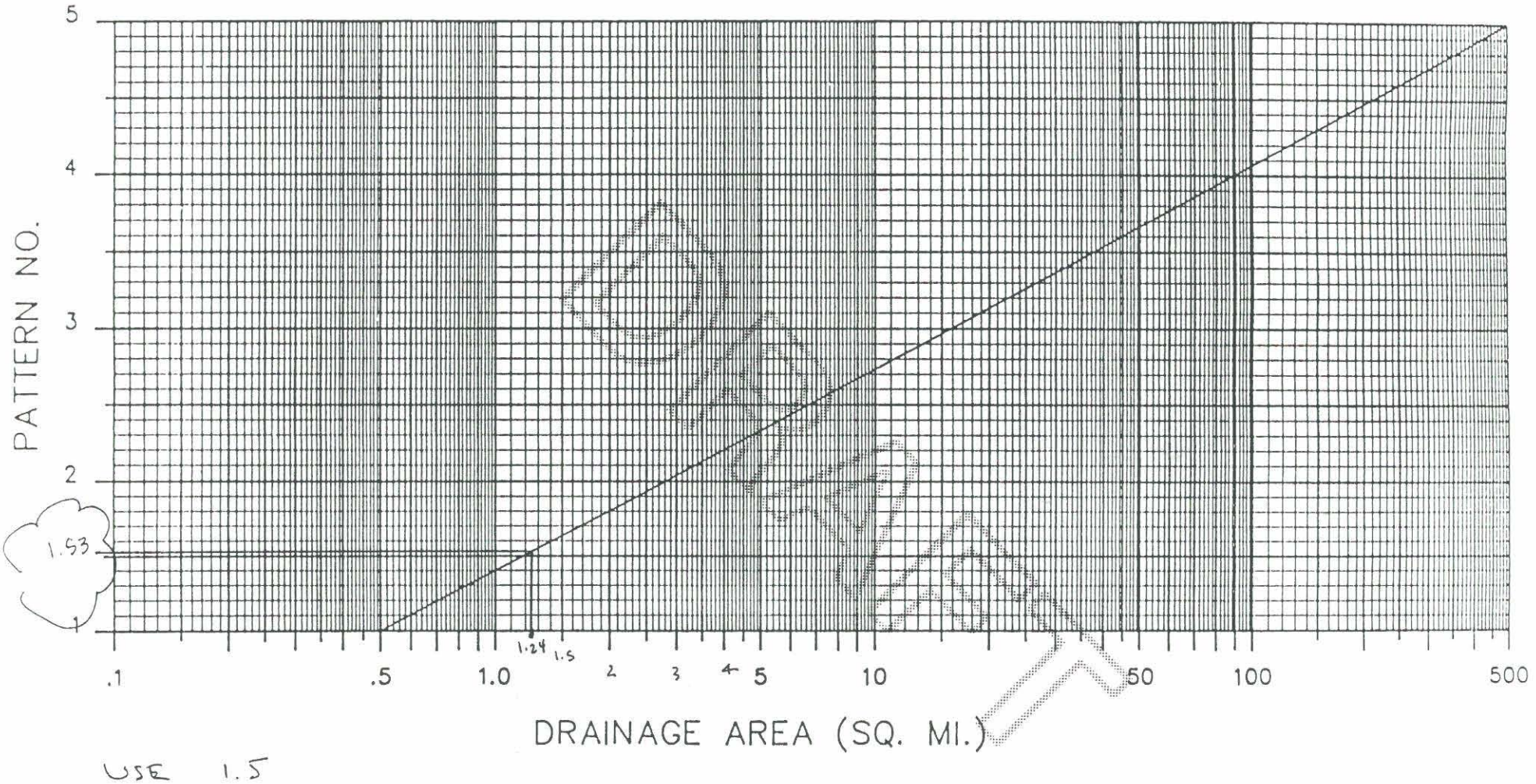

Figure 2.18
Area Versus Pattern Number for Maricopa County

SAZZT 19

input into HEC-1, once the size of the drainage area is determined. Figure 2.17 illustrates the dimensionless rainfall patterns. Use Figure 2.18 to select a rainfall pattern between 1 to 5 and interpolate as necessary for watershed areas of up to 100 square miles. Alternatively, programs MCUHP1 and MCUHP2 can be used for this purpose.

As mentioned earlier, any watershed larger than 100 square miles should be analyzed on a case-by-case basis to determine the design rainfall criteria for the critical storm event considering watershed size, location, and other factors including rainfall depth, duration, and temporal distribution.

INTERPOLATED VALUES

Table 2.3
6-Hour Distributions*

— ROUND TO 1 DECIMAL PLACE

Time (hrs)	Pattern 1		Pattern 2	Pattern 3	Pattern 4	Pattern 5
0:00	0.0	0.0	0.0	0.0	0.0	0.0
0:15	0.8	0.9	0.9	1.5	2.1	2.4
0:30	1.6	1.6	1.6	2.0	3.5	4.3
0:45	2.5	2.5	2.5	3.0	5.1	5.9
1:00	3.3	3.4	3.4	4.8	7.1	7.8
1:15	4.1	4.2	4.2	6.3	8.7	9.8
1:30	5.0	5.1	5.1	7.6	10.5	11.9
1:45	5.8	5.9	5.9	9.0	12.5	14.1
2:00	6.6	6.7	6.7	10.5	14.3	16.2
2:15	7.4	7.5	7.6	11.9	16.0	18.6
2:30	8.7	8.7	8.7	13.5	17.9	21.2
2:45	9.9	10.0	10.0	15.2	20.1	23.9
3:00	11.8	11.9	12.0	17.5	23.2	27.1
3:15	13.8	15.1	16.3	22.2	28.1	32.1
3:30	21.6	23.5	25.2	30.4	36.4	40.8
3:45	37.7	41.6	45.1	47.2	50.0	51.5
4:00	83.4	76.0	69.4	67.0	65.8	62.7
4:15	91.1	87.2	83.7	79.6	77.3	73.5
4:30	93.1	91.5	90.0	86.8	84.1	81.4
4:45	95.0	94.4	93.8	91.2	88.8	86.4
5:00	96.2	95.6	95.0	94.6	92.7	90.7
5:15	97.2	96.7	96.3	96.0	94.5	93.0
5:30	98.3	97.9	97.5	97.3	96.4	95.4
5:45	99.1	98.9	98.8	98.7	98.2	97.7
6:00	100.0	100.0	100.0	100.0	100.0	100.0

*Pattern represents percent Rainfall Depth.

DRAFT

Table 2.2
Depth-Area Reduction Factors
for 6-Hour Duration Rainfall

Area, Square Miles	Ratio to Point of Rainfall
0	1.0
1	0.987
5	0.96
10	0.94
20	0.91
30	0.89
40	0.87
50	0.86
100	0.80
200	0.72
300	0.66
400	0.61
500	0.57

DRAFT

Use the depth-area reduction values from Figure 2.14 or Table 2.2 to correct the 6-hour point rainfall depth from the isopluvial maps (Figures 2.2 through 2.7) for all flood studies in which the 6-hour local storm is the design rainfall criteria (see Table 2.1).

If the flood study is for the design of a retention/detention facility for a small drainage area and the design rainfall criteria is the 100-year, 2-hour storm, then the point rainfall depths from Figure 2.1 are not to be reduced for area. This is because local retention/detention basins will be provided only for very small drainage areas and the point rainfall from Figure 2.1 is representative of the equivalent uniform depth of rainfall over the entire contributing area.

If a general storm is the accepted design rainfall criteria (as opposed to the 6-hour local storm as defined in this manual), then the appropriate depth-area reduction curve will need to be defined to correspond with the rainfall duration and the temporal distribution of the general storm. This will need to be performed on a case-by-case basis depending on the purpose of the study, location of the watershed, and other meteorological and hydrological factors.

2.3.1 Procedure for Depth-Area Adjustment

The following procedure is to be used with the 6-hour local storm rainfall depths (Figures 2.2 through 2.7):

1. Determine the size of the drainage area.

SUBJECT CASANDRO - HYDRA

BY JEF DATE 1/18

SHEET NO. ___ OF ___

PROJECT NO. ___

8. RAINFALL LOSSES

1. SURFACE RETENTION

Table 4.1 p 4-5

DESERT LANDSCAPE = 0.10

NATURAL CONDITIONS - Hillslope, sonoran desert = 0.15" ← theoretical maximum

Development has been residential (up to 4 DU/AC) commercial (on corridors)

Landscaping is mixture of desert, lawn/turf, and pavement

Pavement is theoretical minimum value = 0.05"

Assume IA = 0.10 as future average

2. GREEN - AMPT PARAMETERS

USE AGUILA - CABEFREE SCS SOILS SURVEY RPT

a) Soil Units in Watershed

38 - Clay loam
73 - Sandy Clay loam
94 - Sandy Loam

} See Regional Map

b) Subbasin distribution

D.A.	38 %	73 %	94 %	TOTAL	
SAC 230	163.2 (36)	28.5 (6)	260.5 (58)	452.2	0.71 mi²
SAC 235	159.4 (63)	56.0 (22)	36.5 (14)	251.9	0.39 mi²
SAC 240	89.6 (100)			89.6	0.14 mi

DRAFT

Table 4.1
Surface Retention Loss for Various Land Surfaces in Maricopa County

Land-use and/or Surface Cover (1)	Surface Retention Loss IA, Inches (2)	
Natural		
Desert and rangeland, flat slope	0.35	
Hillslopes, Sonoran Desert	0.15	THEOR. MAX
Mountain, with vegetated surface	0.25	
Developed (Residential and Commercial)		
Lawn and turf	0.20	
Desert landscape	0.10	FUTURE
Pavement	0.05	THEOR. MIN.
Agricultural		
Tilled fields and irrigated pasture	0.50	

DRAFT

Infiltration can be controlled by percolation if the soil does not have a sustained drainage capacity to provide access for more infiltrated water. However, before percolation can be assumed to restrict infiltration for the design rainfalls being considered in Maricopa County, the extent by which percolation can restrict infiltration of rainfall should be carefully evaluated. SCS soil scientists have defined hydrologic soil group D as:

> "Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material."

This definition indicates that hydrologic soil groups A, B, or C could be classified as D if a near impervious strata of clay, caliche, or rock is beneath them. When these soils are considered in regard to long-duration rainfalls (the design events for many parts of the United States) this definition may be valid. However, when considered for short-duration and relatively small design rainfall depths in Maricopa County, this definition could result in underestimation of the rainfall losses. This is because even a relatively shallow horizon of soil overlaying an impervious layer still has the ability to store a significant amount of infiltrated rainfall.

For example, consider the situation where only 4 inches of soil covers an impervious layer. If the effective porosity is 0.30, then 1.2 inches (4 inches x 0.30) of water can be infiltrated and stored in the shallow soil horizon. For design rainfalls in Maricopa County, this represents a significant storage volume for infiltrated rainfall and so when developing loss rate parameters for areas of Maricopa County that contain significant areas classified as hydrologic soil group D, the reason for that classification should be determined.

SUBJECT CASANDRO - HYDRO

BY JBF DATE 1/18

SHEET NO. ____ OF ____

PROJECT NO. ____

c) Areal Average of Green-Ampt Parameters

$$\overline{XKSAT} = \text{anti log}\left(\frac{\sum A_i \log XKSAT_i}{A_T}\right)$$

→ Appendix A

UNIT	~~Log XKSAT~~	XKSAT	Log XKSAT
38	~~-1.398~~	0.13	-0.8861
73	~~-1.222~~	0.09	-1.0458
94	~~-0.398~~	.33	-0.4815
		~~0.04~~	~~-1.3979~~

↳ value wrong in FCD Manual

O.A.	$\overline{XKSAT}$	PSIF	DTHETA (normal)
SAC 230	~~0.064~~ ~~0.15~~ .218	~~5.0~~ 5.2	.25
SAC 235	~~0.101~~ ~~0.06~~ .139	~~8.6~~ 6.2	~~.15~~ .23
CAS 240	~~0.084~~ .130	~~9.6~~ 6.4	~~.15~~ .21

(fig. 4-3, p 4-11

d) Vegetative Adjustment to $\overline{XKSAT}$ (fig 4-4, p 4-14)

% Cover = 20%

SAC 230	~~0.17~~ .242	$\overline{XK} \times 1.11$
SAC 235	~~0.07~~ .154	
CAS 240	~~0.04~~ .144	

$$C_k = \frac{V_c - 10}{90} + 1.0 = 1.11$$

e) Impervious Area Estimate

Future Conditions = 35%

PCFCD Manual for 3 RAC (average)

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The three infiltration parameters are functions of soil characteristics, ground surface characteristics, and land management practices. The soil characteristics of interest are particle size distribution (soil texture), organic matter, and bulk density. The primary soil surface characteristics are vegetation canopy cover, ground cover, and soil crusting. The land management practices are identified as various tillages as they result in changes to soil porosity.

Values of Green and Ampt equation parameters as a function of soil characteristics alone (bare ground condition) have been obtained from published reports (Rawls and others, 1983; Rawls and Brakensiek, 1983), and average values of XKSAT and PSIF for each of the soil texture classes are shown in Columns (2) and (3) of Table 4.2. The values of XKSAT and PSIF from Table 4.2 or Figure 4.3 should be used if general soil texture classification of the drainage area is available. References used to create Table 4.2 can be found in the Documentation Manual.

In Table 4.2, loamy sand and sand are combined. The parameter values that are shown in the table are for loamy sand. The hydraulic conductivity (XKSAT) for sand is often used as 4.6 inches/hour, and the capillary suction (PSIF) is often used as 1.9 inches. Using those parameter values for drainage areas can result in the generation of no rainfall excess—which may or may not be correct. Incorrect results could cause serious consequences for flood control planning and design. Therefore, it is recommended that—for watersheds consisting of relatively small subareas of sand—the Green and Ampt parameter values for loamy sand be used for the sand portion of the watershed. If the area contains a large portion of sand, then either the Green and

Table 4.2
Green and Ampt Loss Rate Parameter Values for Bare Ground

Soil Texture Classification (1)	XKSAT inches/hour (2)	PSIF inches (3)	DTHETA[1]		
			Dry (4)	Normal (5)	Saturated (6)
loamy sand & sand	1.2	2.4	0.35	0.30	0
sandy loam	0.40	4.3	0.35	0.25	0
loam	0.25	3.5	0.35	0.25	0
silty loam	0.15	6.6	0.40	0.25	0
silt	0.10	7.5	0.35	0.15	0
sandy clay loam	0.06	8.6	0.25	0.15	0
clay loam	0.04	8.2	0.25	0.15	0
silty clay loam	0.04	10.8	0.30	0.15	0
sandy clay	0.02	9.4	0.20	0.10	0
silty clay	0.02	11.5	0.20	0.10	0
clay	0.01	12.4	0.15	0.05	0

[1] Selection of DTHETA:
Dry = Nonirrigated lands, such as desert and rangeland;
Normal = Irrigated lawn, turf, and permanent pasture;
Saturated = Irrigated agricultural land.

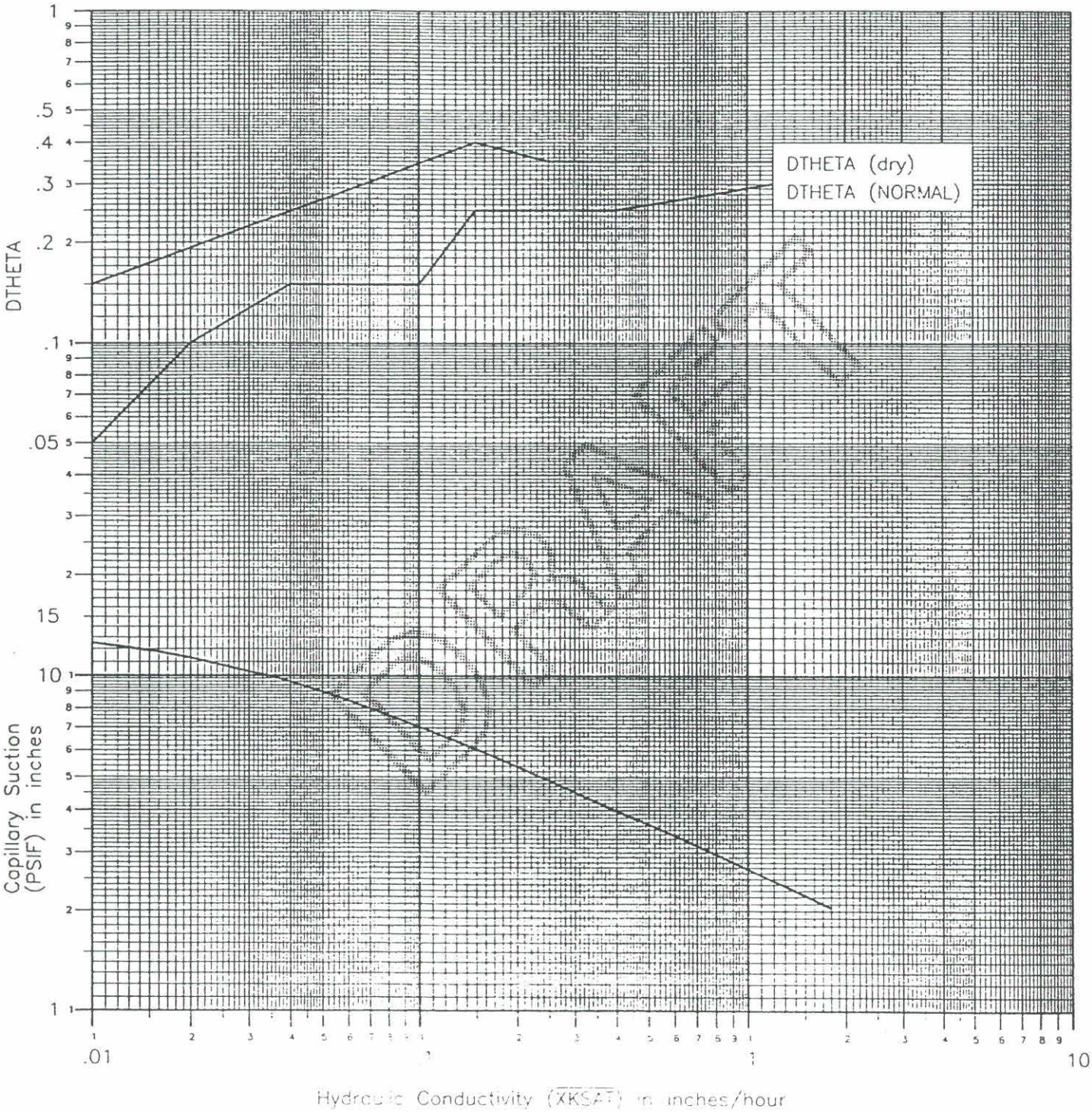

Figure 4.3
Composite Values of PSIF and DTHETA as a function of XKSAT
(To be used for area-weighted averaging of Green and Ampt parameters.)

Map Unit No.	Soil Name	USDA Soil Texture	% of Map Unit	Control Horizon Depth, Inches	Table 4.2 Textural Class	XKSAT, inch/ hour
29, 30	Denure	Fine Sandy Loam	40	0-2	Loam	0.34
	Momoli	Gravelly Sandy Loam	30	0-10	Sandy Loam	
	Carrizo	Gravelly Sandy Loam	20	0-10	Sandy Loam	
	Gilman		3.33		Loam	
	Maripo		3.33		Sandy Loam	
	Carrizo		3.33		Loamy Sand	
31, 32	Dixaleta	Extremely Cobbly Sandy Loam	85	1-8	Sandy Loam	0.33
	Rock Outcrop		35		—	
	Ohaco		2.5		Clay Loam	
	Nickel		2.5		Sandy Loam	
	Cave		2.5		Loam	
	Eba		2.5		Sandy Loam	
	Gran		2.5		Clay Loam	
	Lehmans		2.5		Clay Loam	
33, 34, 35	Eba	Very Gravelly Loam	80	0-3	Sandy Loam	0.23
	Pinalena		10		Sandy Clay Loam	
	Continental		10		Clay	
36	Eba	Very Gravelly Loam	45	(0-3)	Sandy Loam	0.07
	Continental	Clay	35	(1-60)	Clay	
	Ohaco		5		Clay Loam	
	Pinaleno		5		Sandy Clay Loam	
	Sun City		5		Sandy Clay Loam	
	Tres Hermanos		5		Clay Loam	
37, 38	Eba	Very Gravelly Loam	40	(0-3)	Sandy Loam	0.13
	Continental	Clay	25	(1-60)	Clay	ok
	Cave	Loam	20	(1-14)	Loam	
	Anthony		2.5		Sandy Loam	
	Arizo		2.5		Loamy Sand	
	Greyeagle		2.5		Sandy Loam	
	Ohaco		2.5		Clay Loam	
	Nickel		2.5		Sandy Loam	
	Pinaleno		2.5		Sandy Clay Loam	
39	Eba	Very Gravelly Loam	30	0-3	Sandy Loam	0.29
	Nickel	Gravelly Loam	25	1-10	Sandy Loam	
	Cave	Loam	25	1-14	Loam	
	Arizo		4		Loamy Sand	
	Pinaleno		4		Sandy Clay Loam	
	Sun City		4		Sandy Clay Loam	
	Greyeagle		4		Sandy Loam	
	Ohaco		4		Clay Loam	

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Map Unit No.	Soil Name	USDA Soil Texture	% of Map Unit	Control Horizon Depth, Inches	Table 4.2 Textural Class	XKSAT, Inch/ hour
70, 71	Gunsight	Very Gravelly Loam	40	0-11	Sandy Loam	0.36
	Rillito	Gravelly Loam	40	0-12	Sandy Loam	
	Carrizo		2.22		Loamy Sand	
	Chuckawalla		2.22		Silt	
	Ebon		2.22		Clay Loam	
	Mohall		2.22		Loam	
	Pinamt		2.22		Silt	
	Tremant		2.22		Sandy Loam	
	Cipriano		2.22		Sandy Loam	
	Antho		2.22		Sandy Loam	
	Gilman		2.22		Loam	
72, 73	Lehmans	Clay Loam	64	0-2	Clay Loam	0.09 ok
	Rock Outcrop		30		—	
	Arizo		7.2		Loamy Sand	
	Eba		7.2		Sandy Loam	
	Pinaleno		7.2		Sandy Clay Loam	
	Greyeagle		7.2		Sandy Loam	
	Nickel		7.2		Sandy Loam	
74	Luke	Very Gravelly Clay	45	1-28	Silty Clay	0.08
	Cipriano	Very Gravelly Loam	35	0-6	Sandy Loam	
	Beardsley		2.857		Clay	
	Contine		2.857		Clay Loam	
	Ebon		2.857		Silty Clay Loam	
	Pinamt		2.857		Silt	
	Sun City		2.857		Sandy Clay Loam	
	Gunsight		2.857		Loamy Sand	
	Carrizo		2.857		Loamy Sand	
75	Mohall	Loam	80	0-7	Loam	0.23
	Gilman		5		Loam	
	Glenbar		5		Loam	
	Contine		5		Clay Loam	
	Tremont		5		Sandy Loam	
76	Mohall	Loam	80	0-7	Loam	0.23
	Contine		3.33		Clay Loam	
	Mohall		3.33		Clay Loam	
	Tremant		3.33		Sandy Loam	
	Antho		3.33		Sandy Loam	
	Estrella		3.33		Loam	
	Valencia		3.33		Sandy Loam	

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Map Unit No.	Soil Name	USDA Soil Texture	% of Map Unit	Control Horizon Depth, Inches	Table 4.2 Textural Class	XKSAT, inch/hour
86	Mohave	Clay Loam	85	2-15	Clay Loam	0.05
	Anthony		3		Sandy Loam	
	Gila		3		Loam	
	Tres Hermanos		3		Clay Loam	
	Mohave		3		Loam	
	Continental		3		Clay	
87	Mohave	Clay Loam	45	2-11	Clay Loam	0.04
	Mohave	Clay Loam	40	2-5	Clay Loam	
	Mohave		15		Clay Loam	
88	Mohave	Clay Loam	45	2-11	Clay Loam	0.02
	Guest	Clay	40	2-60	Clay	
	Mohave		7.5		Loam	
	Continental		7.5		Clay	
89	Mohave	Clay Loam	50	2-11	Clay Loam	0.06
	Tres Hermanos	Gravelly Clay Loam	30	2-20	Sandy Clay Loam	
	Arizo		5		Loamy Sand	
	Anthony		5		Sandy Loam	
	Continental		5		Clay	
	Pinaleno		5		Sandy Clay Loam	
90	Momoli	Gravelly Sandy Loam	70	0-3	Sandy Loam	0.39
	Carrizo		7.5		Loamy Sand	
	Maripo		7.5		Sandy Loam	
	Pinamt		7.5		Silt	
	Denure		7.5		Sandy Loam	
91, 92	Momoli	Very Gravelly Sandy Loam	45	1-60	Loamy Sand	0.93
	Carrizo	Very Gravelly Sandy Loam	35	0-11	Loamy Sand	
	Mohall		2.5		Loam	
	Tremant		2.5		Sandy Loam	
	Gunsight		2.5		Loamy Sand	
	Chuckawalla		2.5		Silt	
	Denure		2.5		Sandy Loam	
	Gilman		2.5		Loam	
	Maripo		2.5		Sandy Loam	
	Carrizo		2.5		Sandy Loam	
93, 94	Nickel	Gravelly Loam	50	1-10	Sandy Loam	~~0.04~~
	Cave	Loam	35	1-14	Loam	.33 should be
	Arizo		3.75		Loamy Sand	
	Anthony		3.75		Sandy Loam	
	Pinaleno		3.75		Sandy Clay Loam	
	Greyeagle		3.75		Sandy Loam	

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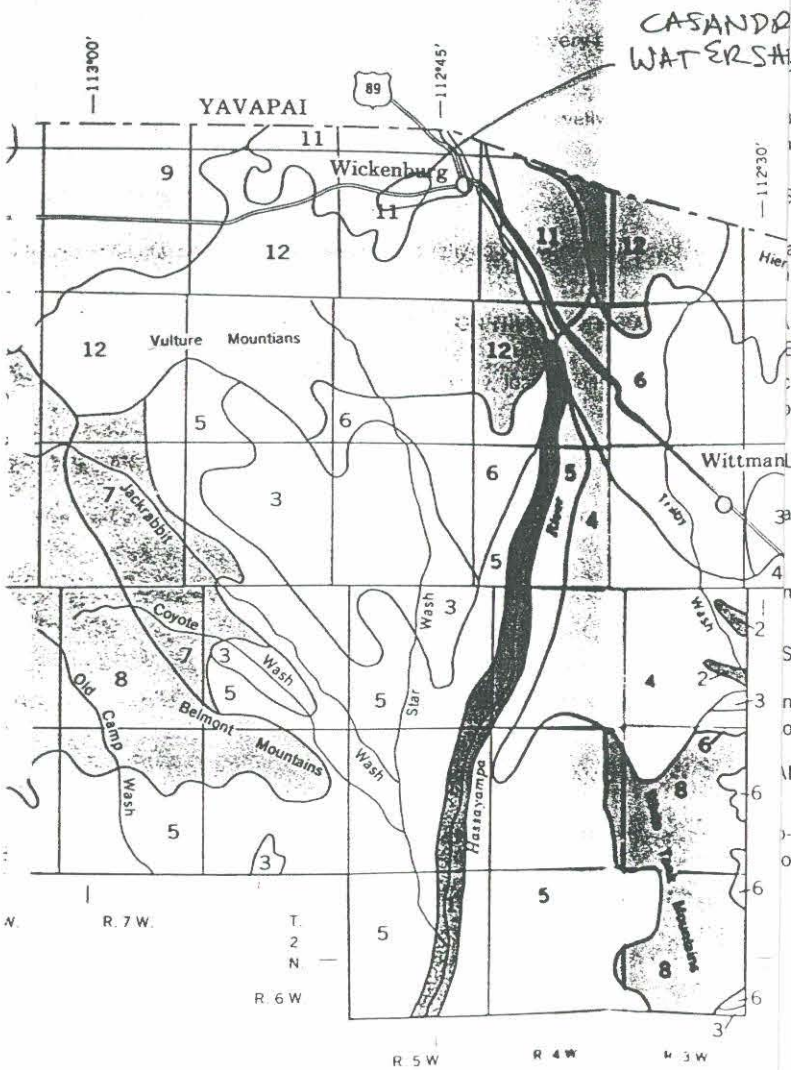
SHEET 24



LEGEND

M SOILS; ON FLOOD PLAINS AND ALLUVIAL FANS

vel and gently sloping, occasionally flooded, very gravelly, sandy soils; on flood plai

vel, rarely flooded, loamy soils; on flood plains and alluvial fans

M SOILS; ON FAN TERRACES

nure: Nearly level, nongravelly to very gravelly, loamy and sandy soils; on fan te

early level and gently sloping, loamy and clayey soils; on fan terraces

uckawalla: Dominantly gently sloping to moderately steep, gravelly and very grav
es

mt: Dominantly gently sloping to moderately steep, gravelly and very gravelly, loa
terraces

SHALLOW, AND DEEP, VERY WARM SOILS; ON FAN TERRACES

arefree: Nearly level and gently sloping, cobbly and nongravelly to very gravelly, c
terraces

ND SHALLOW, VERY WARM SOILS, AND ROCK OUTCROP; ON HILL SLOPES A
ES

crop-Quilotosa: Dominantly strongly sloping to steep, very gravelly, loamy soils, an
pes and mountain slopes

LS; ON FAN TERRACES AND FLOOD PLAINS

al-Guest: Nearly level and gently sloping, clayey and loamy soils; on fan terraces a

minantly gently sloping to moderately steep, very gravelly, clayey and loamy soils;

SHALLOW, AND DEEP, WARM SOILS; ON FAN TERRACES

ntal-Nickel: Dominantly gently sloping to moderately steep, nongravelly and very g
oils; on fan terraces

ND SHALLOW, WARM SOILS, AND ROCK OUTCROP; ON HILL SLOPES AND M

-Lehmans: Dominantly moderately steep and steep, nongravelly and very gravelly
ock outcrop; on hill slopes and mountain slopes

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

U.S. DEPARTMENT OF INTERIOR
BUREAU OF INDIAN AFFAIRS
BUREAU OF LAND MANAGEMENT

ARIZONA AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP

AGUILA-CAREFREE AREA
PARTS OF MARICOPA AND PINAL COUNTIES
ARIZONA

Scale 1:506,880

2 0 2 4 6 8 Miles

2 0 4 8 12 16 Km

SHEET 26

Ground cover, such as grass, litter, and rock will generally increase the infiltration rate over that of bare ground conditions. Similarly, canopy cover—such as from trees, brush, and tall grasses—can also increase the bare ground infiltration rate. The procedures and data that are presented are for estimating the Green and Ampt parameters based solely on soil texture and would be applicable for bare ground conditions. Past research has shown that the wetting front capillary suction parameter (PSIF) is relatively insensitive in comparison with the hydraulic conductivity parameter (XKSAT); therefore only the hydraulic conductivity parameter is adjusted for the influences of cover over bare ground.

Procedures have been developed (Rawls and others, 1989) for incorporating the effects of soil crusting, ground cover, and canopy cover into the estimation of hydraulic conductivity for the Green and Ampt equation; however, those procedures are not recommended for use in Maricopa County at this time. A simplified procedure to adjust the bare ground hydraulic conductivity for vegetation cover is shown in Figure 4.3. This figure is based on the documented increase in hydraulic

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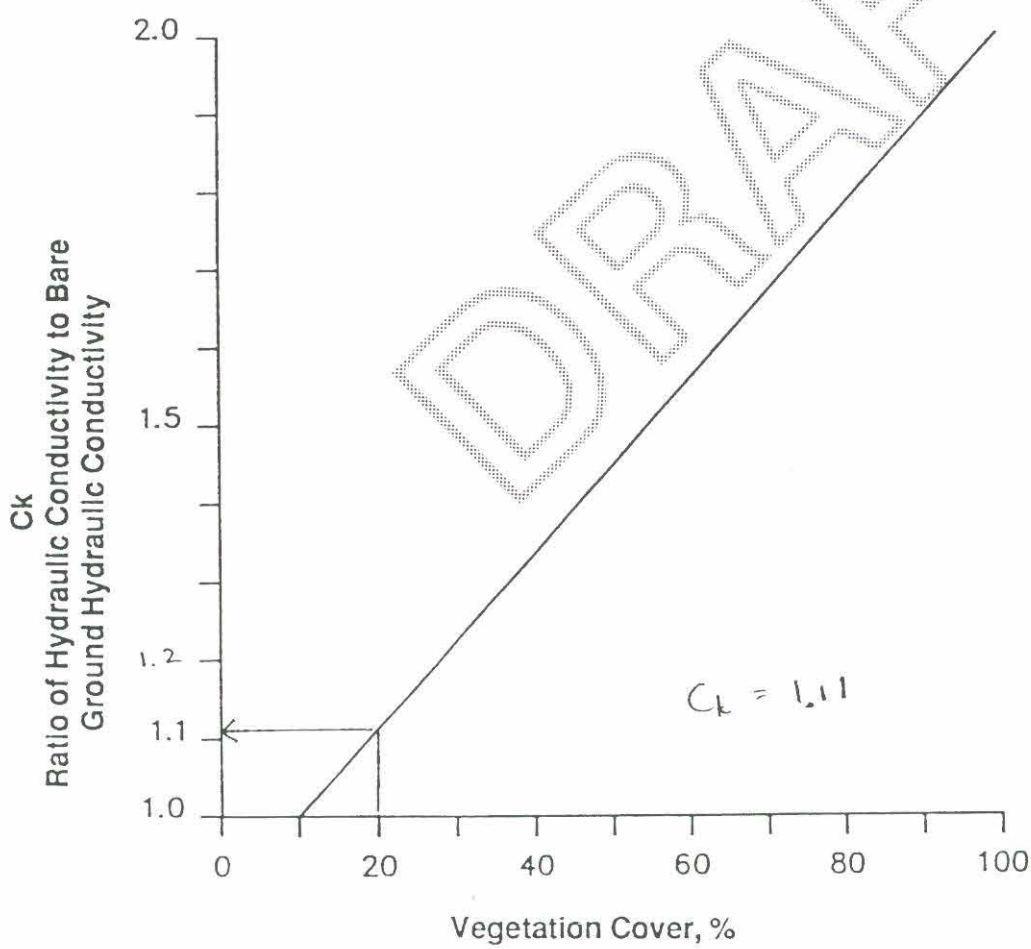

Figure 4.3
Effect of Vegetation Cover on Hydraulic Conductivity
For Hydraulic Soil Groups B, C, and D, and for all Soil Textures
other than Sand and Loamy Sand

SUBJECT CARMINDO - HYDROL

BY JBF DATE 1/17

SHEET NO. 29 OF

PROJECT NO. SWW35441

C. UNIT HYDROGRAPH - USE CLARK UHG

LIMITATIONS

1. D.A. < 5 mi² OK

(1) TIME OF CONCENTRATION (eq'n 5.5. p 64)

$$T_c = 11.4\, L^{0.50}\, k_b^{0.52}\, S^{-0.31}\, i^{-0.38}$$

T_c = hours

L = length flow path (miles)

k_b = resistance coef.

S = ft/mile slope

i = excess intensity in/hr

D.A.	L	k_b	S	i
SAC 230	2.4	.040	137.5	—
SAC 235	2.0	.035	137.0	—
[CAS 240]	0.9	.035	139.9	—

REPORTED BY FLOWC HYDROLOGY (S-GRAPH)

	SAC 230	SAC 235	~~SAC~~ CAS 240
L (mi) :	2.32	1.95	0.57
k_b :	~~0.15~~ ~~0.057~~ 0.023	~~0.15~~ 0.025	~~0.15~~ 0.028

↳ ~~Hillslopes/Alluvial fans, D.A < 1 mi² (Sheet 31)~~ Table 5.1, Residential Areas

$k_b = m \log(D.A) + b$ m = -0.00625 b = 0.04

S,	max elev:	2520	2441	2250 ~~2200~~
	min elev:	2200	2200	2134
	S:	138	124	204
	Adjusted S: (Fig 5.4)	~~135~~	~~120~~	200

- Sheet 30

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Table 5.1
Equation for Estimating K_b in the Tc Equation

$K_b = m \log A + b$ Where A is drainage area, in acres				
Type	Description	Typical Applications	Equation Parameters	
			m	b
A	Minimal roughness: Relatively smooth and/or well graded and uniform land surfaces. Surface runoff is sheet flow.	Commercial/ industrial areas Residential area Parks and golf courses	–0.00625	0.04
B	Moderately low roughness: Land surfaces have irregularly spaced roughness elements that protrude from the surface but the overall character of the surface is relatively uniform. Surface runoff is predominately sheet flow around the roughness elements.	Agricultural fields Pastures Desert rangelands Undeveloped urban lands	–0.01375	0.08
C	Moderately high roughness: Land surfaces that have significant large- to medium-sized roughness elements and/or poorly graded land surfaces that cause the flow to be diverted around the roughness elements. Surface runoff is sheet flow for short distances draining into meandering drainage paths.	Hillslopes Brushy alluvial fans Hilly rangeland Disturbed land, mining, etc. Forests with underbrush	–0.025	0.15
D	Maximum roughness: Rough land surfaces with torturous flow paths. Surface runoff is concentrated in numerous short flow paths that are often oblique to the main flow direction.	Mountains Some wetlands	–0.030	0.20

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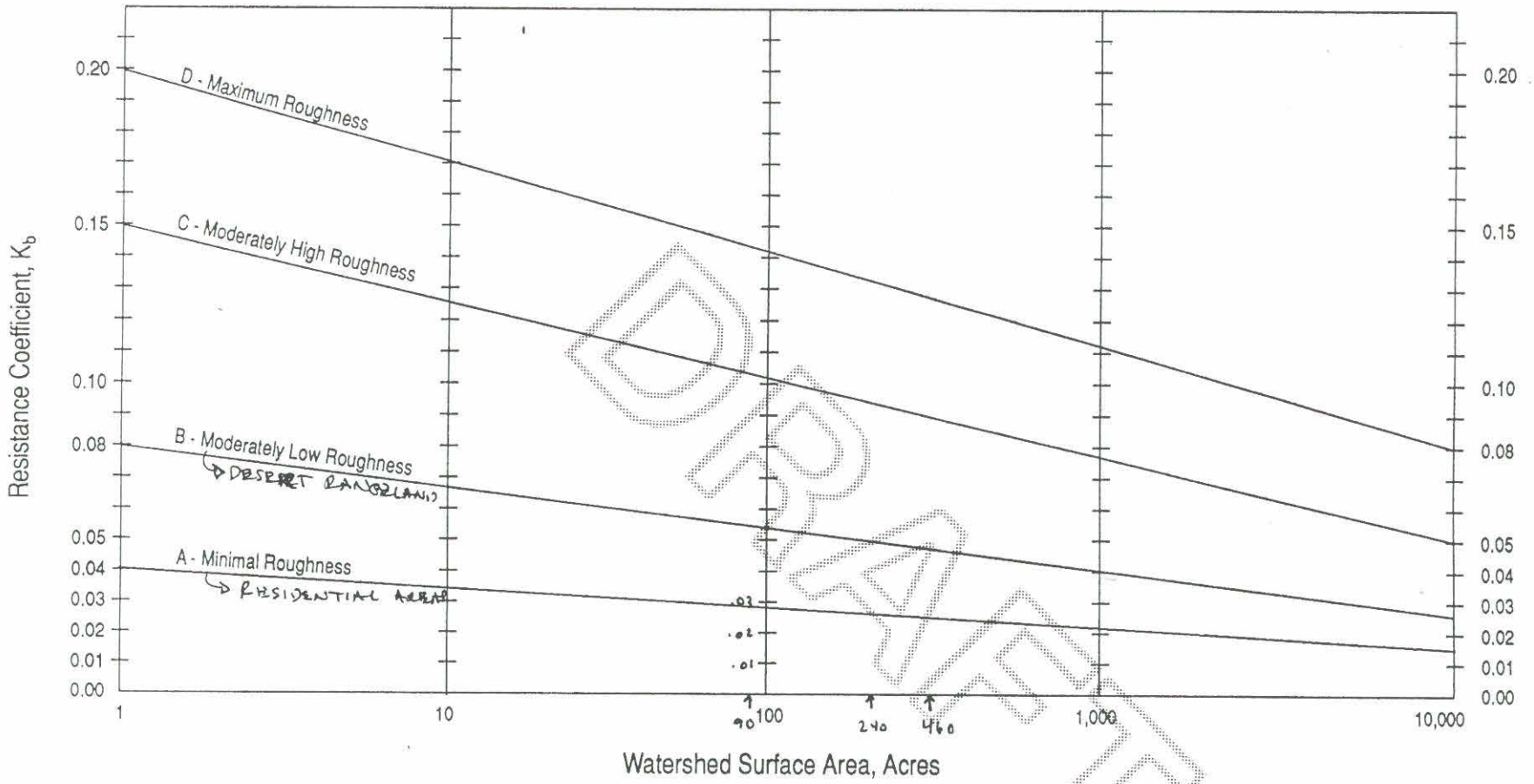

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Figure 5.5

Resistance Coefficient "K_b" as a Function of Watershed Size and Surface Roughness Characteristics

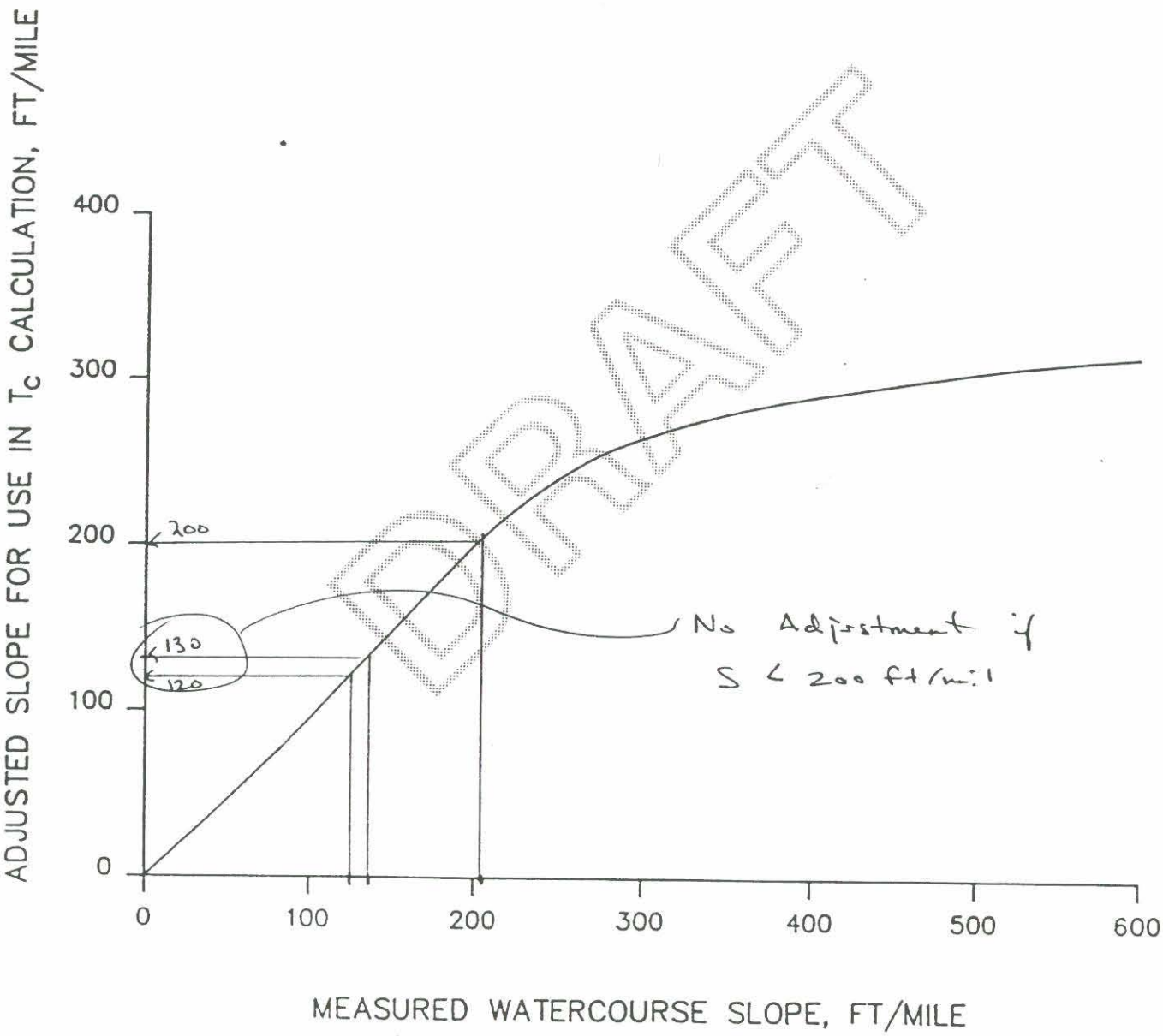

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Figure 5.4
Slope Adjustment for Steep Watercourses in Natural Watersheds
(Source: *Drainage Criteria Manual*, Urban Drainage and Flood Control District, Colorado, May 1984.)

Table 5.2
Values of the Synthetic Dimensionless Time-Area Relations for the Clark Unit Hydrograph

Time, as a percent of Time of Concentration (1)	Contributing Area, as a Percent of Total Area		
	Urban Watersheds (2)	Natural Watersheds (3)	HEC-1 Default (4)
0	0	0	0.0
10	5	3	4.5
20	16	5	12.6
30	30	8	23.2
40	65	12	35.8
50	77	20	50.0
60	84	43	64.2
70	90	75	76.8
80	94	90	87.4
90	97	96	95.5
100	100	100	100.0

USB

NATURAL defined as "Undeveloped"

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5.6 S-Graphs

An S-graph is a dimensionless form of a unit hydrograph and it can be used in the place of a unit hydrograph in performing flood hydrology studies. The concept of the S-graph dates back to the development of the unit hydrograph itself, although the application of S-graphs has not been as widely practiced as that of the unit hydrograph. The use of S-graphs has been practiced mainly by the U.S. Army Corps of Engineers, Los Angeles District, and the U.S. Bureau of Reclamation (USBR).

An example of an S-graph from Design of Small Dams (USBR, 1987) is shown in Figure 5.8. The discharge scale is expressed as percent of ultimate discharge (Qult), and the time scale is expressed as percent lag. Lag is defined as the elapsed time, usually in hours, from the beginning of an assumed continuous series of unit rainfall excess increments over the entire watershed to the instant when the rate of resulting runoff equals 50 percent of the ultimate discharge. The intensity of rainfall excess is 1 inch per duration of computation interval (Δt). An equivalent definition of lag is the time for 50 percent of the total volume of runoff of a unit hydrograph to occur. It is to be noted that there are numerous definitions for lag in hydrology and the S-graph lag should not be calculated by methods that are not consistent with this definition.

Ultimate discharge is the maximum discharge that would be achieved from a particular watershed when subjected to a continuous intensity of rainfall excess of

SUBJECT CASANDRA – HYDROL

BY DEF DATE 1/18

SHEET NO. ___ OF ___

PROJECT NO. ___

C. UNIT HYDROGRAPH – CLARK UHG

USE MCUHP1 PROGRAM

	O.A. (mi²)	L (mi)	K_b	S (ft/mi)	IA	DTHETA	PSIF	KSAT	RTIMP
SAC 230	0.72	2.4	.038 ~~0.023~~	136	0.10	.25	5.2 ~~6.0~~	0.24 ~~0.19~~	35
SAC 235	0.38	2.0	.044 ~~0.025~~	124	0.10	.23 ~~.15~~	6.2 ~~8.6~~	0.15 ~~0.07~~	36 ~~36~~
CAS 240	0.14	0.9	.051 ~~0.028~~	200*	0.10	.21 ~~.15~~	6.4 ~~9.6~~	0.14 ~~0.04~~	21 ~~35~~

↑ Adjusted (>200 ft/mi)

$P_{6HR,100YR}$ = 3.40 (NOT AERIALLY REDUCED)

URBAN BASIN (incl. residential)

OUTPUT FILE P:/SWW3544.1/HY/CAS100G.OUT (in HC1 format)

	DA mi²	(AC)
230	.72	461
235	.38	243
240	.14	90

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SUBJECT CASANDRO WASH

BY JRF DATE 1/21

SHEET NO. ___ OF ___

PROJECT NO. ___

K_b factor weighting

Use Wickenburg Zoning map & FCDMC % Impervious Classification

a) for ≥60% impervious - Curve A

b) for <60% impervious - Curve B

BASIN A	≥60%	<60%	D.A.
230	24%	76%	461
235	14%	86%	243
240	6%	94%	9
	↑	↑	
	Curve A	Curve B	

$K_b = m \log A + b$

m	-.00625	~~-.04~~ -.01375	
b	~~.01375~~ .04	~~.04~~ .08	
	K_b	K_b	Wt'd Kb
230	.023	.043	.038
235	.025	.047	.044
240	.027	.053	.051

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CH2M HILL

SUBJECT

BY DATE

SHEET NO. OF

PROJECT NO.

19.1 0

0%

0

0

22 0

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WEIGHTED	PERCENT	IMPERVIOUSNESS
230	.346	= 35%
235	.362	= 36%
210	.307	21%

1 pes for Estimation of Imperviousness

	Tempe Zoning Unit	Tempe Description	County Zoning Unit	County Description	Phoenix Zoning Unit	Phoenix Description	Cave Creek FIS % Imp. Area (including R.O.W.
	AG	Agriculture					
			RURAL-190	190,000 sq. ft./dwelling unit	S-1	Ranch or Farm Residential, > 1 acre	15
			RURAL-70	70,000 sq. ft./dwelling unit	S-2	Ranch or Farm Commercial	18
			RURAL-43	one acre/dwelling unit	RE-43	Single Family, 1 acre minimum	20
			R1-35	Single Family Residential,	RE-35	SF, 35,000 sq.ft min.	22
				35,000 sq. ft./dwelling unit	RE-24	SF, 24,000 sq.ft min.	25
			R1-18	SFR, 18,000 sq. ft./unit	R1-18	SF, 18,000 sq.ft min.	25
	R1-15	One Family Residential			R1-14	SF, 14,000 sq.ft min.	30
	R1-10	One Family Residential	R1-10	SFR, 10,000 sq. ft./unit	R1-10	SF, 10,000 sq.ft min.	38
	R1-8	One Family Residential	R1-8	SFR, 8,000 sq. ft./unit	R1-8	SF, 8,000 sq.ft min.	45
	R1-7	One Family Residential					
	R1-6	One Family Residential	R1-6	SFR, 6,000 sq. ft./unit	R1-6	SF, 6,000 sq.ft min.	50
g Family	RO	Residence/Office			R-O	Res. Office	50
pl. Resid.	R-2	Multi-Family Residential	R-2	2 Family Residence	R-2	MF, 4,000 sq.ft./unit	60
Resid.	R-3R	Multi-Family Restricted	R-3	Multiple Family, Residential	R-3	MF, 3,000 sq.ft./unit	65
Resid.	R-3	Multi-Family Limited	R-4	Multiple Family, Residential	R-4	MF, 1,500 sq.ft./unit	65
	R-4	Multi-Family General	R-5	Multiple Family, Residential	R-4A	MF, 1,000 sq.ft./unit	70
	R-Th	Townhouse			R-5	MF, 1,000 sq.ft./unit	70
Multi-Res.	RMH	Mobile Home Residence	MHR	Manufactured Housing, Resid.	CP/BP	Business Park	65
	MHS	Manufactured Housing Subd.			R-H	Resort District	65
	TP	Trailer Park					
	I-1	Light Industrial			IND PARK	Industrial Park	75
	I-2	General Industrial	I-2	Light Industrial	A-1	Light Industrial	75
	I-3	Heavy Industrial	I-3	Heavy Industrial	A-2	Heavy Industrial	75
	CCR	Convenience Commercial	C-1	Neighborhood Commercial	C-1	Neighborhood Commercial	95
	C-1	Neighborhood Commercial	C-2	Intermediate Commercial	C-2	Intermediate Commercial	95
	C-2	General Commercial	C-3	General Commercial	C-3	General Commercial	95
	CCD	Central Comm. District	C-O	Commercial Office	C-O	Commercial Office	75
fixed Use					HR	High Rise District	85
General Manufacturing							
mm./ Light Manufacturing							
	S	Private School	PD	Planned Development Overlay	PAD	Planned Area Development	85
			CS	Planned Shopping Center	PSC	Planned Shopping Center	85
nt Park							
			SU	Special Uses			
			SC	Senior Citizen Overlay	PCD	Planned Community Development	60
			NUP	Neighborhood Plan of Development			
			RUP	Residential Plan of Development			
			IUP	Industrial Plan of Development			
					R.O.W.	Right of Way	VARIABLE
					P-1	Parking, Open	VARIABLE
					P-2	Parking, Structures	VARIABLE
					D.G	Dwelling Group	85
RR							

DRAFT

Table 4.1 Classification of Zoning Typ

Gilbert-Chandler ADMS Land Use Category	Impervious Area (percent)	Gilbert Zoning Unit	Gilbert Description	Chandler Zoning Unit	Chandler Description	Mesa Zoning Unit	Mesa Description
Agriculture	0	AG	Agriculture	AG-1	Agriculture	AG	Agriculture
Very Low Density Residential	15					R1-90	Single Residence
						SR	Suburban Ranch
		R1-43	Rural				
Low Density Residential	25	R1-35	Rural Residential	SF-33	Single Family	R1-35	Single Residence
		R1-20	SF, Residential	SF-18	Single Family		
		R1-15	" "			R1-15	Single Residence
Medium Density Residential	45	R1-10	" "	SF-10	Single Family	R1-9	Single Residence
		R1-8	" "				
		R1-7	" "	SF-7	Single Family	R1-7	Single Residence
						R1-6	Single Residence
						TCR-1	Town Center. Single Fa
Multiple Family Residential	65	R-2	Duplex	MF-1	Medium Density	R-2	Restricted Multiple Res
		R-3	Multi-Family, Apartments	MF-2	Multi-Family	R-3	Limited Multiple Resid.
		R-4	Multi-Family, General	MF-3	High Density	R-4	General Multiple Resid
		R-5	Townhouse Residential				
		MH	Mobile Home	MH-1	Mobile Homes	TCR-2	TC, Restricted Multi-Re
		CTP	Commercial Trailer Park			TCR-3	TC, General Res.
Industrial	75	I-1	Garden Type Industrial			M-1	Limited Industrial
		I-2	Light Industrial	I-1	Light Industrial		
		I-3	General Industrial	I-2	General Industrial	M-2	General Industrial
Commercial	90	C-1	Light Commercial	C-1	Neighborhood Commercial	C-1	Neighborhood Comm.
		C-2	General Commercial	C-2	Community Commercial	C-2	Limited Comm.
		C-3	Central Commercial	C-3	Regional Comercial	C-3	General Comm.
		RS	Residential Services			OS	Office-Servives
		RCC	Residential Conveniences			TCC	TC,High Intensity Mixe
						TCB-1	TC, Limited Comm./Ge
						TCB-2	TC. General Comm./ Li
		MISCELLANEOUS CATEGORIES: These map units should be evaluated on a case by case basis.					
		PAD	Planned Area Development	PAD	Planned Area Development		
		PSC-1	Planned Neighborhood Shopping				
		PSC-2	Planned Shopping Center				
		IB	Industrial Buffer				
				PCO	Planned C Offices	PEP	Planned Employment P
						PF	Public Facilities
Mixed Use Area	55	Town of Gilbert ONLY – added for future conditions land uses for an area east of the Eastern Canal south of the SPRR					

DRAFT

SUBJECT CASANORO - HYDROL. ROUTING

BY JCF DATE 1/18

SHEET NO. ___ OF ___

PROJECT NO. ___

D. CHANNEL ROUTING

- USE FCDMC ROUTING UNIT, SHORTEN REACH LENGTH TO REFLECT NEW DAM LOCATION

REACH LENGTH = 4200 FT (-200)

E. DIAGRAM WATERSHED

SAC230 ⎤ ADD ——— CONTR ——— Add ⊣ END
SAC235 ⎦ CAS240

F. RUN MODEL

		FCD - DAMB6100.HC1
Q_{100} =	~~2108~~ 1769 CFS	1416
Vol_{100} =	~~152~~ 149 AF	112 AF

G. ADD DAM - PLANIMETER 2-FT CONTOURS & ENTER ON SA, SE, SV RECORDS

MAX STORAGE ELEVATION - 2160.3 - NO OUTFLOW

2159.7 - APPROX OUTFLOW = 30 CFS

DRAFT

CH2M HILL

SUBJECT CAMANDRO WASH
PROPOSED RESERVOIR SURFACE AREAS
- SUMMARY TABLE -

BY K. BRADFORD DATE 1-20-96
SHEET NO. 1 OF 2
PROJECT NO. SWW 25411.GT.10

ELEV. (ft)	WATER SURFACE AREA (ac.)
2136	0.01
2138	0.06
2140	0.12
2142	3.95
2144	5.31
2146	6.15
2148	6.60
2150	7.45
2152	8.23
2154	9.57
2156	10.79
2158	11.37
2160	12.92

DRAFT

CH2M HILL

SUBJECT _____

- RAW DATA -

BY _____ DATE _____

SHEET NO. 2 OF 2

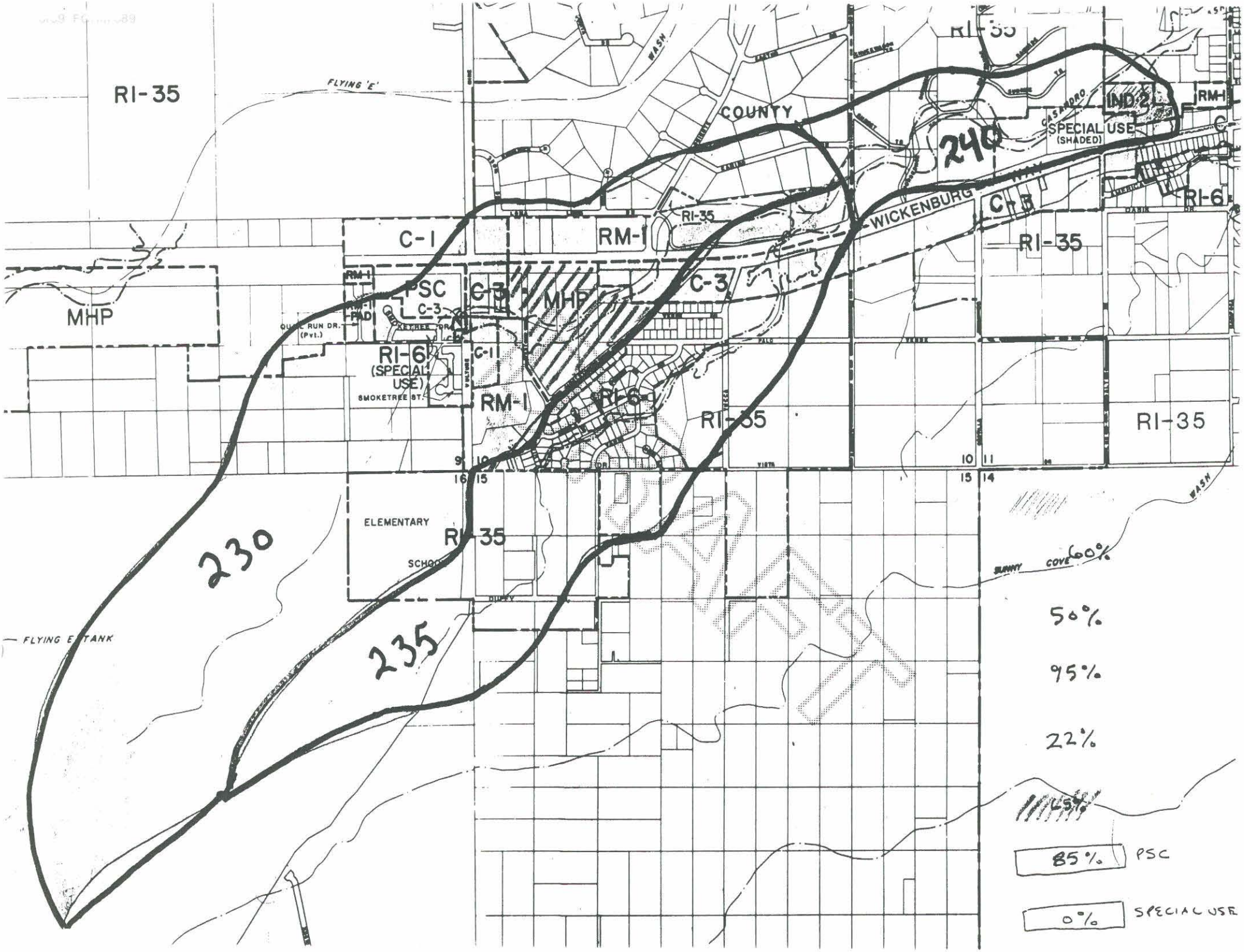
PROJECT NO. _____

SCALE: 1" = 40'

ELEV (FT)	PLANIMETER AREA (IN²)*	SURFACE AREA (acres)
2136.0	5.34	[illegible]
2138.0	1.61	[illegible]
2140.0	5.31	[illegible]
2142.0	107.55	[illegible]
2144.0	[illegible]	[illegible]
2146.0	[illegible]	[illegible]
2148.0	[illegible]	[illegible]
2150.0	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

DRAFT

SAJ 175
SAJ 215
SAC 230
SAC 235
SAC 240
Wickenburg
Wash
VULTURE
38
94
73
7
9
Contracted
6/C/D
38 - D
73 -
94 - B/D


RI-35
FLYING 'E'
COUNTY
WASH
RI-35
IND-2
RM-1
SPECIAL USE
(SHADED)
240
WICKENBURG
C-3
RI-6
RI-35
C-1
RM-1
RI-35
MHP
RM-1
PSC
C-3
C-3
MHP
C-3
QUAIL RUN DR.
(Pvt.)
RI-6
(SPECIAL
USE)
SMOKETREE ST.
C-1
RM-1
RI-6
RI-35
RI-35
9
10
10
11
16
15
15
14
ELEMENTARY
SCHOOL
RI-35
230
235
FLYING E TANK
WASH
SUNNY COVE
60%
50%
95%
22%
15%
85%
PSC
0%
SPECIAL USE

175
SAJ 215
Wickenburg
SAC 240
SAC 230
SAC 235
Wash
VULTURE
MINE
Cemetery
Turtleback
40' CI

Earthwork

CASANDRO WASH DAM
EARTHWORK COMPS.

6-2-94
SWW35441.PS

DAM CUT AND FILLS

STA	DIST FT	CUT AREA SQ FT	VOLUME CU YD	FILL AREA SQ FT	VOLUME CU YD
0		0		480	
	100		0.00		4870.37
100		0		2150	
	75		0.00		7652.78
175		0		3360	
	0		0.00		0.00
175		0		2420	
	85		0.00		7429.63
260		0		2300	
	0		0.00		0.00
260		0		3440	
	40		0.00		4548.15
300		0		2700	
	100		0.00		8351.85
400		0		1810	
	100		0.00		4648.15
500		0		700	
	100		333.33		1759.26
600		180		250	
	100		740.74		1111.11
700		220		350	
	100		407.41		1944.44
800		0		700	
TOTAL DAM			1,481		42,316

× 1.15
48663

TOT CUT = 62,017 cy

TOT COMP. FILL = 62,173 cy

DRAFT

RESERVOIR CUT AND FILLS

STA	DIST FT	CUT AREA SQ FT	VOLUME CU YD	FILL AREA SQ FT	VOLUME CU YD
0		108.5		2520	
	100		4391.67		5429.62963
100		2263		412	
	100		10394.44		1837.037037
200		3350		580	
	100		12962.96		1148.148148
300		3650		40	
	100		11101.85		601.8518519
400		2345		285	
	100		9083.33		870.3703704
500		2560		185	
	100		8629.63		861.1111111
600		2100		280	
	100		3972.22		1000
700		45		260	
TOTAL RESERVOIR =			60,536		11,748

x 1.15

13510 CY

DRAFT

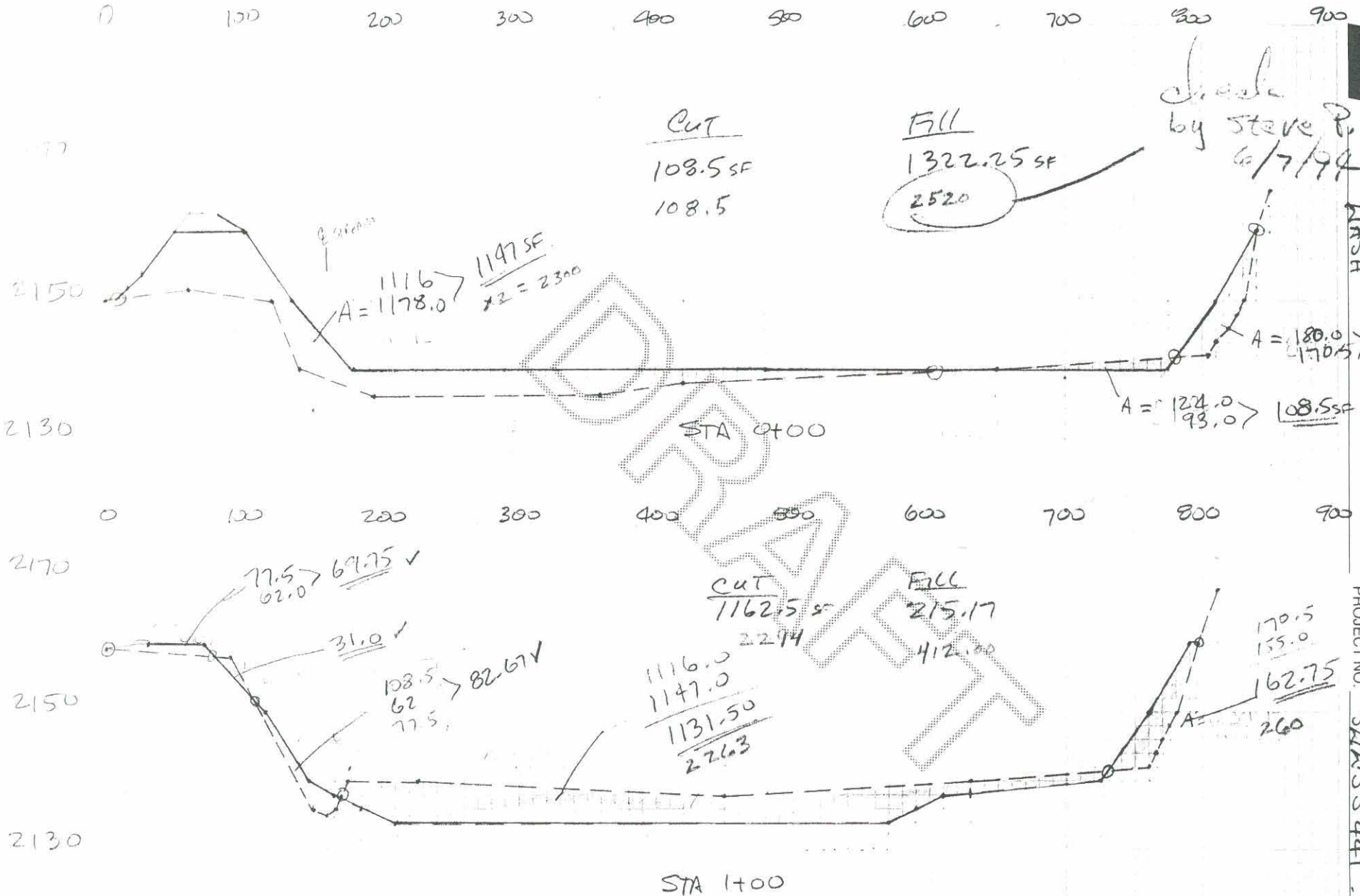
CKM HILL

SUBJECT SASANDRO WASH

BY W. PAIR

SHEET NO. 1 of 4 DATE 6-2-94

PROJECT NO. SAW35441.P5



DRAFT

CH2M HILL

SUBJECT CASANDRO WASH DAM

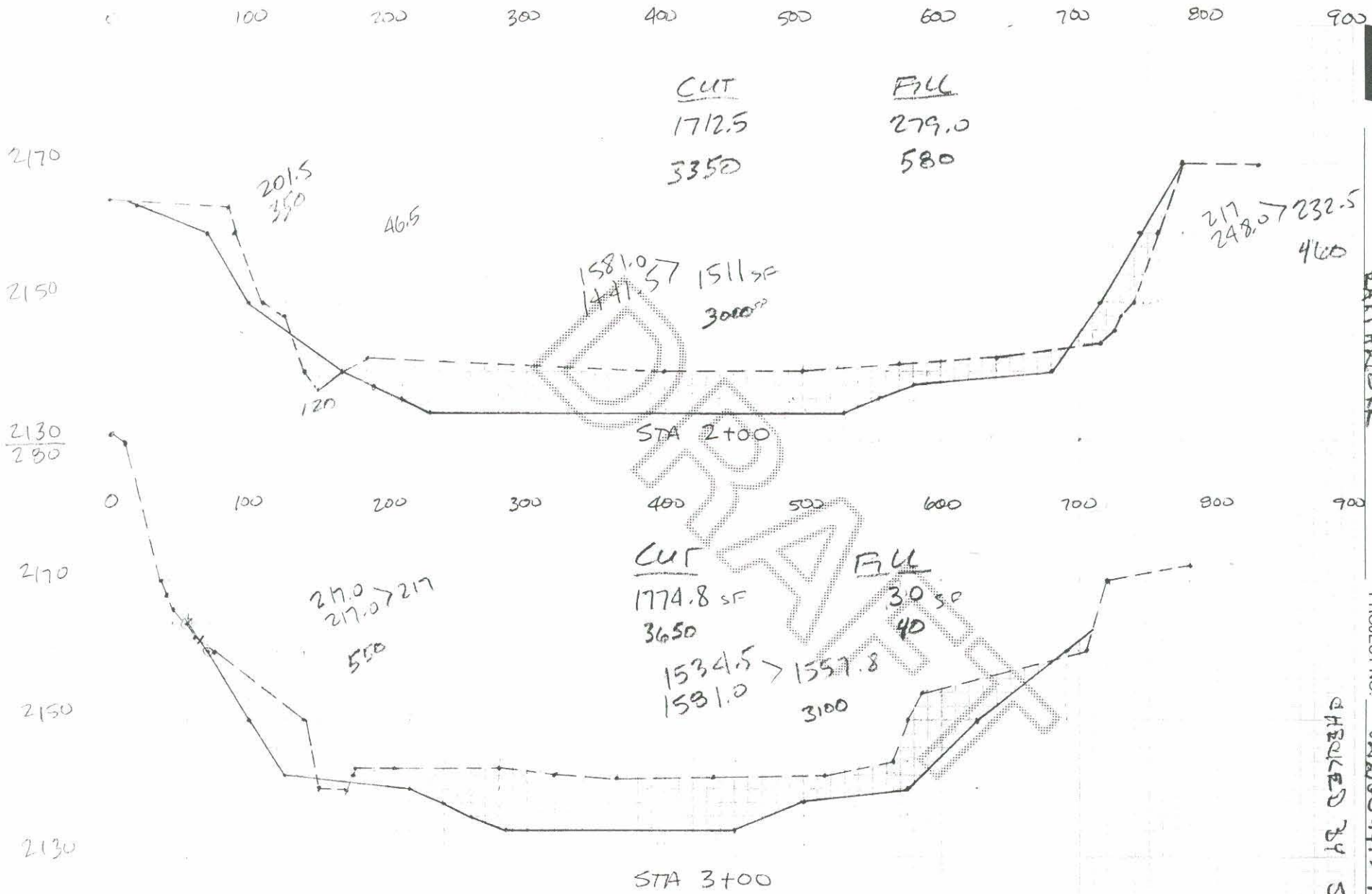
EAST HILLSIDE

BY W. DAIZ

SHEET NO. 2 of 4 DATE 6-2-94

PROJECT NO. 544/55441.P5

CHECKED BY STEVE P.

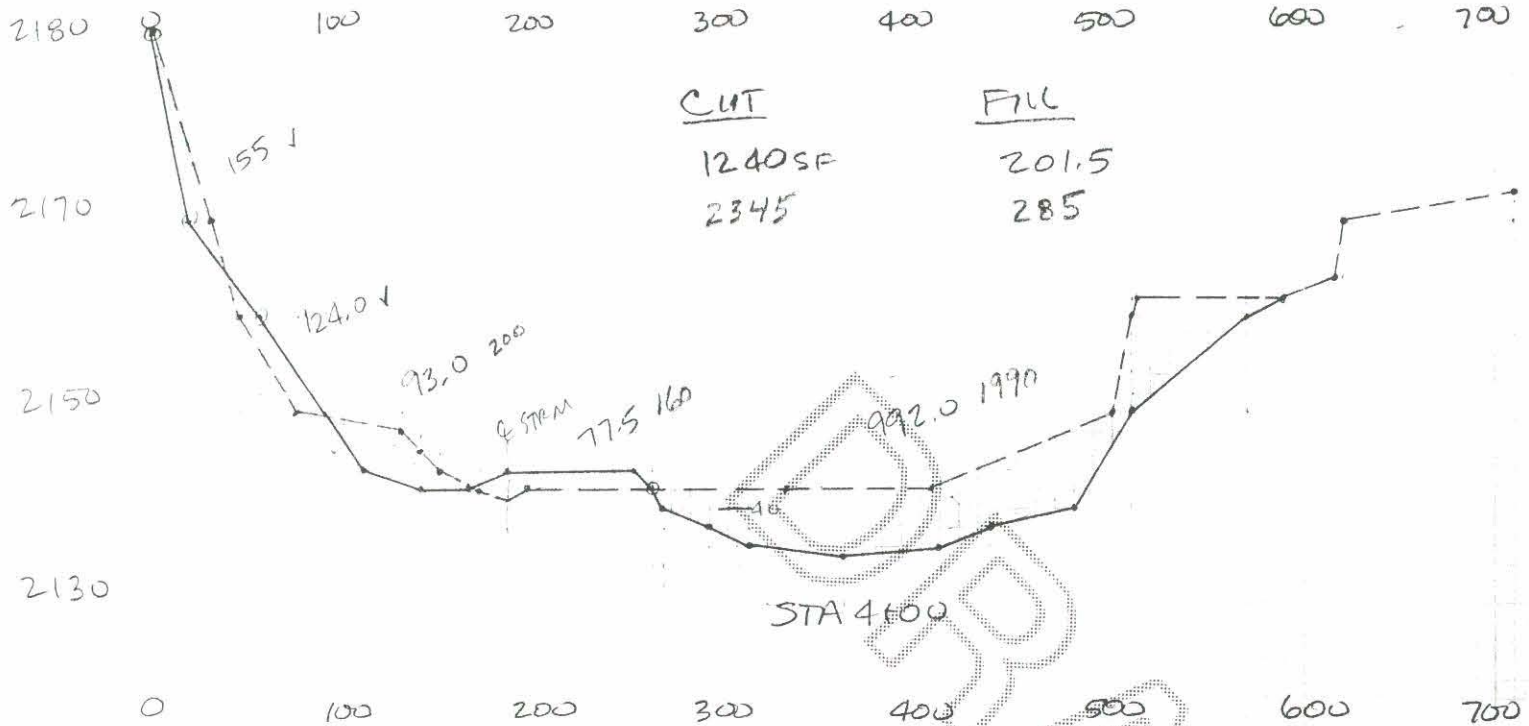


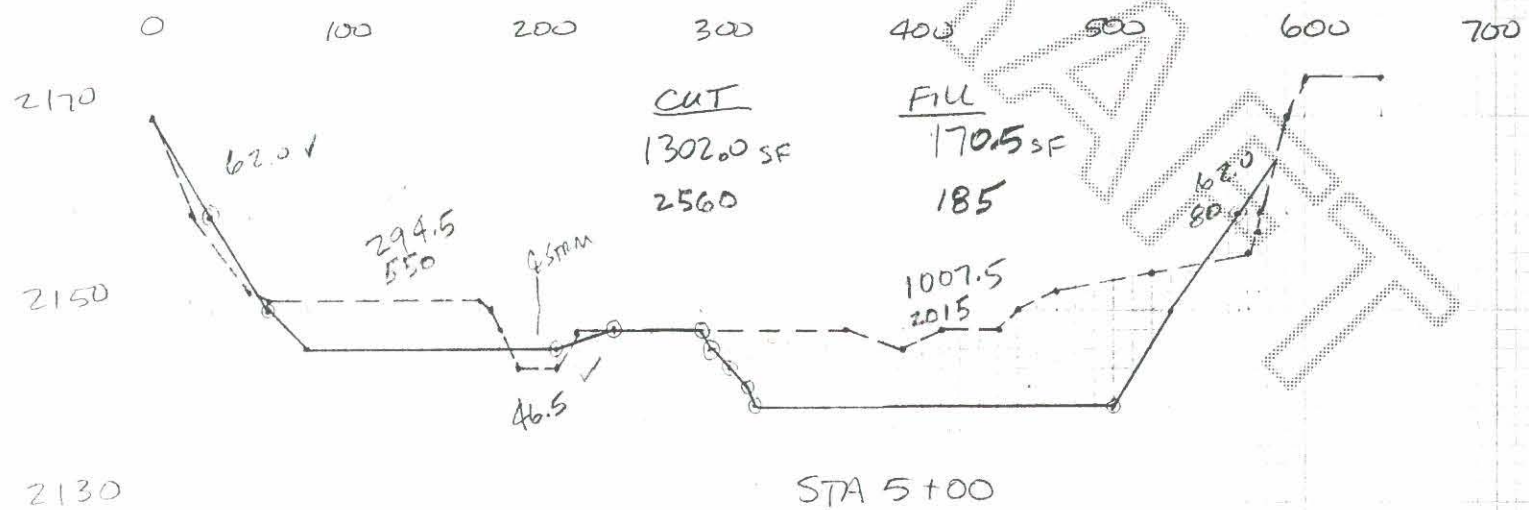
DRAFT

CH2M HILL

SUBJECT: CASANDRA WASH DAM
EARTH WORK

BY: W. PAIZ
SHEET NO. 3 of 4
DATE 6-2-94
PROJECT NO.





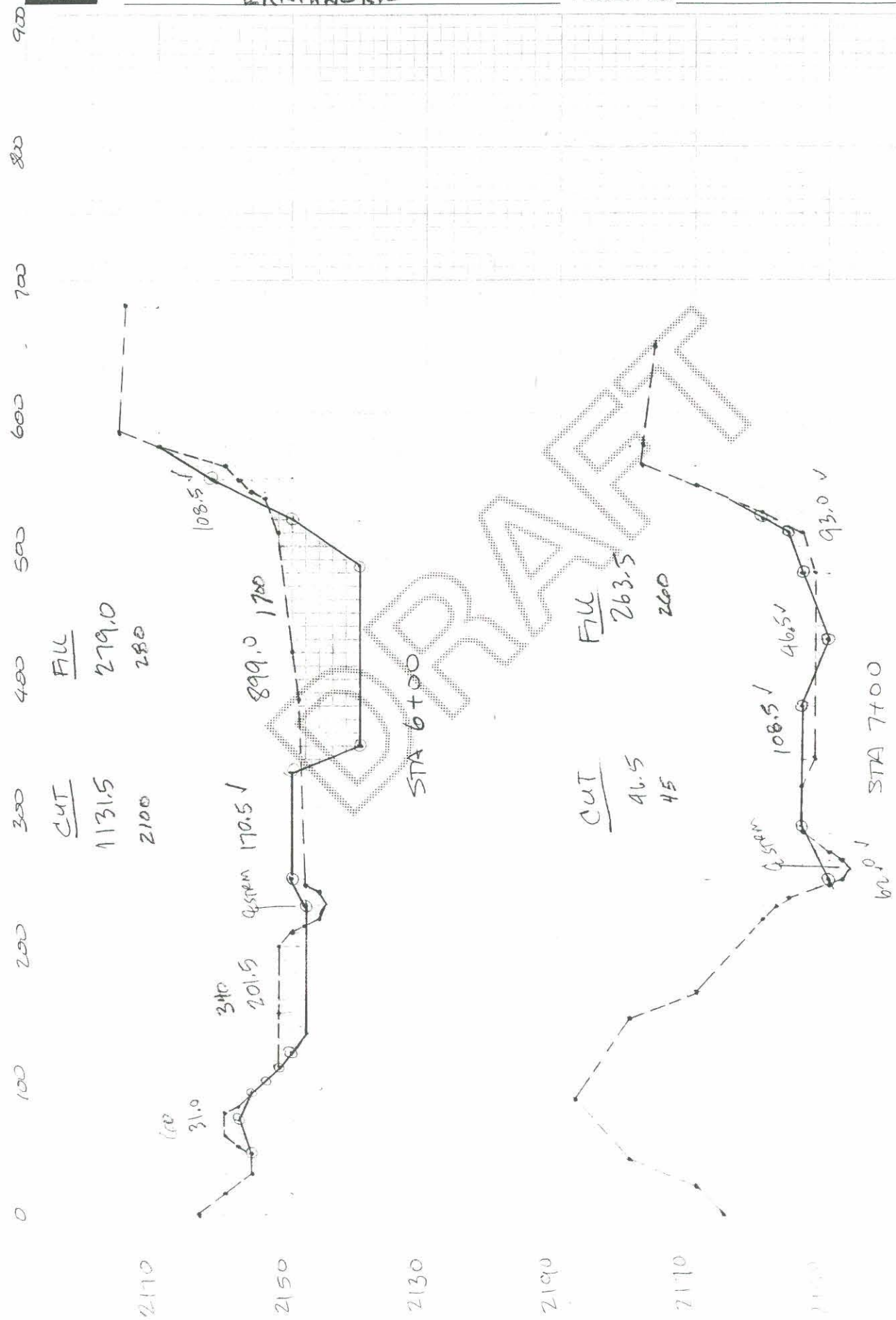
DRAFT

SUBJECT CASANDRO WASH DAM EARTHWORK

BY W PAIR

SHEET NO. 4 of 4 DATE 6-2-94

PROJECT NO.

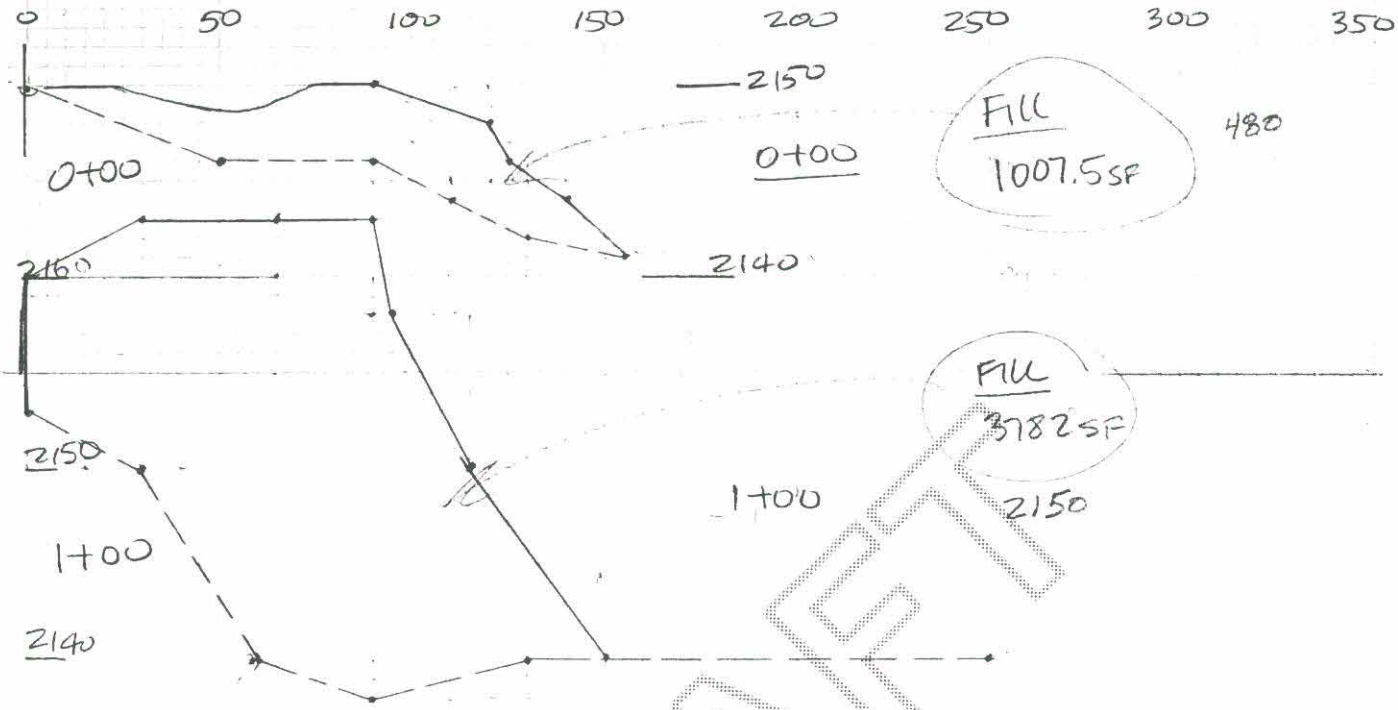


SUBJECT: DAM ALIGNMENT

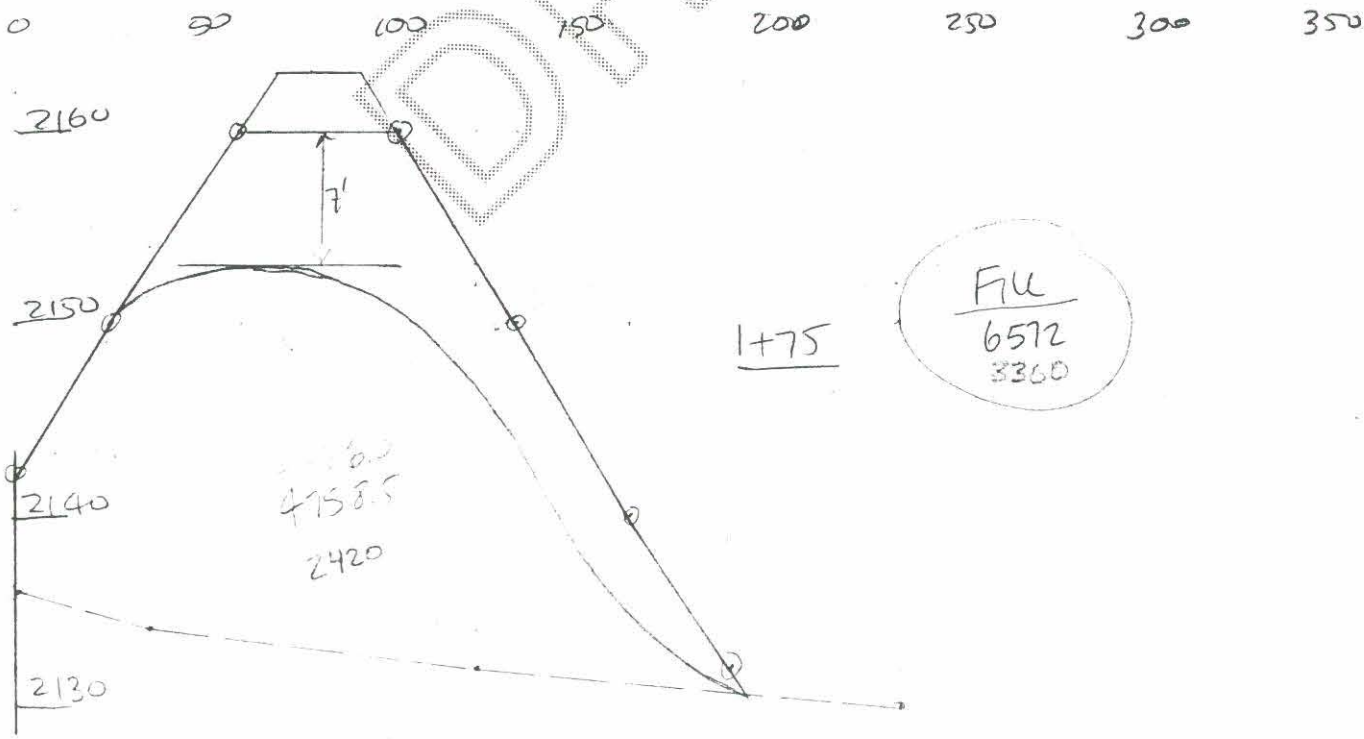
BY: H. PALZ

SHEET NO. 1 of 4 DATE

PROJECT NO.



DRAFT

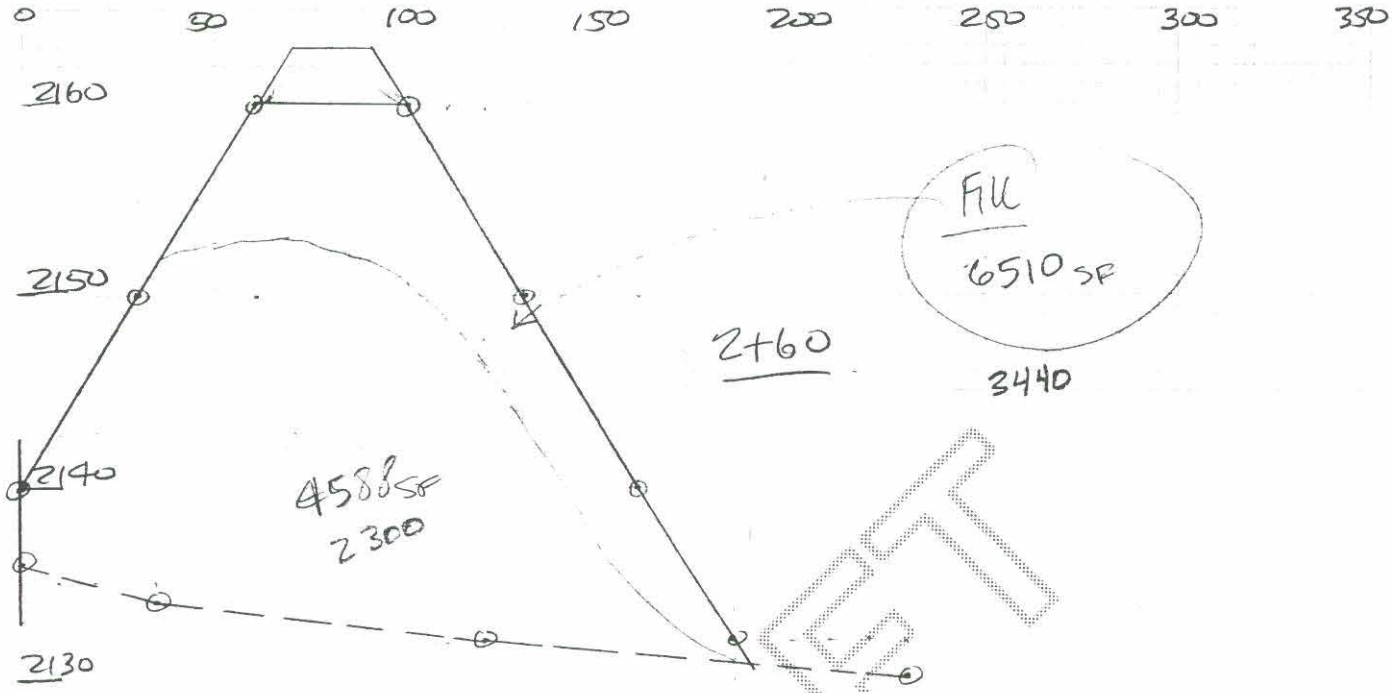


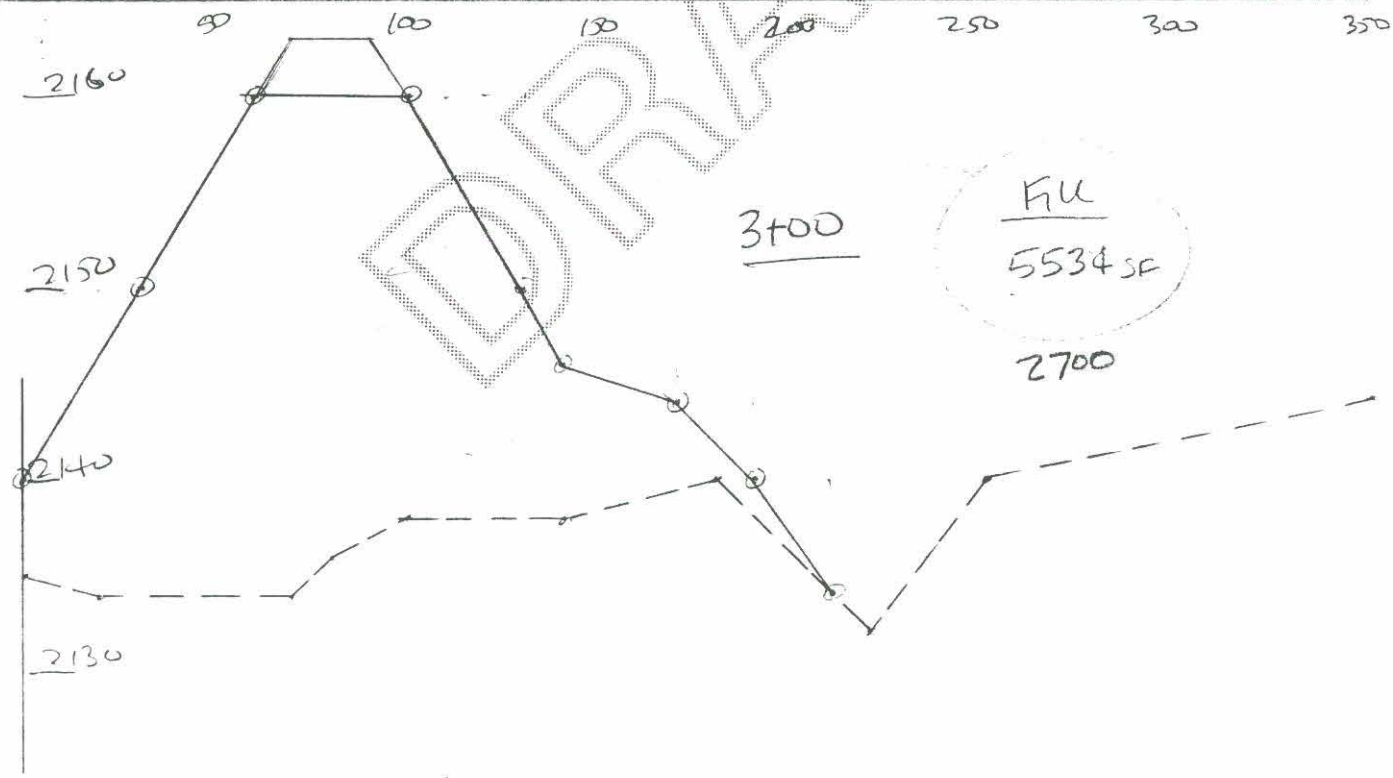
CH2M HILL

SUBJECT _____ BY W. PAIR

SHEET NO. 2 of 4 DATE _____

PROJECT NO. _____





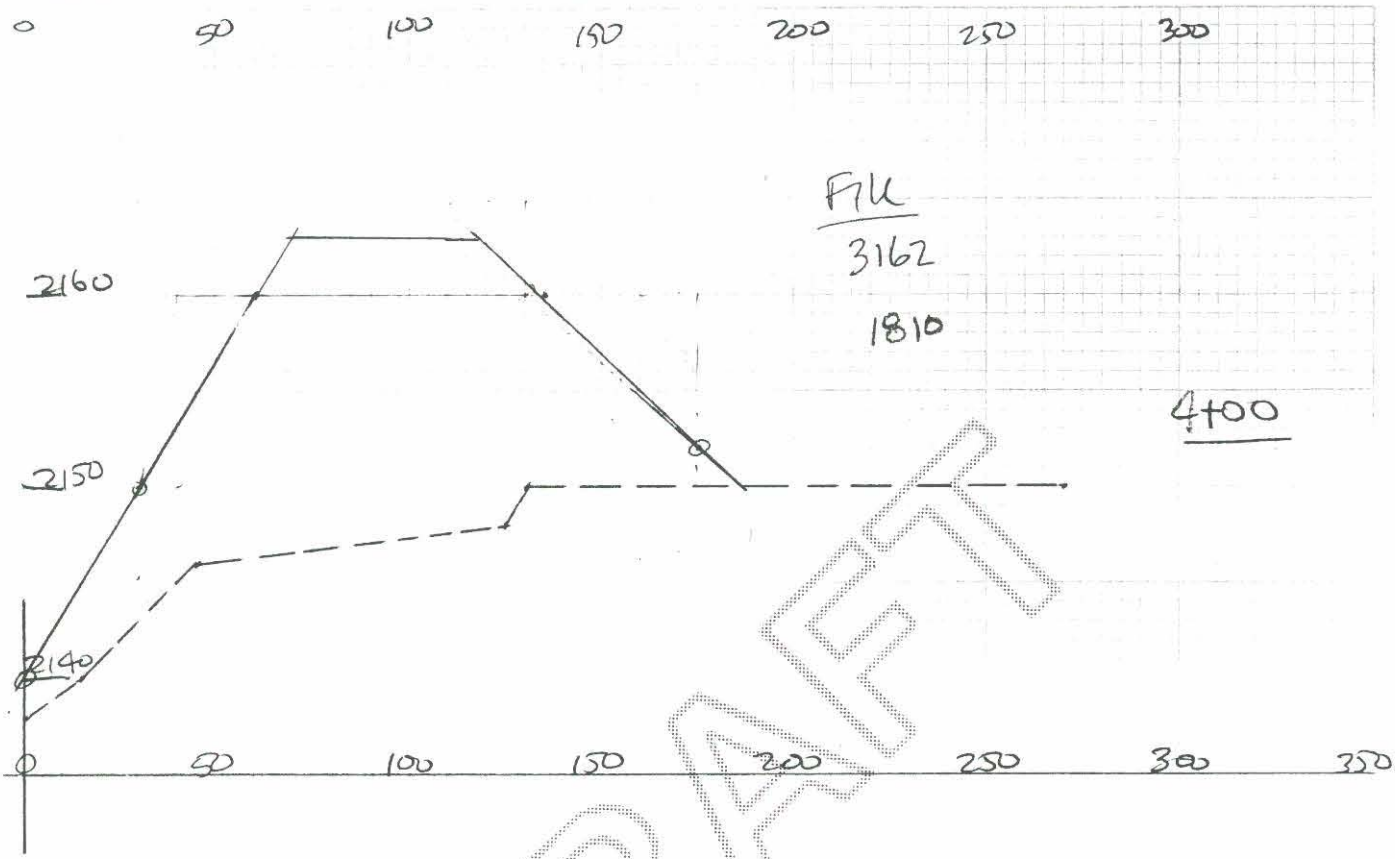
DRAFT

CH2M HILL

SUBJECT _____ BY W. PAIZ

SHEET NO. 3 of 4 DATE _____

PROJECT NO. _____



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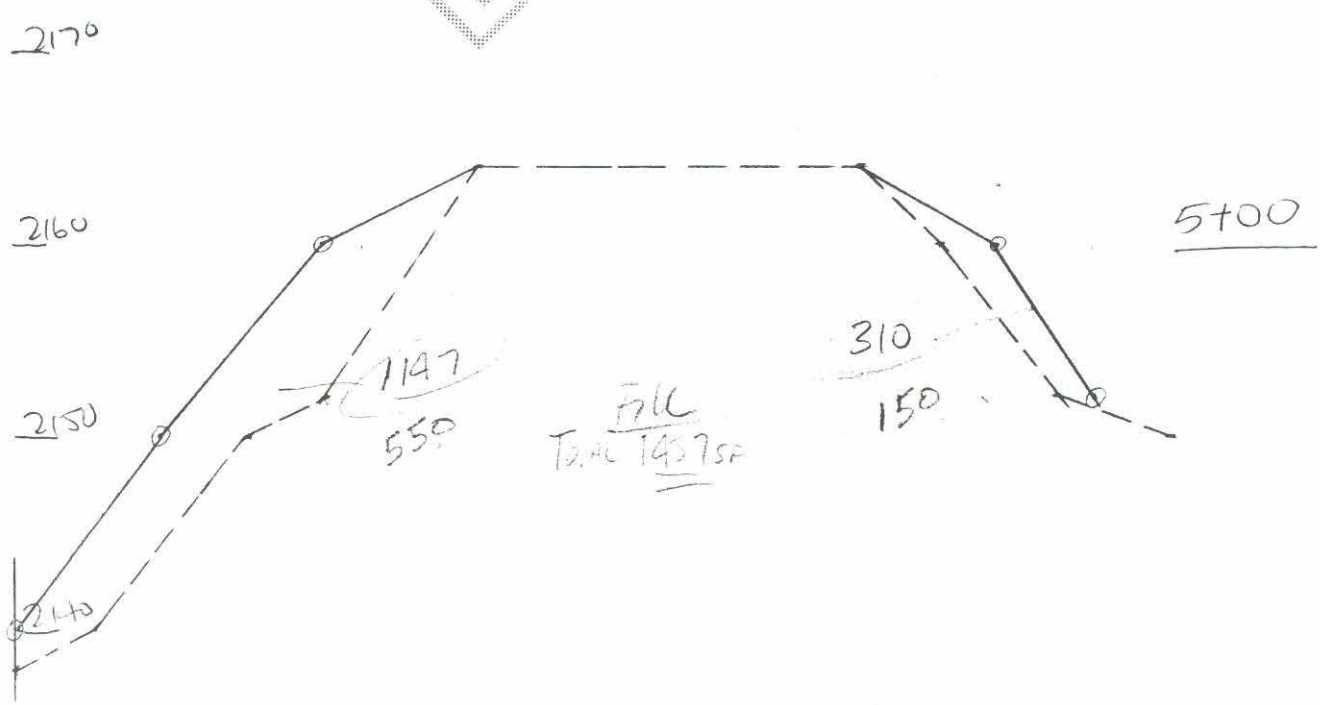
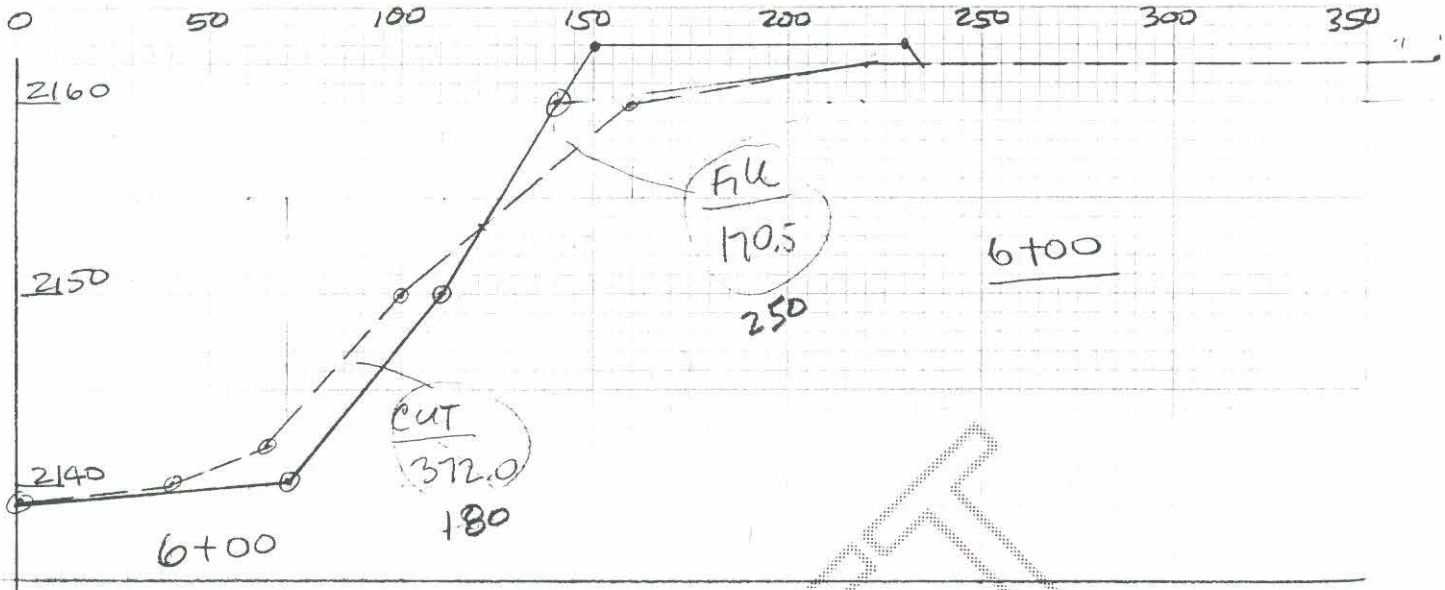
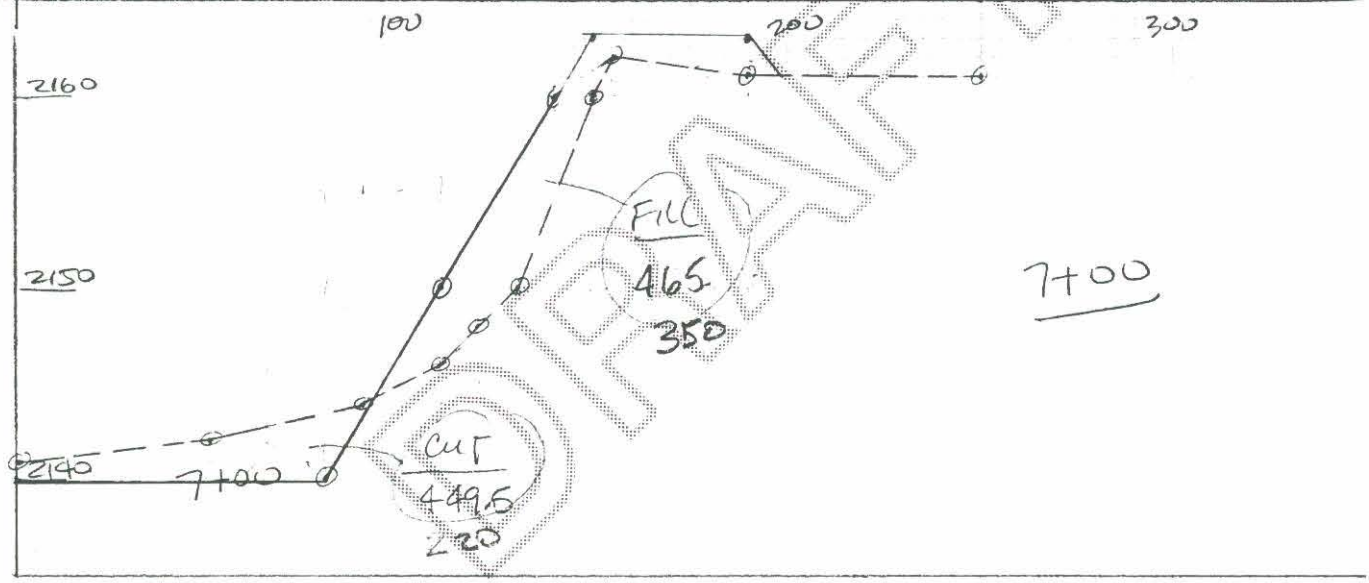


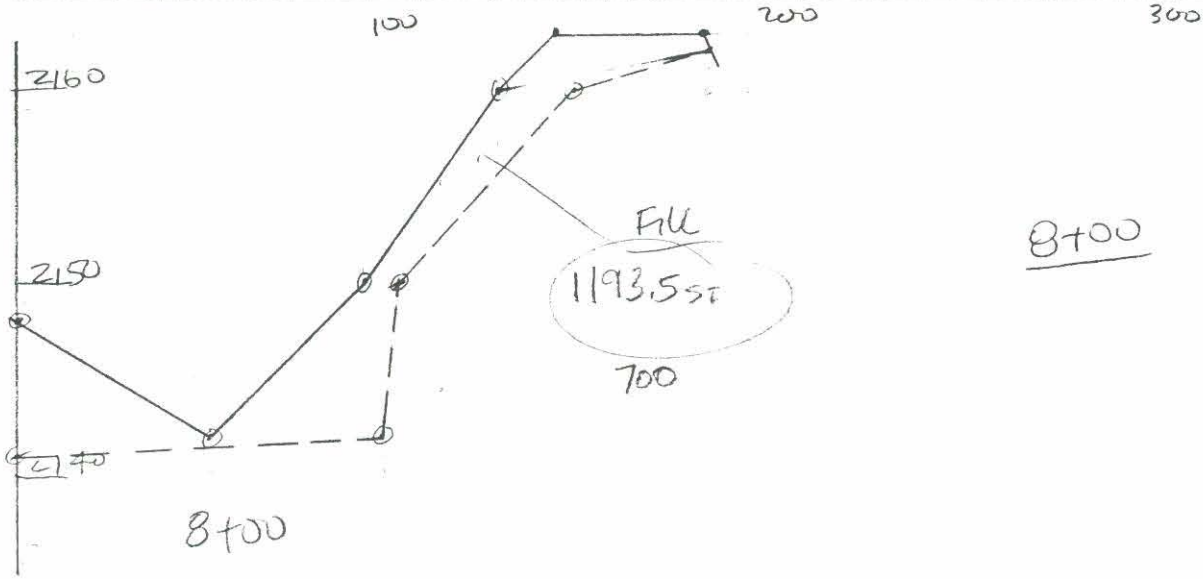
SUBJECT _____ BY W. PAIZ

SHEET NO. 4 of 4 DATE _____

PROJECT NO. _____







DRAFT

CH2M HILL

SUBJECT _____ BY W. PAIR.

SHEET NO. 1 of 2 DATE _____

PROJECT NO. _____

RESERVOIR

STA	DIST (FT)	CUT AREA (FT²)	CUT VOLUME (YD³)	FILL AREA (FT²)	FILL VOLUME (YD³)
0+00		108.5		1322.3	
	100		2353.7		2847.2
1+00		1162.5		215.2	
	100		5324.1		915.2
2+00		1712.5		279.0	
	100		6458.0		572.2
3+00		1774.8		30.0	
	100		5583.0		428.7
4+00		1240.0		201.5	
	100		4707.4		688.9
5+00		1302.0		170.5	
	100		4506.5		832.4
6+00		1131.5		279.0	
	100		2181.5		1004.6
7+00		46.5		263.5	
TOTAL RESERVOIR			31,114.2		7,289.2

DAM

0+00 (BEGIN DAM)		0		1007.5	
	100		0		8869.4
1+00		0		3782.0	
	75		0		14,380.6
1+75 (END DAM)		0		6572.0	
1+75 (BEGIN SPILLWAY)		0		4758.5	
	85		0		14,712.1
2+60 (END SPILLWAY)		0		4588.0	
2+60 (BEGIN DAM)		0		6510.0	
	40		0		8,921.5
3+00		0		5534.0	
	100		0		16,103.7
4+00		0		3162.0	
	100		0		8553.7
5+00		0		1457.0	
	100		688.9		3013.9
6+00		372.0		170.5	
	100		1521.3		1,176.9
7+00		449.5		465.0	
	100		832.4		3071.3
8+00 (END DAM)		0		1193.5	
			3,042.6		78,803.1

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CH2M HILL

SUBJECT

BY H. PAIZ

SHEET NO. 2 of 2 DATE

PROJECT NO.

TOTAL VOLUMES	CUT (YD^3)	FILL (YD^3)
RESERVOIR	31,114.2	7,289.2
DAM	3,042.6	78,803.1
	34,156.8	86,092.3
NET (FILL)		51,935.5

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CH2M HILL

SUBJECT: DAM ALIGNMENT PROPOSED GRADE X-SEC.

BY: W. PAIR

SHEET NO. 1 of 1 DATE

PROJECT NO.

0+00	2150/90	2148/120	2146/125	2144/140			
1+00	2160/0	2160/65	2158/90	2150/115	2140/150		
2+00	2140/0	2150/35	2160/60	2160/90	2132/185		
1+75	2142/0	2150/25	2160/58	2160/100	2150/130	2140/160	2132/185
spillway							
2+60	2140/0	2150/30	2160/60	2160/100	2150/130	2140/160	2132/185
3+00	2140/0	2150/30	2160/60	2160/100	2150/130	2146/140	2144/170
	2140/190	2134/210					
4+00	2140/0	2150/30	2160/60	2160/130	2152/175		
5+00	2140/5	2150/38	2160/80	2160/255	2152/280		
6+00	2140/70	2150/110	2160/140				
7+00	2140/80	2150/110	2160/140				
8+00	2148/0	2142/30	2150/90	2160/125			

DRAFT

CH2M HILL

SUBJECT: DAM ALIGNMENT
EXST GRND X-SEC

BY: W-PAZ
SHEET NO. 1 of 1 DATE
PROJECT NO.

0+00	2150 / 0	2146 / 50	2146 / 90	2144 / 110	2142 / 130	2141 / 155
1+00	2153 / 0	2150 / 30	2140 / 60	2138 / 90	2140 / 130	2140 / 250
2+00	2136 / 0	2134 / 35	2132 / 120	2130 / 230		
3+00	2135 / 0	2134 / 20	2134 / 70	2136 / 80	2138 / 100	2148 / 140
	2140 / 180	2132 / 220	2140 / 250	2144 / 350		
4+00	2138 / 0	2140 / 15	2146 / 45	2148 / 125	2150 / 130	2150 / 270
5+00	2138 / 0	2140 / 20	2150 / 60	2160 / 80	2164 / 120	2164 / 220
	2160 / 240	2152 / 270	2150 / 300			
6+00	2139 / 0	2140 / 40	2142 / 65	2150 / 100	2160 / 160	2162 / 220
	2162 / 370					
7+00	2141 / 0	2142 / 50	2144 / 90	2146 / 110	2148 / 120	2150 / 130
	2160 / 150	2162 / 155	2161 / 190	2161 / 250		
8+00	2141 / 0	2142 / 95	2150 / 100	2160 / 195	2162 / 180	

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SUBJECT CASANDRA WASH
EXST GRND X-SEC DATA
(See attached TAPE)

BY W. PATZ
SHEET NO. 1 of 4 DATE 6/2/94
PROJECT NO. SWW 35441.CV

0+00 2150/0, 2151.7/60, 2150/120, 2140/140, 2136/195, ℄ STREAM 160, 2136/360, 2138/420, 2140/650, 2142/805, 2144/810, 2146/820, 2148/825, 2150/830, 2160/840, 2166/850 — 2166.7

1+00 2159/0, 2158/90, 2136/150, 2135 ℄ STREAM 160, 2136/165, 2138/170, 2140/175, 2140/225, 2138/450, 2140/630, 2142/760, 2144/765, 2146/770, 2148/775, 2150/780, 2160/795, 2168/810

2+00 2165/0, 2164/85, 2160/90, 2150/110, 2148/125, 2140/140, 2137.5 ℄ STREAM 150, 2140/168, 2142/175, 2140/400, 2140/500, 2141/570, 2142/640, 2144/715, 2146/725, 2148/730, 2150/740, 2160/758, 2170/775, 2170/830

DRAFT

SUBJECT: EXST GRND X-SEC

BY:

SHEET NO. 2 of 4 DATE:

PROJECT NO.:

3+00

2181/0, 2180/10, 2170/35, 2168/40, 2166/45,

2164/55 2162/60 2160/75 2150/140 2140/150 @ STREAM 2140/170

2142/173 2143/175 2143/205 2143/280 2142/320 2141.5/365

2141.5/435 2142/515 2144/565 2150/575 2154/585

2160/705 2170/720 2172/780

4+00

2180/0 2170/30 2160/45 2150/75 2148/128 2146/138

2144/150 2142/170 @ STREAM 185 2142/195 2142/330

2142/405 2150/500 2160/510 2162/512 2162/590

2164/615 2170/620 2173/710

DRAFT

CH2M HILL

SUBJECT: EXST GRND X-SEC

BY:

SHEET NO. 3 of 4 DATE:

PROJECT NO.

5+00

2170 / 0	2160 / 20	2152 / 50	2154 / 60	2151 / 170
2150 / 175	2148 / 180	2144 / 190	℄ STREAM / 200	
2144 / 210	2148 / 220	2148 / 360	2146 / 390	
2148 / 410	2148 / 440	2150 / 450	2152 / 470	
2154 / 520	2156 / 570	2158 / 573	2160 / 575	2170 / 590
2174 / 600	2174 / 640			

6+00

2164 / 0	2160 / 15	2156 / 30	2156 / 45	2158 / 50
2160 / 58	2160 / 75	2158 / 80	2152 / 110	2152 / 150
2152 / 200	2150 / 210	2148 / 215	2146 / 220	℄ STREAM / 230
2146 / 240	2148 / 245	2149 / 385	2150 / 420	2152 / 510
2154 / 535	2156 / 540	2158 / 550	2160 / 560	2170 / 575
2176 / 585	2175 / 680			

DRAFT

CH2M HILL

SUBJECT: EXST GRND X-SEC

BY:

SHEET NO. 4 of 4 DATE:

PROJECT NO.:

7+00

2166 / 0	2170 / 20	2180 / 40	2188 / 85	2180 / 145
2170 / 165	2160 / 220	2158 / 230	2156 / 235	
2150 / 245	2148 / 250	[illegible] / 260	2148 / 265	2150 / 270
2154 / 285	2154 / 320	2152 / 340	2152 / 480	
2154 / 510	2160 / 525	2170 / 545	2178 / 560	2178 / 575
2176 / 650				

DRAFT

CH2M HILL

SUBJECT CASANDRO WASH
PROPOSED GRND X-SECT.

BY
SHEET NO. 1 of 2 DATE
PROJECT NO.

0+00	2152 / 15	2154 / 25	2160 / 50	2160 / 100	2150 / 135
	2140 / 180	2140 / 480	2140 / 775	2150 / 810	2160 / 840
1+00	2160 / 30	2160 / 70	2150 / 115	2140 / 148	2138 / 165
	2136 / 185	2134 / 210	2134 / 570	2136 / 590	2138 / 610
	2140 / 725	2150 / 760	2160 / 790		
2+00	2164 / 40	2160 / 70	2150 / 100	2140 / 165	2138 / 190
	2136 / 210	2134 / 230	2134 / 530	2136 / 555	2138 / 580
	2140 / 680	2150 / 715	2160 / 745		
3+00	2164 / 55	2160 / 70	2150 / 100	2142 / 125	2140 / 215
	2138 / 240	2136 / 260	2134 / 285	2134 / 450	2136 / 480	2138 / 500
	2140 / 575	2150 / 625	2160 / 690		

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CH2M HILL

SUBJECT: PROPOSED GRADE X-SEC

BY:

SHEET NO. 2 of 2 DATE:

PROJECT NO.

4+00	2180 / 0	2170 / 20	2160 / 55	2150 / 90	2144 / 110
	2142 / 140	2142 / 165	2144 / 185	2144 / 250	2142 / 260
	2140 / 265	2138 / 290	2136 / 310	2135 / 360	2136 / 410
	2138 / 435	2140 / 480	2150 / 510	2160 / 570	

5+00	2160 / 30	2150 / 60	2146 / 80	2146 / 210	2148 / 240
	2148 / 285	2146 / 290	2144 / 300	2142 / 308	2140 / 312
	2140 / 500	2150 / 530	2160 / 565		

6+00	2156 / 45	2158 / 70	2156 / 90	2154 / 100	2152 / 110
	2150 / 120	2148 / 135	2148 / 230	2150 / 250	2150 / 330
	2140 / 360	2140 / 485	2150 / 520	2160 / 550	

7+00	2150 / 250	2154 / 290	2154 / 380	2150 / 430	2154 / 480
	2156 / 510	2160 / 520			

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2160
2150
2140
2130
2120
2110
2100
2090
2080
2170
2180
2190
2200
2210
2220
R=50'
33:1 (38)
3:1
2:1
10:1
1" = 100'

Appendix D.

Detailed Cost Estimate

ORDER OF MAGNITUDE
COST ESTIMATE

PROJECT: CASANDRO WASH
MARICOPA COUNTY FLOOD CONTROL DISCTRICT
PROJECT NO. SWW35441.CV

	DESCRIPTION	QTY	UNIT	INSTALLED UNIT COST	TOTAL
	A. RESERVOIR CONSTRUCTION				
1.	CLEAR BRUSH, DOZER & BRUSH RAKE, LIGHT	18	Acre	$1,600.00	$28,800
2.	DEVELOP WATER SUPPLY	1	L.S.	$6,000.00	$6,000
	PRE-WET BORROW AREAS	1	L.S.	$1,500.00	$1,500
3.	GRADING RESERVOIR W/ SCRAPERS				
a.	SCRPR HAUL TO DAM SITE	70,000	C.Y.	$3.07	$214,900
4.	FINISH GRADING	12,000	S.Y.	$0.12	$1,440
	B. DAM CONSTRUCTION				
1.	PRE-WET BORROW AREAS	1	L.S.	$1,500.00	$1,500
2.	FOUNDATION EXC - SCRAPERS - 600' HAUL	13,000	C.Y.	$2.50	$32,500
3.	CHIMENY DRAIN CONSTRUCTION:				
a.	TRENCH EXCAVATE	1,700	C.Y.	$4.00	$6,800
b.	PLACE DRAIN MATERIAL	1,700	C.Y.	$12.00	$20,400
c.	DRAIN PIPE - 6" PVC	300	L.F.	$5.00	$1,500
4.	SPREAD EARTH BACKFILL - DOZER:	70,000	C.Y.	$1.34	$93,800
5.	COMPACTION, SHEEPSFOOT, 6" LIFT, 4 PASS	70,000	C.Y.	$0.53	$37,100
6.	FINISHING GRADING SLOPES	6,100	S.Y.	$0.12	$732
	C. STRUCTURES				
1.	**SPILLWAY CONSTRUCTION**				
a.	EXCAVATE SPILLWAY CHANNEL	8,000	C.Y.	$5.00	$40,000
b.	CAST IN-PLACE CONC SLAB W/ REINF	870	C.Y.	$200.00	$174,000
c.	CAST IN-PLACE CONC WALLS W/ REINF	230	C.Y.	$350.00	$80,500
d.	CAST IN-PLACE CONC FOOTINGS W/ REINF	50	C.Y.	$170.00	$8,500
2.	**STILLING BASINS**				
a.	EXCAVATE STILLING BASIN	200	C.Y.	$5.00	$1,000
b.	DISIPATORS: CAST IN-PLACE CONC W/ REINF	10	C.Y.	$350.00	$3,500
c.	CAST IN-PLACE CONC SLAB W/ REINF	138	C.Y.	$200.00	$27,600
d.	CAST IN-PLACE CONC WALLS W/ REINF	52	C.Y.	$350.00	$18,200
e.	CAST IN-PLACE CONC FOOTINGS W/ REINF	15	C.Y.	$170.00	$2,550
3.	**DRAIN STRUCTUES & PIPELINE**				
a.	DRAIN INLET - CONC W/ REINF	10	C.Y.	$350.00	$3,500
b.	DRAIN OUTLET - CONC W/ REINF	5	C.Y.	$350.00	$1,750
c.	PIPELINE - 36" RCP	220	L.F.	$73.00	$16,060
d.	TRENCH EXC & BCKFL W/ CONC SLURRY	200	L.F.	$30.00	$6,000
e.	DRAIN OUTLET - MISC METALS	1	L.S.	$500.00	$500

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ORDER OF MAGNITUDE
COST ESTIMATE

PROJECT: CASANDRO WASH
MARICOPA COUNTY FLOOD CONTROL DISCTRICT
PROJECT NO. SWW35441.CV

	DESCRIPTION	QTY	UNIT	INSTALLED UNIT COST	TOTAL
	D. SEWER RE-ALIGNEMENT				
1.	LOCATE & CUT EXISTING SEWER LINE	2	Ea.	$500.00	$1,000
a.	REMOVE EXSITING 10" VCP & MANHOLE	430	L.F.	$8.00	$3,440
2.	NEW MANHOLES	3	Ea.	$7,000.00	$21,000
3.	NEW 12" DIA VCP SEWER LINE	440	L.F.	$12.00	$5,280
4.	TRENCH EXCAVATION	1,900	C.Y.	$2.36	$4,484
a.	TRENCH BACKFILL	1,500	C.Y.	$5.00	$7,500
b.	BCKFL W/ CONC UNDER DAM AREA	630	C.Y.	$25.00	$15,750
	E. SITE DEVELOPMENT				
1.	ACCESS ROAD (APPROX 400 LF X 12' WIDE)				
a.	GRADING ROADWAY	1,250	S.Y.	$2.74	$3,425
b.	BASE, PREPARE&ROLL SUBBASE	1,250	S.Y.	$1.11	$1,388
c.	BASE COURSE, GRAVEL, 6"DEEP	1,250	S.Y.	$2.32	$2,900
2.	LANDSCAPING				
	SEEDING	4.00	Acre	$1,800.00	$7,200
3.	FENCING				
a.	CHAINLINK FENCE - 72"	1,500	L.F.	$8.50	$12,750
b.	DOUBLE WIDE GATE - 12'	2	EA	$1,500.00	$3,000
4.	SIGNING	1	L.S.	$1,000.00	$1,000
	F. DOWN STREAM IMPROVEMENTS				
1.	GRADING				
a.	SCRPR HAUL TO STOCKPILE - 1500' HAUL	500	C.Y.	$2.00	$1,000
2.	RIPRAP - DUMPED 12"	1,400	C.Y.	$40.66	$56,924
3.	FINISH GRADING	19,000	S.Y.	$0.12	$2,280
	CONTRACTOR SURVEYS	5	Mths	$2,000.00	$10,000
	SUBTOTAL CONSTRUCTION COST				$991,000
	MARK-UPS:				
	MOB/BOND/INSURANCE	5%			$50,000
	CONTINGENCY	20%			$208,000
	TOTAL CONSTRUCTION COST				$1,249,000
	FIELD / LAB TESTING	2%			$25,000
	CONSTRUCTION MGNT & ADMIN.	5%			$64,000
	TOTAL CONSTRUCTION COST W/ TESTING, CM & ADMIN				$1,338,000

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Appendix E.

Value Engineering Meeting

MEETING NOTES

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DATE:	May 2, 1994
PROJECT:	SWW35441.MC.10
SUBJECT:	Casandro Wash Detention Dam Value Engineering and Review Board Meeting
MEETING DATE:	April 12, 1994 (8:30 a.m. to 4:15 p.m.)
LOCATION:	Fire Station Meeting Room, Wickenburg, Arizona
ATTENDEES:	See Attached List
REVIEW BOARD MEMBERS:	Peter Binney, Larry Roth, Roger Lindquist
AGENDA:	Attached
HANDOUTS:	Attached
PREPARED BY:	Roger Lindquist

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Summary

The purpose of the meeting was to present the work accomplished to date on the Casandro Wash Detention Dam for information and review by the dam review board and client representatives. The project hydrology and geology were presented, followed by a brief site visit and observation of test pits. After the site visit, the project was broken down into the major elements and the opinion of conceptual level construction cost for each element presented. Just before lunch, a brainstorming session was held to develop ideas for improving the conceptual design and reducing the cost. Following lunch, the meeting focused on evaluating the ideas, eliminating the less acceptable ones, and developing the ideas to be presented to the design team for further review.

Decisions

The following decisions were made at the conclusion of the meeting:

1. The Design Flood--½ PMF (5400 cfs), with 3 feet of freeboard; full PMF (10,900 cfs) without overtopping the dam, with just a few inches of freeboard.

2. Storage--Provide approximately 157 ac-ft of flood storage to contain the 100-year flood below the spillway crest, less the flow released from the orifice, plus 2 ac-ft for sediment storage.

3. Upstream Development--Assume the upstream drainage area is fully developed to the present zoning regulations

4. Sediment Accumulation--Assume sediment is removed every 5 years with an 5-year accumulation of average sediment yield (5 years at average 0.4 ac ft/yr). This storage of 2 ac-ft will be below the lip of the outlet orifice.

5. Reservoir Level at Start of Flood--Assume the reservoir is empty at the start of the flood.

6. Dam Crest Elevation--Assume the dam crest will be between elevation 2161 and 2163 because of abutment topography constraints. Construct wide flat dike across the right abutment to fill in the low spot (only about 2 or 3 feet high). Leave house in place, and buttress the area around the house. Excavate the trash and loose soil from the slope around the house. Remolded embankment permeability is about 1×10^{-4} cm/sec, and foundation permeability is about 1×10^{-3} cm/sec. Angle of friction is about 38 to 40 degrees. Settlement of foundation and embankment are expected to be small.

7. Dam Section--Even though the reservoir will normally be emptied quickly after every storm (assumed completely empty within seven days), assume there is a remote chance that the reservoir will remain full long enough for steady state seepage to develop. So, leave the chimney drain in as shown, and extend it in a trench so it is a few feet below foundation excavation. Assume the dam is a homogenous dam with a chimney drain; no core will be included. No special slope erosion protection will be provided, similar to Sunset Dam.

8. Outlet--Assume an outlet will be provided with an orifice that limits the discharge to 20 cfs (with water surface about 3 feet below the spillway crest). Also provide the outlet with a gate that will allow up to 340 cfs (capacity of downstream drainage facility). Gate will be operated by a stem up the sloping face of the dam. Provide a trash rack around both the orifice and gate. Outlet pipe will be 36-inches in diameter. The stilling basin for the outlet pipe will be the spillway stilling basin. The outlet will be backfilled with concrete or a pourable backfill. Seepage collars

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perpendicular to the pipe centerline may be excavated and poured against undisturbed ground. A drainage backfill may be used for the downstream 30 to 50 feet of the outlet pipe.

9. Maintenance Access--Provide truck access to the reservoir for removal of sediment, to each abutment for maintenance and inspection, and to downstream toe for repair after severe flooding.

10. Horse/Motorbike Access--Access through the reservoir for horse and bike traffic will be allowed via maintenance road but away from the dam.

11. Fencing--Delay final decision until O&M staff review, but consider fencing around the spillway and outlet similar to Sunset Dam.

12. Relocation of Sewer Pipe--Develop reservoir excavation to leave as much of the sewer pipe undisturbed in the reservoir as possible but still excavate the required embankment footprint and provide the needed flood storage. Relocate/replace sewer pipe under dam, so pipe is not interfering with the foundation excavation of the dam or the excavation of the stilling basin. Sewer pipe should be concrete encased under the embankment.

13. Spillway Entrance--Further develop the spillway entrance as an ogee crest to pass the ½ and full PMF. Check the width reduction of the entrance, entrance coefficient, etc., during final hydraulic computations of the spillway so the flood is safely passed without dam overtopping.

14. Spillway Chute--Evaluate the convergence angle of chute, the freeboard on the training walls, and the construction materials. Consider soil cement (CSA or RCC) using onsite materials with a strength of about 2000 psi. Consider constructing the walls with soil cement. Soil cement shall be placed in layers about 10 feet wide with 2- or 3-foot-high steps. State Dam Safety will be concerned about seepage along the spillway walls, so discuss this issue with them and use cutoff walls if necessary.

15. Spillway Stilling Basin--Consider providing a soil-cement-lined stilling basin. Consider shortening basin by having a deep, lined pool with a high downstream end weir. Fill stilling basin with sand that will wash out when used in flood.

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16. Water for Construction--Assume water needed for construction will be about 50 to 100 gallons per cubic yard of fill. Discuss with City about supply that may be available as well as preferred timing for construction or storage requirements.

17. Waste Material--Assume waste excavation material may be placed downstream of dam, probably on right abutment area downstream from house. Client should review potential for some waste material to be hauled from site for use in other civil projects.

18. Structures in Reservoir--County will arrange for removal of all structures, debris, and obstructions in reservoir.

19. Inert Debris in Reservoir--Inert debris may be buried downstream of dam.

20. Debris--Other solid waste unsuitable for incorporation in fill areas will be taken to City landfill.

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Design Team Review

The following suggestions were made to the design team for further review:

- *New Dam Alignment and Elevation*--The advantage of modifying the dam axis alignment is to provide better downstream alignment of the spillway discharge. The advantage to locating the dam downstream and raising the crest of the dam and spillway is to reduce the excavation required in the reservoir and to balance the cut and fill volume. The suggested dam crest elevation is 2163, with the spillway wide enough to pass the ½ PMF with the 3 feet of freeboard and pass the full PMF with just a few inches of freeboard. Recalculate the volume of fill in the dam, and consider steepening the downstream face to 2:1 if necessary, but remember that erosion control and maintenance will be better on a flatter slope. Consider reducing the crest width to 15 feet.

- *Raise the Crest of the Dam Along Alternate II to Elevation 2,163*--This concept would determine if the storage could be obtained while reducing the volume of excess excavation in the reservoir.

Casandro Wash Value Engineering Meeting
April 12, 1994
Agenda

8:30 - 8:50: **Goals and Objectives**

8:50 - 9:10: **Hydrology and Hydraulics**
- Precipitation
- 100-year Flood
- 1/2, Full PMF
- Outlet Criteria/consideration/controls/operation
- Hydraulic design concepts of spillway and outlet works
- Dam Configuration, top width, hydraulic structures, etc.
- Sediment yield

9:10 - 9:30: **Geology and Geotechnical**
- Site Constraints: Private property, access
- General geology, seismicity and background information
- Foundation strength, settlement, cutoff etc.
- Construction materials - core, random, filters, drains and erosion protection
- Stability analysis: Static and dynamic
- Cross sections, alternatives
- Construction cost estimates
- Discussion of performance of similar adjacent dams, risk, allowable seepage, maintenance, landscaping etc.

9:30 - 11:00: **Break and site inspection, observe test pits**

11:00 - 12:00: **Break down costs into major components and functions**
- Embankment - foundation, cutoff, fill material, cross section, erosion protection
- Outlet works - Intake, conduit, stilling basin, diversion during construction etc.
- Spillway - type, location, materials, entrance, chute, stilling basin, etc.

12:00 - 1:30: **Lunch**

1:30 - 2:30: **Breakout Discussion Session**

2:30 - 4:30: **Identification and Development of VE suggestions to address possible cost savings in the major items; discussion**

4:30 - 4:45: **Wrap up**

5:00: **Depart from meeting**

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SUBJECT MCFCD
CASANDRO WASH
DETENTION DAM

BY _____ DATE _____
SHEET NO. ____ OF ____
PROJECT NO. _____

VALUE ENGINEERING MEETING

APRIL 12, 1994

WICKENBURG, AZ

ATTENDEES LIST

NAME	POSITION/REPRESENTING	PHONE
Ton Wolf	CIVIL DES./CH2M HILL	966-8188
Steve Walker	PM CH2M Hill	"
Willie Aiz	Cost Estimator/CH2M Hill	"
Michael Lopez	Proj Mgr/FCD	506-1501
Stan Smith	Eng.	506-1501
Dawn Stingle	Project Assistant/CH2M	966-8188
Larry Roth	Geotechnical Engr/CH2M Hill	510-251-2426
Peter Binney	HYDRAULIC ENGR/CH2M HILL	303-771-0900
Warren Rosebraugh	CE/FCD	506-1501
Ed Raleigh	Engineering/FCD	" "
Jon Fuller	Hydrol./CH2m	966 8188
Roger Lindquist	Civil/Geotech/CH2mHill	503-752-4227
John Livingston	Geotechnical/CH2m Hill	966-8188
Sandra Spren	FCDMC (until noon)	506-1501
Jim Opstiene	FCDMC (until noon)	506-1501
David Allard	Geotechnical Engineer	966-8188

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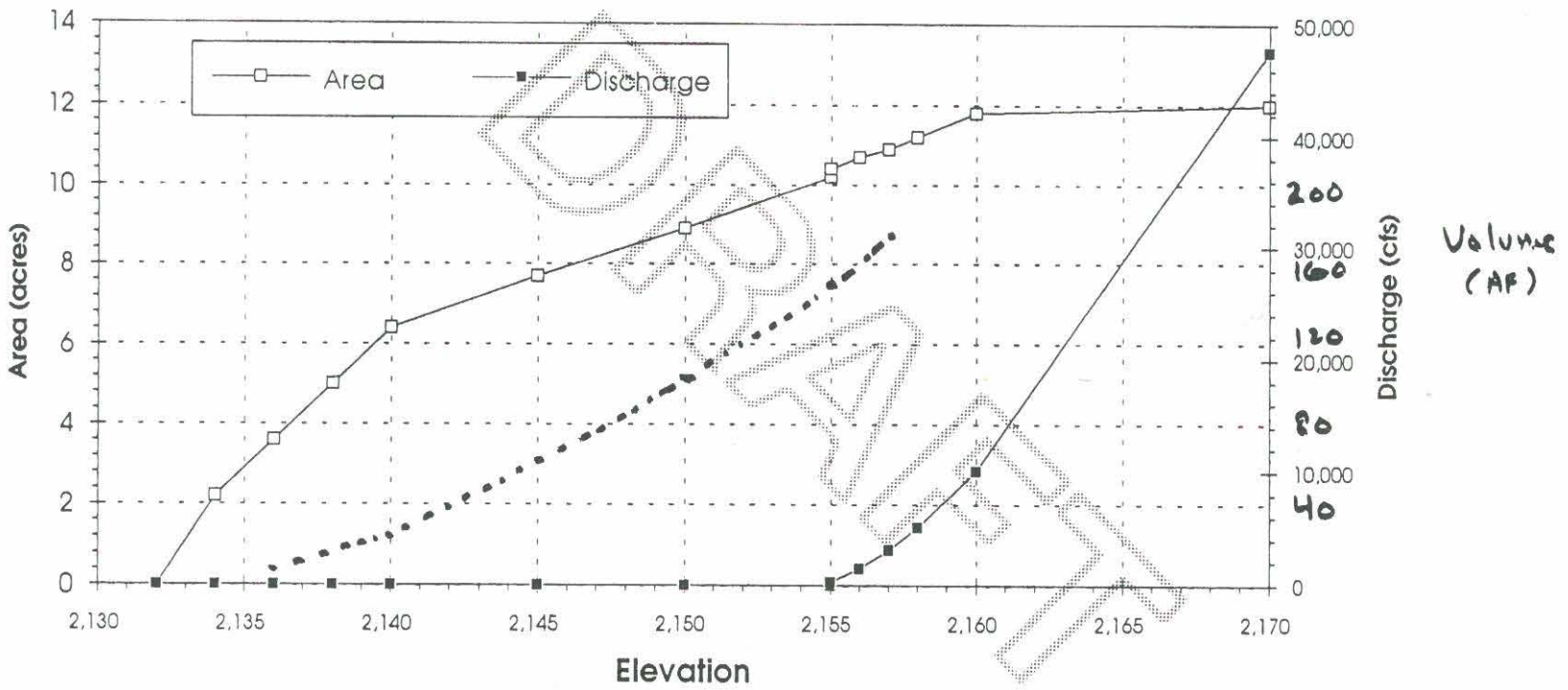
AREA-DISCHARGE VS. ELEVATION RELATIONSHIPS



02-24-94 SWW35441.CIT\5441C004.DWG

FIGURE 2. GEOTECHNICAL EXPLORATION PLAN
CASANDRO WASH DETENTION BASIN
WICKENBURG, AZ.

CH2M HILL

04-07-9. 5441C005.DWG

CH2M HILL	DSGN					
	DR SWK35441\5441C005					
	CHK					
	APVD	NO.	DATE	REVISION	BY	APVD

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ALTERNATIVE DAM ALIGNMENT I

CASANDRO WASH DETENTION BASIN
WICKENBURG, AZ.

SHEET	1
DWG NO.	
DATE	
PROJ NO.	

PRELIMINARY

04-07-94 54410003.DWG

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	DR SWK35441\54410003					
	CHK					
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ALTERNATIVE DAM ALIGNMENT II

CASANDRO WASH DETENTION BASIN
WICKENBURG, AZ.

SHEET 2
DWG NO.
DATE
PROJ NO.

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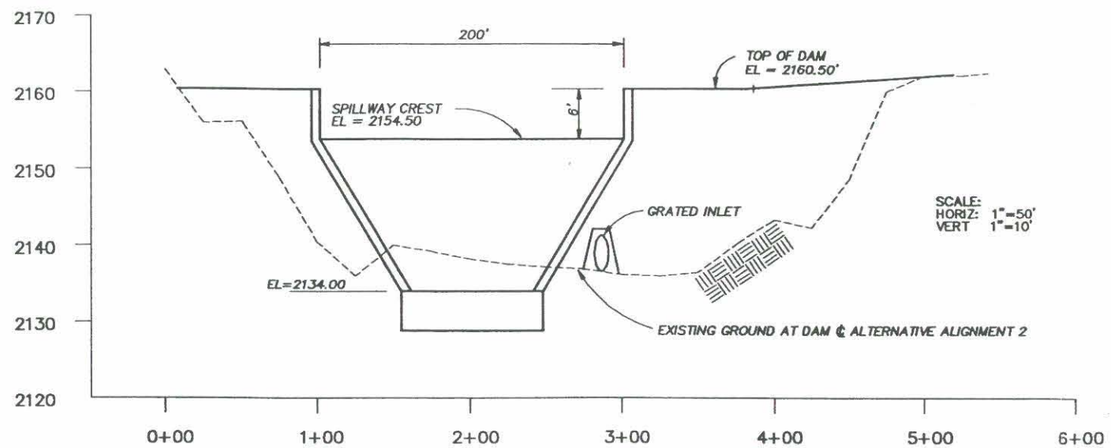
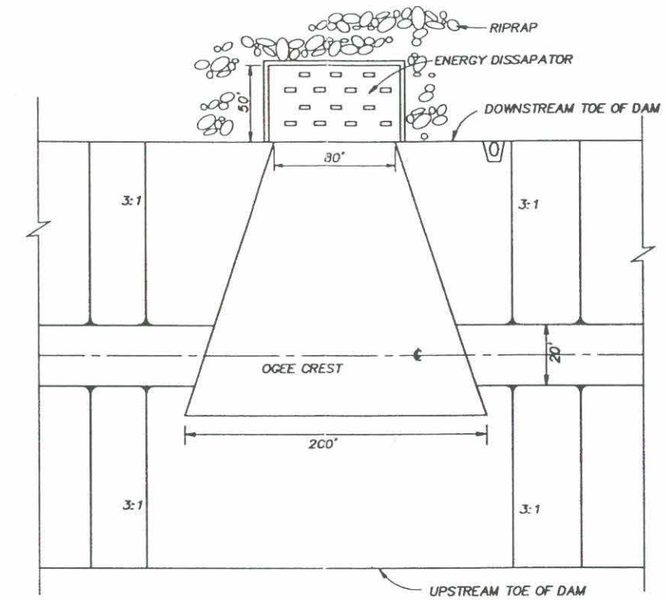
04-04-94 C:\USR2\PROJECTS\PROJECTS\TYPSEC.DWG

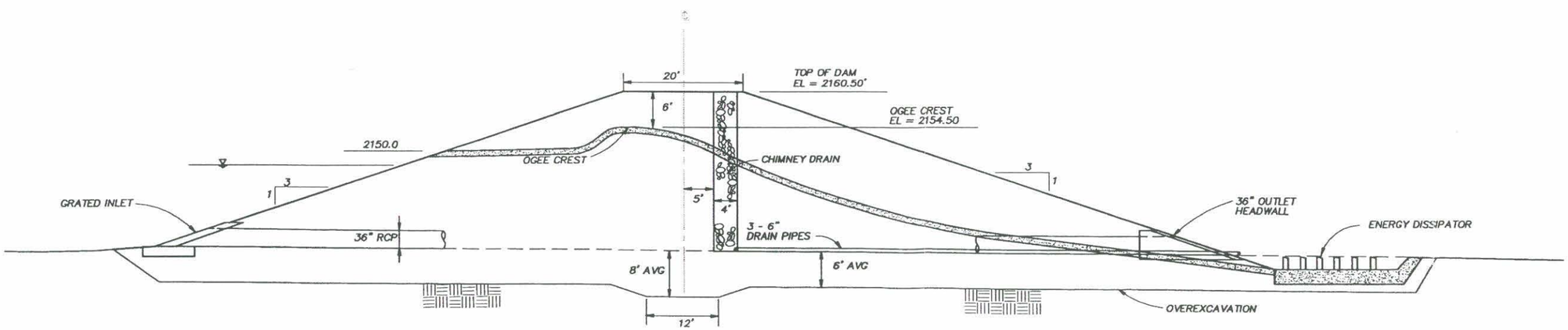


ELEVATION VIEW LOOKING DOWNSTREAM



SPILLWAY PLAN VIEW

SCALE: 1"=50'



TYPICAL SECTION

SCALE: 1"=20'

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	DR PROJECTS\TYPSEC					
	CHK					
	APVD	NO.	DATE	REVISION	BY	APVD

1=1

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DAM TYPICAL SECTIONS

SHEET	3
DWG NO.	
DATE	
PROJ NO.	

04-04-04 5441C008.DWG

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	DR SWK35441\5441C008					
	CHK					
	APVD	NO.	DATE	REVISION	BY	APVD

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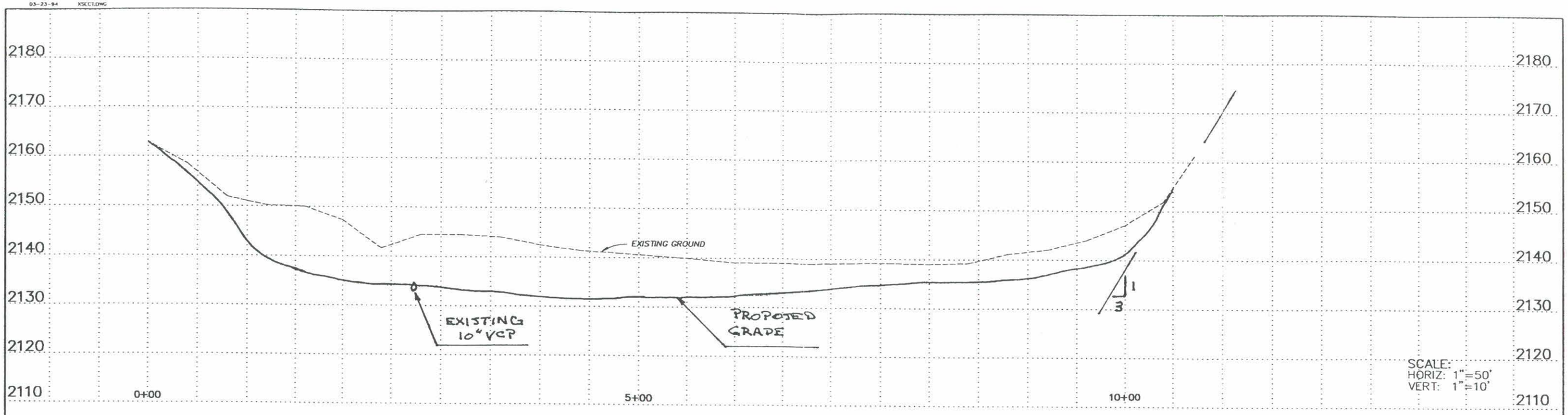
PROPOSED GRADING PLAN
ALTERNATIVE DAM
ALIGNMENT II

CASANDRO WASH DETENTION BASIN
WICKENBURG, AZ.

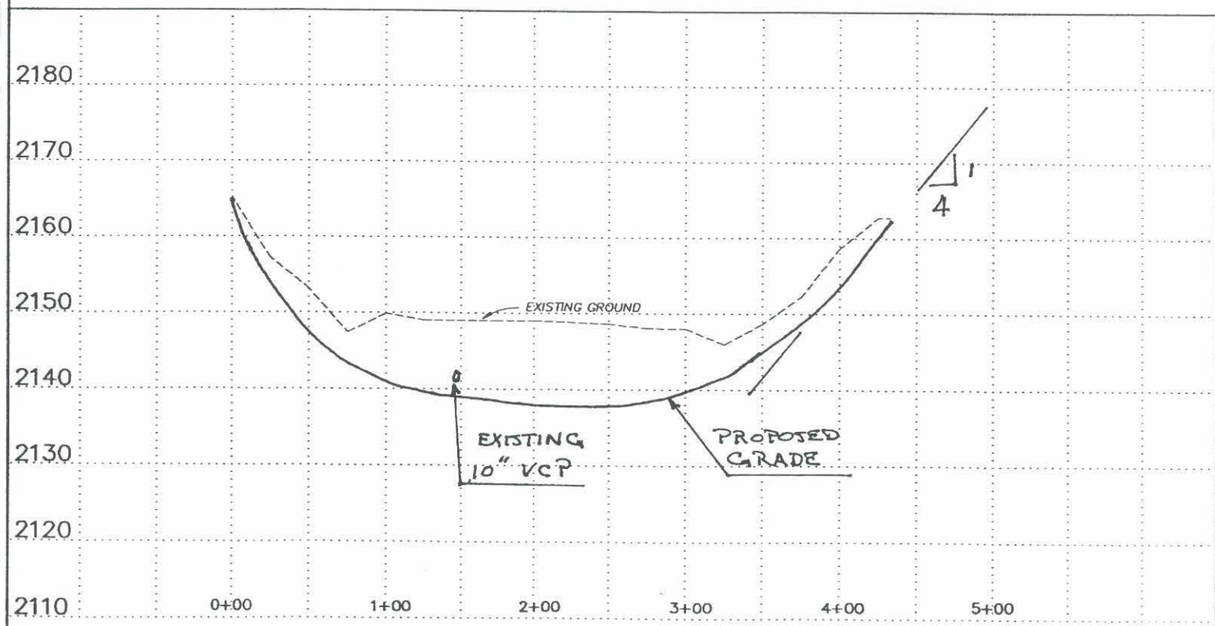
SHEET 4
DWG NO.
DATE
PROJ NO.

PRELIMINARY

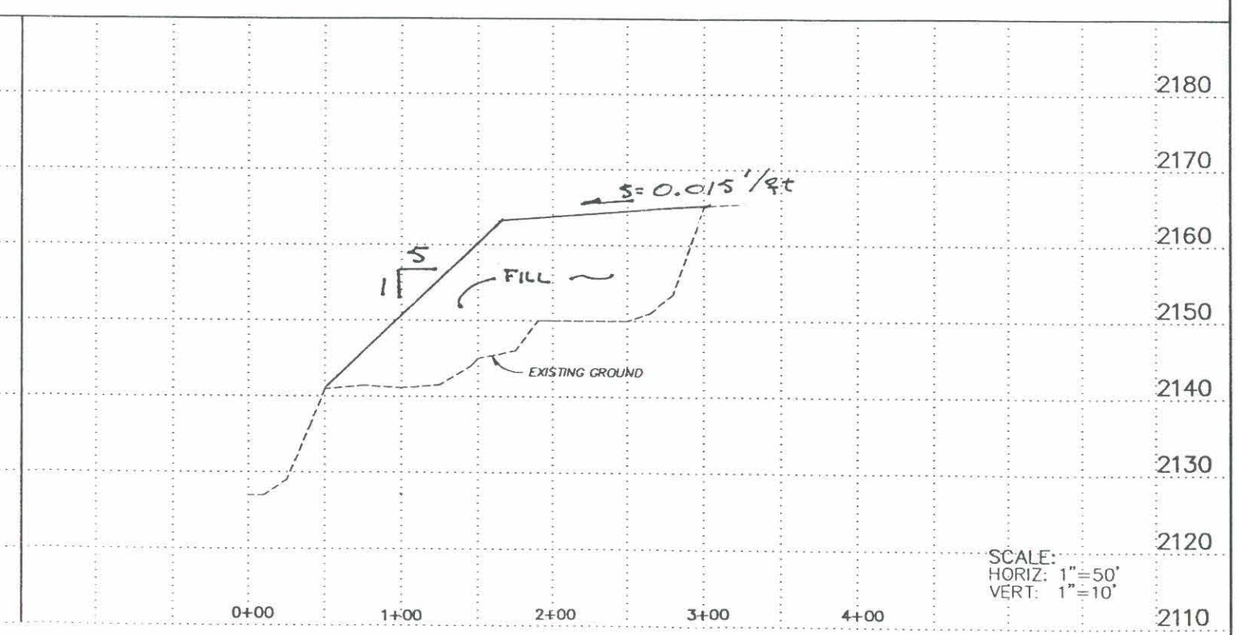
03-23-94 XSECT.DWG



SECTION A - 150' OFFSET FROM DAM AXIS I LOOKING DOWNSTREAM



SECTION B - 400' OFFSET FROM DAM AXIS I LOOKING DOWNSTREAM



SECTION C – PROPOSED FILL AREA

1=100

CH2M HILL

DSGN	
DR SWM35441\XSECT	
CHK	
APVD	

NO.	DATE	REVISION	BY	APVD

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PLAN AND PROFILE
BASIN CROSS SECTIONS

SHEET 5

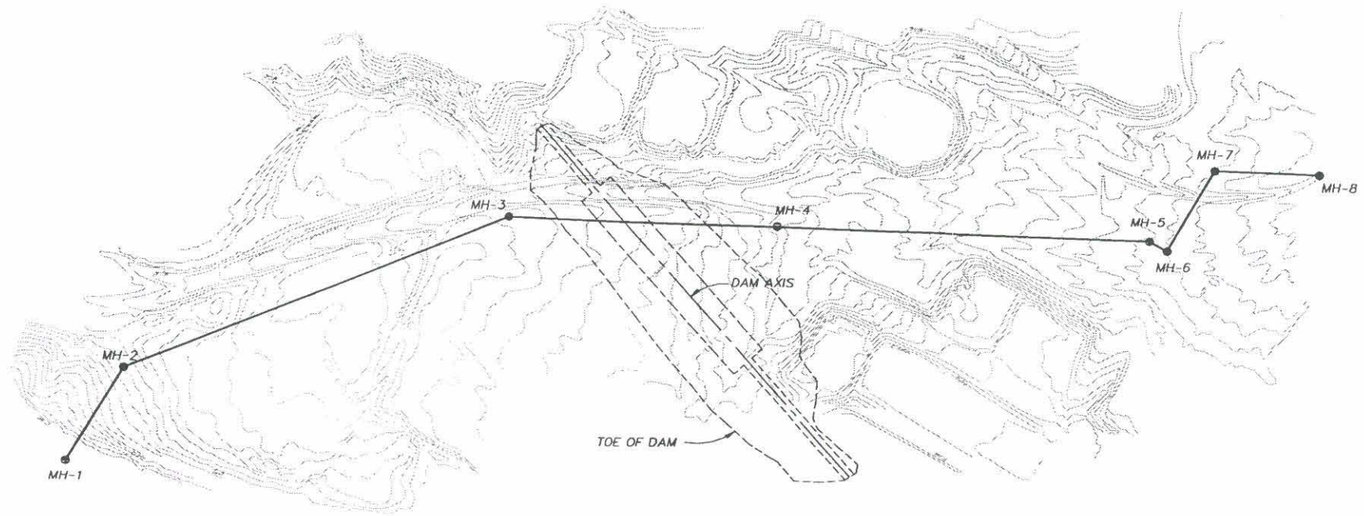
DWG NO.

DATE

PROJ NO.

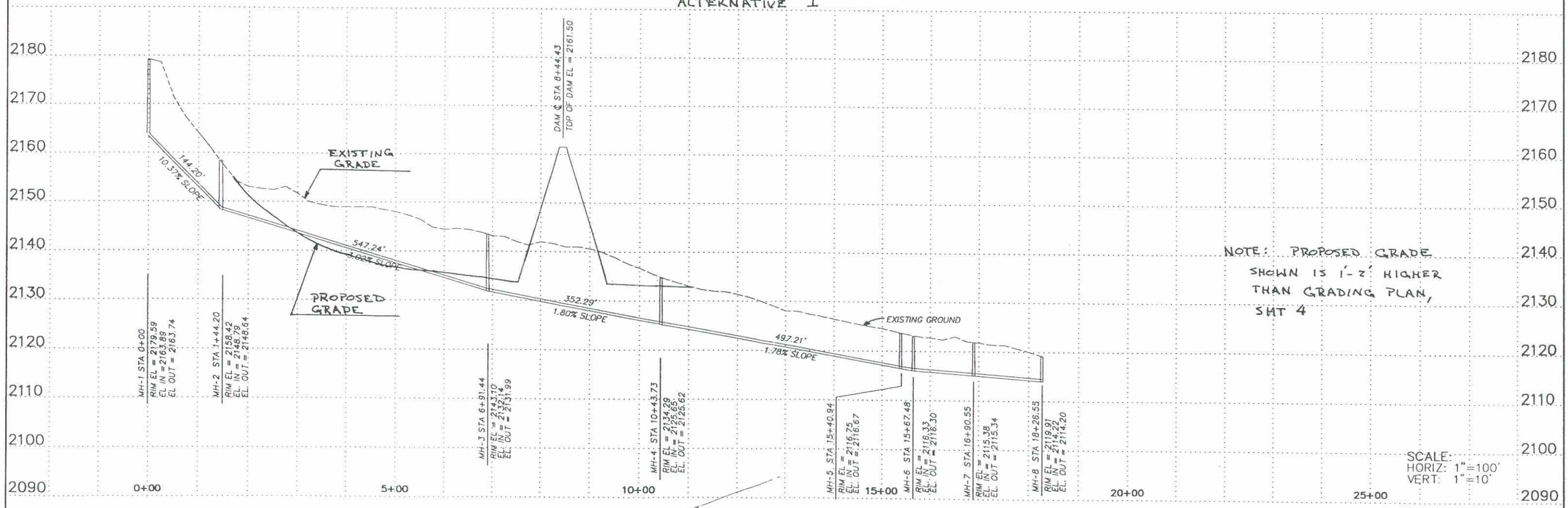
PRELIMINARY

03-25-94 C:\USR2\PROJECTS\PROJECTS\CWSEWPRO.DWG



DAM ALIGNMENT
ALTERNATIVE I

0 100ft. 200ft. 300ft. 400ft.
SCALE: 1"=100'



NOTE: PROPOSED GRADE SHOWN IS 1'-2' HIGHER THAN GRADING PLAN, SHT 4

SCALE:
HORIZ: 1"=100'
VERT: 1"=10'

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DSGN	
DR PROJECTS\CWSEWPRO	
CHK	
APVD	

1=100

NO.	DATE	REVISION	BY	APVD

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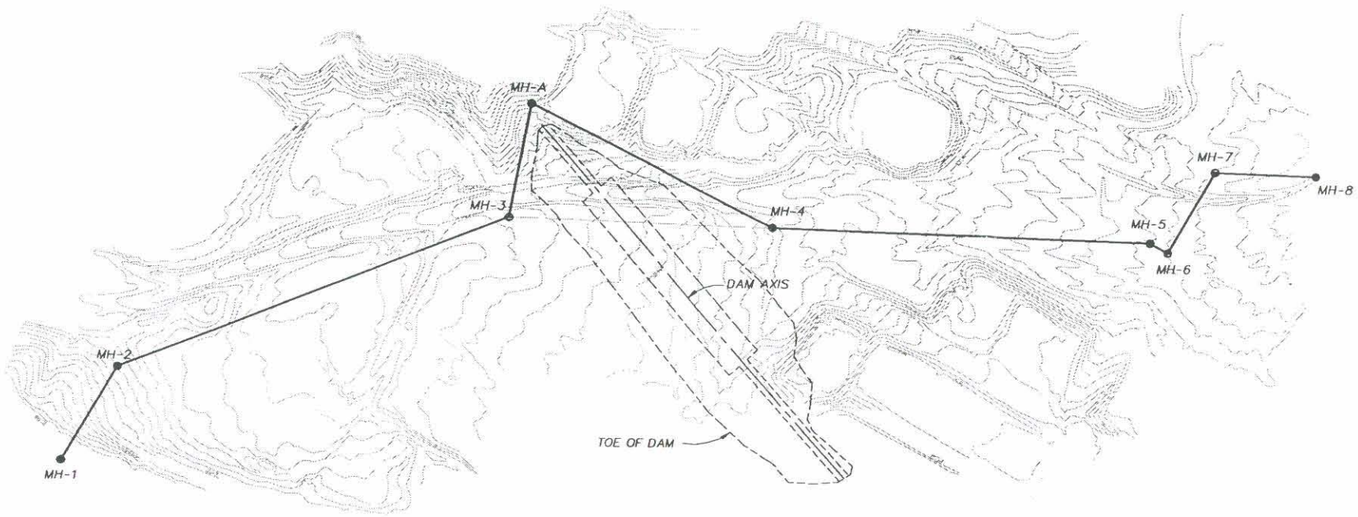
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

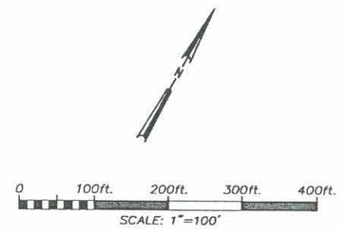
PLAN AND PROFILE
CASANDRO WASH EXISTING SEWER

SHEET 6
DWG NO.
DATE
PROJ NO.

PRELIMINARY

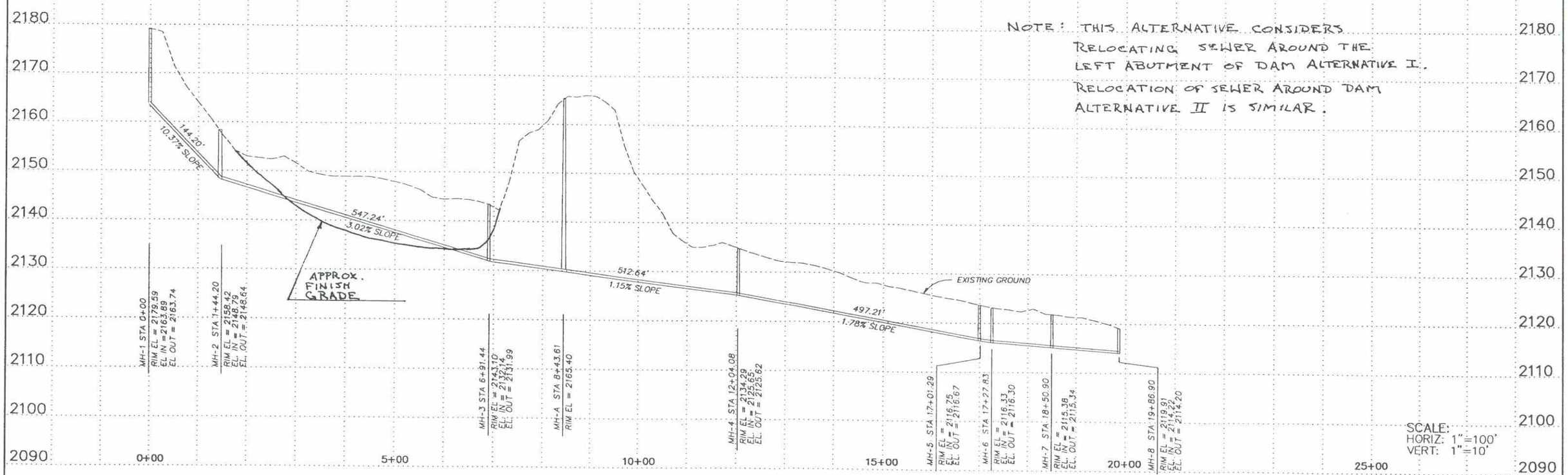
03-29-94 C:\USR2\PROJECTS\CWSWAPRO.DWG





DAM ALIGNMENT
ALTERNATIVE I

NOTE: THIS ALTERNATIVE CONSIDERS RELOCATING SEWER AROUND THE LEFT ABUTMENT OF DAM ALTERNATIVE I. RELOCATION OF SEWER AROUND DAM ALTERNATIVE II IS SIMILAR.



1=100

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DR CWSWAPRO	
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0 1"

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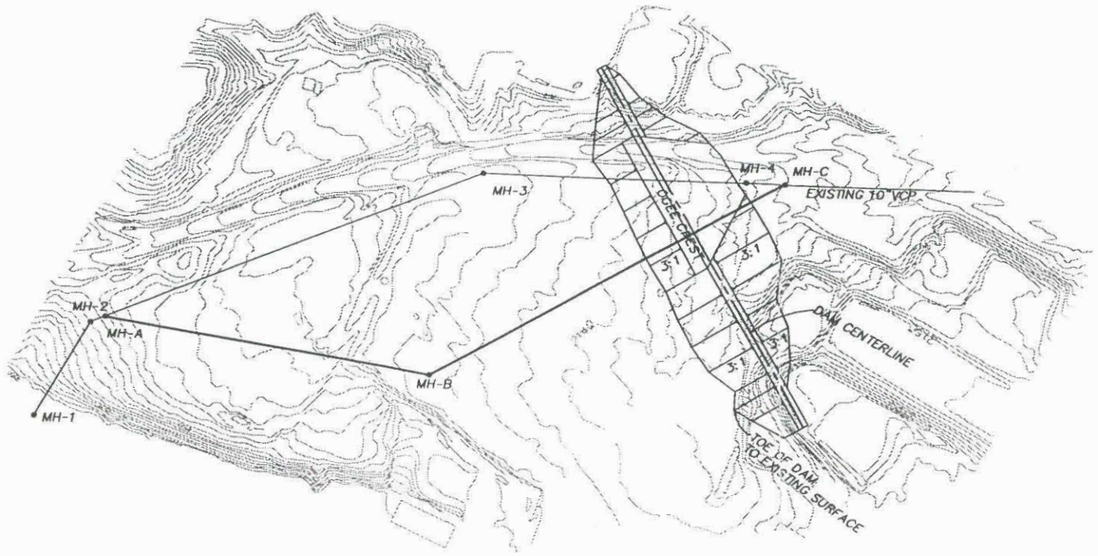
PLAN AND PROFILE
SEWER ALTERNATIVE A

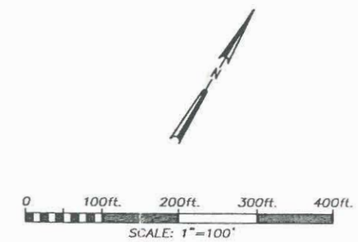
SHEET 7
DWG NO.
DATE
PROJ NO.

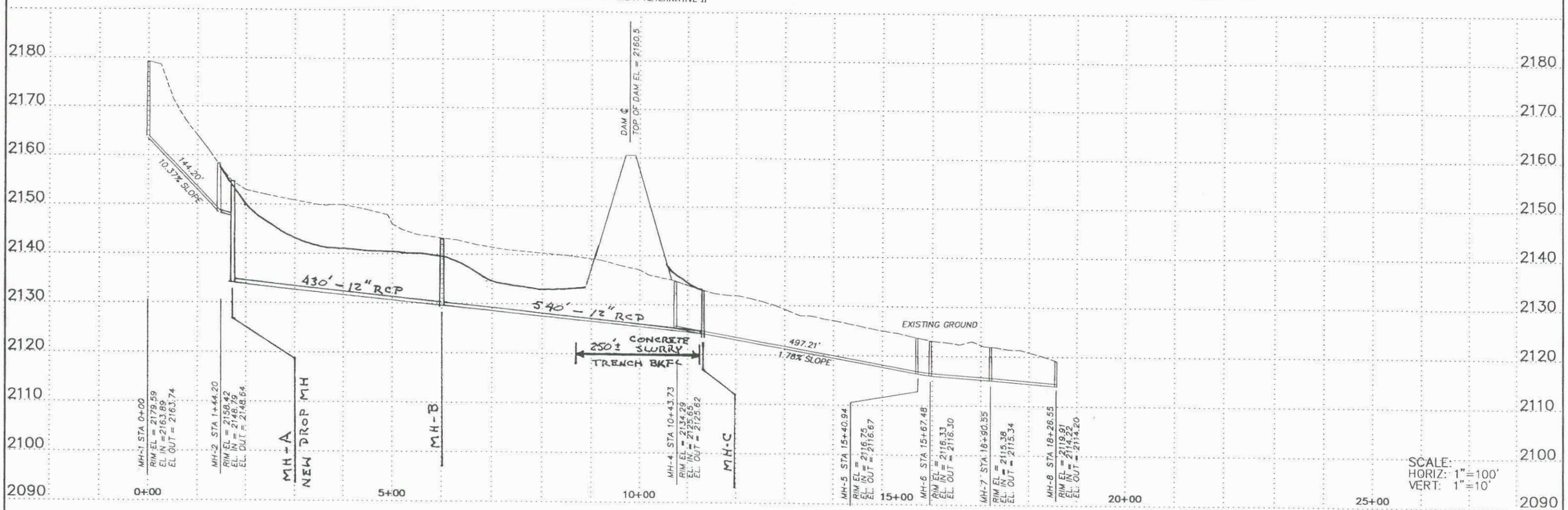
PRELIMINARY

04-07-94 C:\USRZ\PROJECTS\PROJECTS\CWSEWPRO.DWG



DAM ALIGNMENT ALTERNATIVE II





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DSGN				
DR PROJECTS\CWSEWPRO				
CHK				
APVD	NO.	DATE	REVISION	BY	APVD

1=100

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VERIFY SCALES

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0 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

PLAN AND PROFILE
SEWER ALTERNATIVE B

SHEET 8
DWG NO.
DATE
PROJ NO.

PRELIMINARY