CHOLLA POWER PLANT BOTTOM ASH MONOFILL

Periodic Run-on And Run-off Control System Plan

October 2021
AECOM Project 60664605

Delivering a better world

Prepared for:

Arizona Public Service
400 North 5th Street
Phoenix, AZ 85004

Prepared by:

AECOM
7720 North 16th Street, Suite 100
Phoenix, AZ 85020
aecom.com

Table of Contents

Attachment

Attachment A: AECOM, 2016, *Cholla Power Plant, Bottom Ash Monofill, Run-on and Run-off Control System Plan*, CH_RunOO_001_20161017, October 17, 2016.

1. Introduction

This periodic update to the Run-On and Run-Off Control System Plan for the Bottom Ash Monofill at Cholla Power Plant, operated by Arizona Public Service (APS), has been prepared in accordance with the requirements of Title 40 of the Code of Federal Regulations Part 257 (40 CFR 257) ("the Coal Combustion Residuals [CCR] Rule", or "the Rule") and the specific requirement of 40 CFR § 257.81(c)(4) that "(t)he owner or operator of the CCR unit must prepare periodic run-on and run-off control system plans required by paragraph (c)(1) of this section every five years."

2. Methodology

The methodology used to prepare this 2021 Update and Recertification of the Run-on and Run-off Control System Plan for the Bottom Ash Monofill at the Cholla Power Plant is for the certifying Qualified Professional Engineer (QPE) to:

1. Perform a documented review of the 5 years of annual inspection reports since 2016;
2. Perform a documented review of each major component of the contributing technical information from:
   a. AECOM, 2016. *Cholla Power Plant, Bottom Ash Monofill, Run-on and Run-off Control System Plan*, CH_RunOO_001_20161017, October 17, 2016 (hereafter referred to as the "2016 Plan" and incorporated and referenced directly as Attachment A to this document).
3. Consider and document whether the 2016 Plan and its conclusions:
   a. Meet the current reporting requirements of the Rule;
   b. Reflect the current condition of the structure, as known to the QPE and documented in the annual inspections;
   c. Are compromised by any identified issues of concern; and
   d. Are consistent with the standard of care of professionals performing similar evaluations in this region of the country; and
4. Identify any additional analyses, investigations, inspections, and/or repairs that should be completed in order to complete this 2021 Recertification.

This report documents the results of these considerations, incorporates the 2016 Plan as an Appendix, identifies any additional technical investigation or evaluations (if needed), and presents an updated certification by the QPE.

3. 2017–2021 Annual Inspection Reports

Information relevant to the current adequacy and performance of the run-on and run-off control system were reviewed. No issues were identified during the review that would affect the performance of the system and its compliance, as described in the 2016 Plan, with the requirements of 40 CFR § 257.81(c)(5).

4. 2016 Plan – Review by Section

Other than as described in the remainder of this section, the details presented in this section of the 2016 Plan adequately represent current conditions and satisfy the requirements of the Rule.

4.1 "Overview"

The details presented in this section of the 2016 Plan adequately represent current conditions and satisfy the requirements of the Rule.

4.2 "§257.81 (a)(1)(2) Run-on and Run-off Controls for CCR Landfills"

The 2016 Plan presents the details of a control system to capture and convey the 24-hour, 100-year off-site, run-on design storm event. The design storm exceeds the minimum (24-hour, 25-year) event required by §257.81 (a)(1).

The review addressed the suitability of the hydrologic basis used for the 2016 Plan. The methods used to estimate the rainfall and losses were based on the Arizona Department of Transportation *Highway Drainage Design Manual* published 1993. A newer manual was released in 2007 that is similar to the original manual. In this application, the 1993 Manual is assessed to be conservative in that it did not account for a reduction in the C-value for smaller return events (such as the 25-year).

The details presented in this section of the 2016 Plan adequately represent current conditions and satisfy the requirements of the Rule.

4.3 "§257.81 (b) Run-on and run-off controls for CCR landfills"

The 2016 Plan presents the details of a control system to capture, convey, and store the 24-hour, 25-year on-site, run-off design storm event as required by §257.81 (a)(2). As described in the 2016 Plan, there will be no discharge from the on-site retention basin.

The details presented in this section of the 2016 Plan adequately represent current conditions and satisfy the requirements of the Rule.

4.4 “§257.81 (c)(1)(2)(3)(4)(5) Run-on and run-off controls for CCR landfills”

The owner or operator continues to acknowledge and will comply with these requirements.

A certification of this Periodic Run-On and Run-Off Control Plan by a QPE is included in this document per the requirement of §257.81 (c)(5).

4.5 “§257.81 (d) Run-on and run-off controls for CCR landfills”

The owner or operator continues to acknowledge and will comply with these requirements.

5. Recommended Additional Technical Investigations or Evaluations

None identified and none recommended.

6. Conclusion

The 2016 Plan and its conclusions meet the current reporting requirements of the Rule, reflect the current condition of the structure as known to the QPE and documented in the annual inspections, are not compromised by any identified issues of concern, and are consistent with the standard of care of professionals performing similar evaluations in this region of the country.

7. Limitations

This document is for the sole use of APS on this project only and is not to be used for other projects. In the event that conclusions based upon the data presented in this document are made by others, such conclusions are the responsibility of others.

The Periodic Run-on And Run-off Control System Plan presented in this document is based on the 2016 Plan and relies and incorporates any Limitations expressed in that document.

The Certification of Professional Opinion in this report is limited to the information available to AECOM at the time this Assessment was performed in accordance with current practice and the standard of care. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this area performing the same services under similar circumstances during the same period. Professional judgments presented herein are primarily based on information from previous reports that have been assumed to be accurate, knowledge of the site, and partly on our general experience with dam safety evaluations performed on other dams.

No warranty or guarantee, either written or implied, is applicable to this work. The use of the word “certification” and/or “certify” in this document shall be interpreted and construed as a

Statement of Professional Opinion and is not and shall not be interpreted or construed as a guarantee, warranty, or legal opinion.

8. Certification Statement

Certification Statement for:

- Certification Statement 40 CFR § 257.81(c)(5) – Periodic Run-on and Run-Off Control System Plan for an Existing CCR Landfill
- CCR Unit: Arizona Public Service; Cholla Power Plant; Bottom Ash Monofill

I, Alexander W. Gourlay, being a Registered Professional Engineer in good standing in the State of Arizona, do hereby certify, to the best of my knowledge, information, and belief, that the information contained in this certification has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the information contained in this Periodic Run-On and Run-Off Control System Plan dated October 2021, including the technical content in Attachment A, meets the requirements of 40 CFR § 257.81.

Alexander W. Gourlay, P.E.
Printed Name

October 11, 2021
Date

CERTIFICATE NO.
22867
ALEXANDER W.
GOURLAY
Date Signed 10/11/2021

Attachment A:

AECOM, 2016. *Cholla Power Plant, Bottom Ash Monofill, Run-on and Run-off Control System Plan*, CH_RunOO_001_20161017, October 17, 2016.

ATTACHMENT A

AECOM, 2016. ***Cholla Power Plant, Bottom Ash Monofill, Run-on and Run-off Control System Plan*****, CH_RunOO_001_20161017, October 17, 2016.**

CHOLLA POWER PLANT
BOTTOM ASH MONOFILL
RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN
CH_RunOO_001_20161017

This *Run-on and Run-off Control System Plan* (Plan) document has been prepared specifically for the Bottom Ash Monofill (BAM) at the Cholla Power Plant in accordance with our understanding of the requirements prescribed in §257.81(3)(i) of the Federal Register, Volume 80, Number 74, dated April 17, 2015 (U. S. Government, 2015) for run-on and run-off controls associated with existing Coal Combustion Residual (CCR) landfills. Section §257.81 from the Federal Register is reproduced below for reference purposes. This document serves as the initial run-on and run-off control system plan described in §257.81(3)(i).

The BAM is an existing CCR landfill facility. The location of the BAM is illustrated on Exhibit 1. Calculations prepared previously in support of the facility operation have been referenced and reproduced herein to address the requirements listed.

<u>§257.81 Run-on and run-off controls for CCR landfills</u>

(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain:

(1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm; and

(2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.

(b) Run-off from the active portion of the CCR unit must be handled in accordance with the surface water requirements under §257.3-3.

(c) *Run-on and run-off control system plan –*

(1) *Content of the plan.* The owner or operator must prepare initial and periodic run-on and run-off control system plans for the CCR unit according to the timeframes specified in paragraphs (c)(3) and (4) of this new section. These plans must document how the run-on and run-off control systems have been designed and constructed to meet the applicable requirements of this section. Each plan must be supported by the appropriate engineering calculations. The owner or operator has completed the initial run-on and run-off control system plan when the plan has been placed in the facility's operating record as required by §257.105(g)(3).

(2) *Amendment of the plan.* The owner or operator may amend the written run-on and run-off control system plan at any time provided the revised plan is placed in the facility's operating record as required by §257.105(g)(3). The owner or operator must amend the written run-on and run-off control system plan whenever there is a change in conditions that would substantially affect the written plan in effect.

(3) *Timeframes for preparing the initial plan –*

(i) *Existing CCR landfills*. The owner or operator of the CCR unit must prepare the initial run-on and run-off control system plan no later than October 17, 2016.

(ii) *New CCR landfills and any lateral expansion of a CCR landfill*. The owner or operator must prepare the initial run-on and run-off control system plan no later than the date of initial receipt of CCR in the CCR unit.

(4) *Frequency for revising the plan*. The owner or operator of the CCR unit must prepare periodic run-on and run-off control system plans required by paragraph (c)(1) of this section every five years. The date of completing the initial plan is the basis for establishing the deadline to complete the first subsequent plan. The owner or operator may complete any required plan prior to the required deadline provided the owner or operator places the completed plan into the facility's operating record within a reasonable amount of time. In all cases, the deadline for completing a subsequent plan is based on the date of completing the previous plan. For purposes of this paragraph (c)(4), the owner or operator has completed a periodic run-on and run-off control system plan when the plan has been placed in the facility's operating record as required by §257.105(g)(3).

(5) The owner or operator must obtain a certification from a qualified professional engineer stating that the initial and periodic run-on and run-off control system plans meet the requirements of this section.

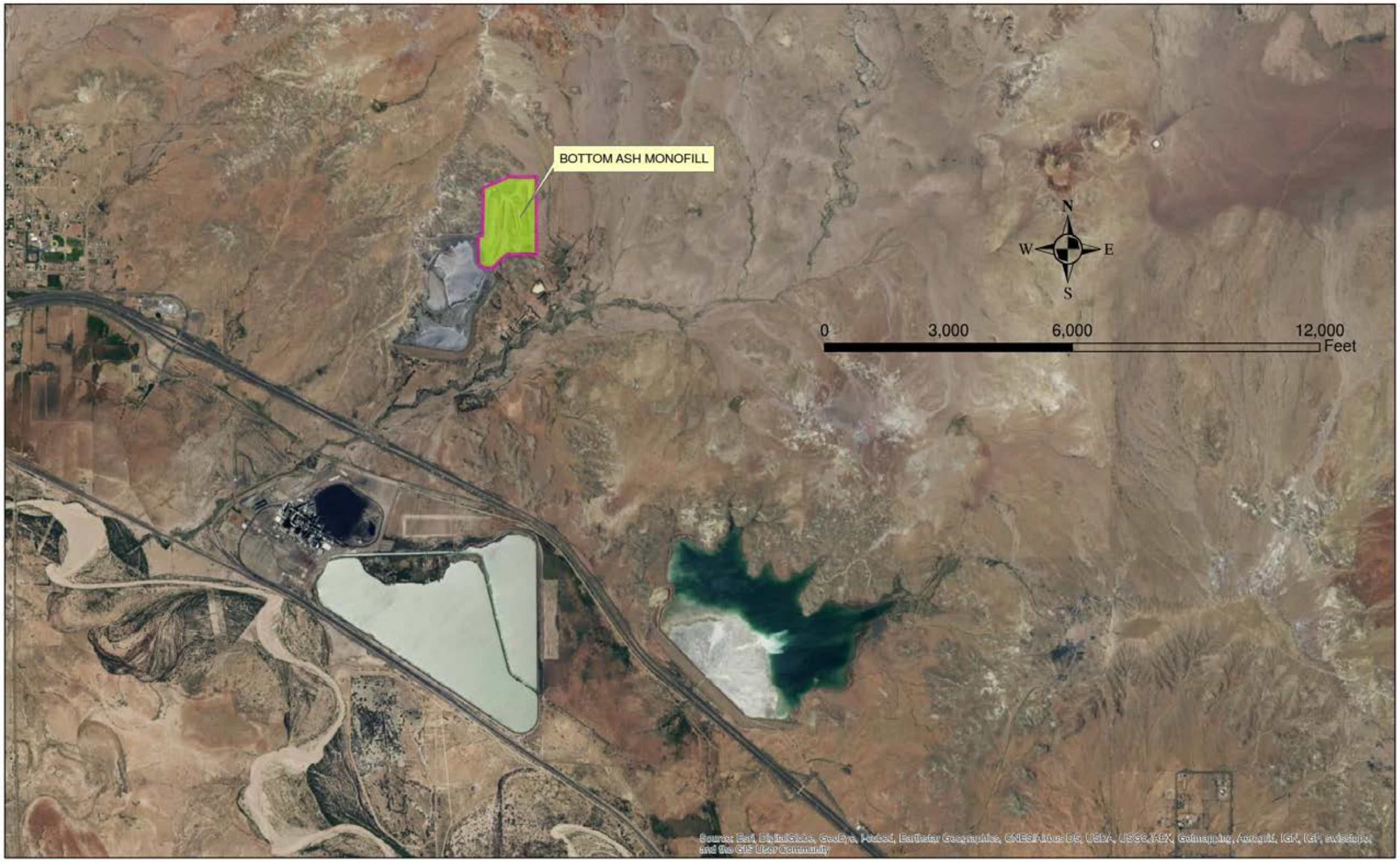
(d) The owner or operator of the CCR unit must comply with the record keeping requirements specified in §257.105(g), the notification requirements specified in §257.106(g), and the internet requirements specified in §257.107(g).

SITE INFORMATION	
Site Name / Address	Cholla Power Plant / 4801 Frontage Road, Joseph City, AZ 86032
Owner Name / Address	Arizona Public Service / 400 North 5th Street, Phoenix, AZ 85004
CCR Unit	Bottom Ash Monofill (BAM)

OVERVIEW

The Bottom Ash Monofill (BAM) located at the Cholla Power Plant is an existing CCR landfill. Construction of the BAM began in the late 1990s. An offsite flow channel system that intercepts and conveys offsite storm water from a 98-acre contributing watershed with outfall to the south is located immediately upstream of the BAM.

This run-on / run-off control plan describes the existing controls that preclude run-on of offsite storm flows from the landfill and the run-off of onsite storm flows from the landfill. Run-on / run-off control systems that prevent flow onto and from active CCR units from a 24-hour, 25-year storm are required. An existing diversion channel located on the perimeter of the BAM was designed and constructed to collect and convey contributing offsite flows in order to fulfill this requirement.



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Exhibit 1 – Bottom Ash Monofill (BAM) at Cholla Power Plant Facility

§257.81 (a)(1)(2) Run-on and run-off controls for CCR landfills	
(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain: (1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm;	An offsite flow collection system is constructed on the upstream perimeter of the BAM. This system captures and conveys the 24-hour, 100-year offsite / run-on flows produced by the 98-acre offsite watershed around the project site and toward one of three historic discharge points. The historic outfall discharge points have been maintained with the use of undersized culverts placed within the offsite flow channel that allow excess flow to overtop the channel at historic discharge points as shown on the **Cholla Generating Station, Ash Monofill APP** Plan (URS 2009 A). This 100-year storm magnitude design exceeds the 24-hour, 25-year requirement shown in §257.81(a)(1). The **Cholla Generating Station, Ash Monofill APP** Plan is included in Appendix 1. Estimates of the 24-hour, 100-year run-on peak flows captured and conveyed within the perimeter channel system are based on the ***Cholla Power Plant, Ash Monofill Drainage Study, Preliminary Drainage Report*** (URS 2009 B). The 24-hour, 100-year offsite peak flows were estimated with the use of the rational method of hydrology for three offsite drainage areas identified below: ▪ OFF1: 23.8 cfs ▪ OFF2: 50.7 cfs ▪ OFF3: 60.9 cfs These 24-hour, 100-year run-on peak flows to the BAM Site are intercepted and conveyed in a trapezoidal channel system characterized by seven sections. The sections include a 10-foot bottom width, 2.5H: 1V side slopes, maximum channel depth of 5 feet, longitudinal slope ranging from 0.5% to 1.04%, and riprap erosion protection lining. The trapezoidal channel segment design and conveyance characteristics by Channel Section

	include the following: ▪ Peak Flows: o Channel Section 1: 25 cfs o Channel Section 2: 80 cfs o Channel Section 3: 140 cfs o Channel Section 4: 150 cfs o Channel Section 5: 80 cfs o Channel Section 6: 80 cfs o Channel Section 7: 25 cfs ▪ Longitudinal Slope: o Channel Section 1: 0.0089 ft/ft o Channel Section 2: 0.0104 ft/ft o Channel Section 3: 0.0050 ft/ft o Channel Section 4: 0.0100 ft/ft o Channel Section 5: 0.0100 ft/ft o Channel Section 6: 0.0100 ft/ft o Channel Section 7: 0.0050 ft/ft ▪ Normal Depth: o Channel Section 1: 0.73 feet o Channel Section 2: 1.35 feet o Channel Section 3: 2.22 feet o Channel Section 4: 1.91 feet o Channel Section 5: 1.36 feet o Channel Section 6: 1.36 feet o Channel Section 7: 0.86 feet The normal depth calculations for the offsite flow channel system, developed as part of the ***Cholla Power Plant, Ash Monofill Drainage Study, Preliminary Drainage Report*** (URS 2009 B) are included in Appendix 2.
(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain: (2) A run-off control system from the active portion of the CCR unit to collect and control at	An existing onsite storage basin located at the BAM landfill facility is designed to collect the onsite runoff volume generated by a 25-year, 24-hour storm which is estimated to be 5.2 acre-feet. The BAM yields a total 25-year, 24-hour storm water runoff volume of 5.23 acre-feet from the

least the water volume resulting from a 24-hour, 25-year storm.	onsite portion of the BAM based on the following parameters: ▪ Surface Area: 47.2 acres ▪ Runoff Coefficient: 0.60 ▪ 25-year, 24-hour Precipitation Depth: 2.22 inches The ***Cholla Power Plant, Ash Monofill Drainage Study, Preliminary Drainage Report***, dated February 2009 indicates that the onsite storm water storage basin adjacent to the BAM provides a volume of 8.3 acre-feet at a depth of 12-feet and a surface area of 1.04 acres. This exceeds the 25-year, 24-hour storm water runoff volume of 5.23 acre-feet. The additional volume provided may accommodate sediment in addition to surface water resulting from dust control activities and compaction efforts. The storm water runoff and storage volume capacity calculations are included in Appendix 2.
§257.81 (b) Run-on and run-off controls for CCR landfills	
(b) Run-off from the active portion of the CCR unit must be handled in accordance with the surface water requirements under §257.3-3.	Onsite 25-year, 24-hour storm water runoff produced from the BAM Site is accommodated by a storm water storage basin contiguous to the BAM and does not discharge into waters of the United States.
§257.81 (c)(1)(2)(3)(4)(5) Run-on and run-off controls for CCR landfills	
(c)(1) *Content of the plan.* The owner or operator must prepare initial and periodic run-on and run-off control system plans for the CCR unit according to the timeframes specified in paragraphs (c)(3) and (4) of this section. These plans must document how the run-on and run-off control systems have been designed and constructed to meet the applicable requirements of this section. Each plan must be supported by appropriate	This *Run-on and Run-off Control System Plan* serves as the initial plan prescribed herein.

engineering calculations. The owner or operator has completed the initial run-on and run-off control system plan when the plan has been placed in the facility's operating record as required by §257.105(g)(3).	
(c)(2) *Amendment of the Plan*. The owner or operator may amend the written run-on and run-off control system plan at any time provided the revised plan is placed in the facility's operating record as required by §257.105(g)(3). The owner or operator must amend the written run-on and run-off control system plan whenever there is a change in conditions that would substantially affect the written plan in effect.	The owner or operator acknowledges and will comply with this requirement.
(c)(3*) Timeframes for preparing the initial plan* – (i) *Existing CCR landfills*. The owner or operator of the CCR unit must prepare the initial run-on and run-off control system plan no later than October 17, 2016. (ii) *New CCR landfills and any lateral expansion of a CCR landfill*. The owner or operator must prepare the initial run-on and run-off control system plan no later than the date of initial receipt of CCR in the CCR Unit	The BAM is an existing CCR landfill at Cholla Power Plant. The run-on and run-off control system plan is described and included herein. The owner or operator acknowledges and will comply with this requirement.
(c)(4) *Frequency for revising the plan*. The owner or operator of the CCR unit must prepare periodic run-on and run-off control system plans required by paragraph (c)(1) of this section every five years. The date of completing the initial plan is the basis for establishing the deadline to complete the first subsequent plan. The owner or operator may complete any required plan prior to the required deadline provided the owner or operator places the completed plan into the facility's operating record within a reasonable amount of time. In all cases, the deadline for completing a subsequent	The owner or operator acknowledges and will comply with this requirement.

plan is based on the date of completing the previous plan. For purposes of this paragraph (c)(4), the owner or operator has completed a periodic run-on and run-off control system plan when the plan has been placed in the facility's operating record as required by §257.105(g)(3).	
(c)(5) The owner or operator must obtain a certification from a qualified professional engineer stating that the initial and periodic run-on and run-off control system plans meet the requirements of this section.	Certification by a professional engineer is included as an attachment to this document.
§257.81 (d) Run-on and run-off controls for CCR landfills	
(d) The owner or operator of the CCR unit must comply with the recordkeeping requirements specified in §257.105(g), the notification requirements specified in §257.106(g), and the internet requirements specified in §257.107(g).	The owner or operator acknowledges and will comply with this requirement.

References

U. S. Government, April 17, 2015, ***Federal Register, Volume 80, Number 74.***

URS Corporation, February 2009, ***Cholla Generating Station, Ash Monofill APP***.

URS Corporation, February 2009, ***Cholla Power Plant, Ash Monofill Drainage Study, Preliminary Drainage Report.***

Certification Statement 40 CFR § 257.81(c)(5) – Initial Run-on and Run-Off Control System Plan for an Existing CCR Landfill

CCR Unit: Arizona Public Service; Cholla Power Plant; Bottom Ash Monofill

I, Alexander W. Gourlay, being a Registered Professional Engineer in good standing in the State of Arizona, do hereby certify, to the best of my knowledge, information, and belief, that the information contained in this certification has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the information contained in the initial run-on and run-off control system plan dated August, 31, 2016 meets the requirements of 40 CFR § 257.81.

Alexander W. Gourlay, P.E.

Printed Name

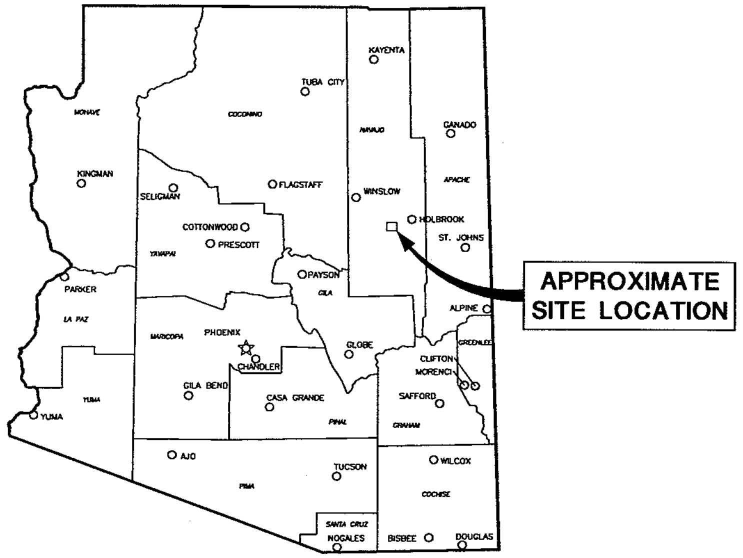
August 31, 2016

Date

CERTIFICATE NO.
22867
ALEXANDER W.
GOURLAY
Date Signed 8-31-16
EXPIRES 12-31-2016

APPENDIX 1 – CHOLLA GENERATING STATION, ASH MONOFILL APP PLAN

ARIZONA PUBLIC SERVICE
CHOLLA GENERATING STATION
CHOLLA ASH MONOFILL APP
JOSEPH CITY, ARIZONA



LOCATION MAP

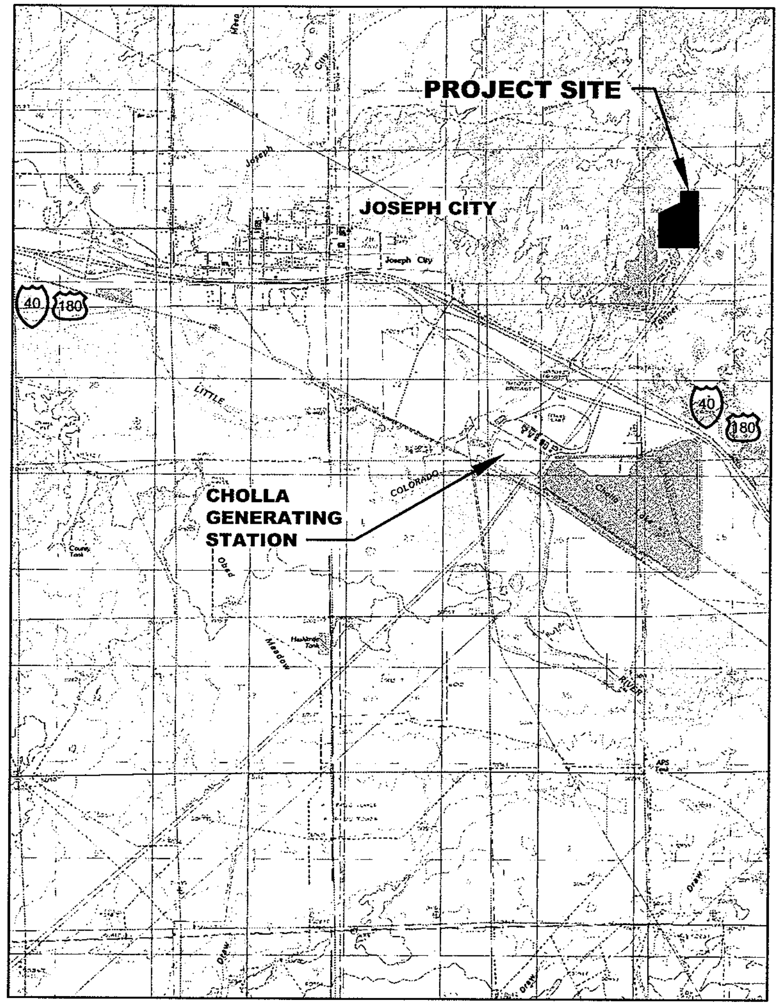
NTS

OWNER: ARIZONA PUBLIC SERVICE COMPANY
CHOLLA GENERATION STATION
JOSEPH CITY, AZ 85XXX

A.P.S. PROJECT MANAGER:
PROJECT MANAGER PERSON
(602) XXX-XXXX
(602) XXX-XXXX FAX

ENGINEER: URS CORPORATION
7720 N. 16TH STREET, SUITE 100
PHOENIX, AZ 85020

ENGINEER OF RECORD
TODD RINGSMUTH, P.E.
(602) 371-1100
(602) 371-1615 FAX



VICINITY MAP

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SCALE IN FEET

DRAWING INDEX

DRAWING NO.	REV.	DRAWING TITLE
5548-CHOLLA-ASH-XX01	A	COVER SHEET
5548-CHOLLA-ASH-XX02	A	GENERAL SITE PLAN
5548-CHOLLA-ASH-XX03	A	SECTION AND DETAILS
5548-CHOLLA-ASH-XX04	A	PLAN AND PROFILES
5548-CHOLLA-ASH-XX05	A	PLAN AND PROFILES
5548-CHOLLA-ASH-XX06	A	SECTION AND DETAILS

PRELIMINARY
NOT FOR
CONSTRUCTION

URS
7720 N. 16th Street Suite 100
Phoenix, Arizona 85020
(602) 371-1100

NO.	DATE	REVISION	DWN	CHD	EXD	RVWD	APVD	W.A.
A	02-09	APP SUBMITTAL	RBZ	KLP	CDW	TER		

CHOLLA GENERATING STATION
ASH MONOFILL APP

COVER SHEET

APS

SCALE NOTED
DATE 02-09

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CHD KLP
EXD CDW
RVWD TER

APPROVED
XXX
ENGINEERING SUPERVISOR

W A
XXX

UNIT	DISC	TYPE	SYS	NUMBER	SHEET
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Blue Stake Center
CALL COLLECT

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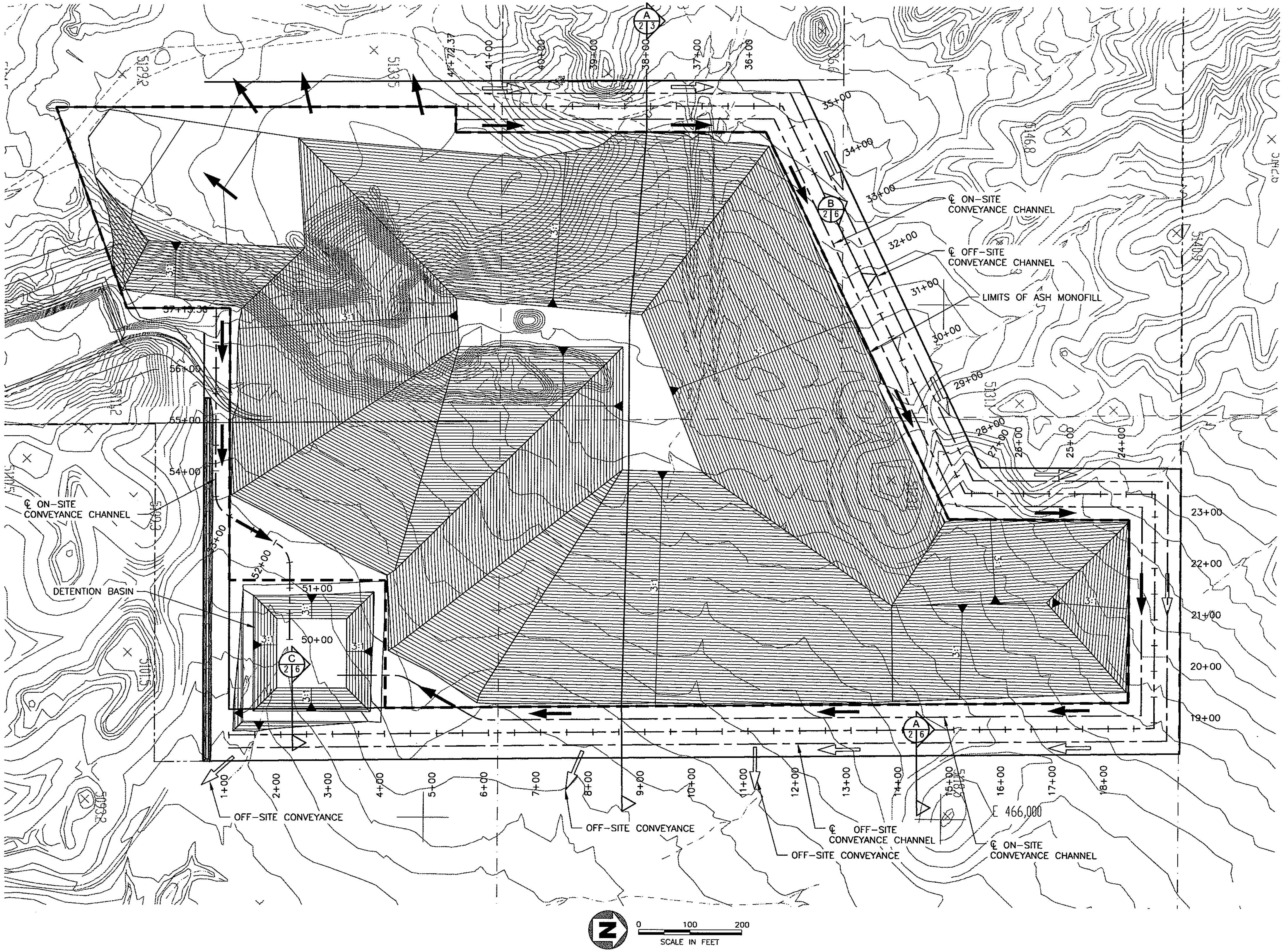

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CHOLLA GENERATING STATION
ASH MONOFILL APP

GENERAL SITE PLAN

APS

SCALE NOTED
DATE 02-09

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APPROVED
XXX
ENGINEERING SUPERVISOR

W A
XXX

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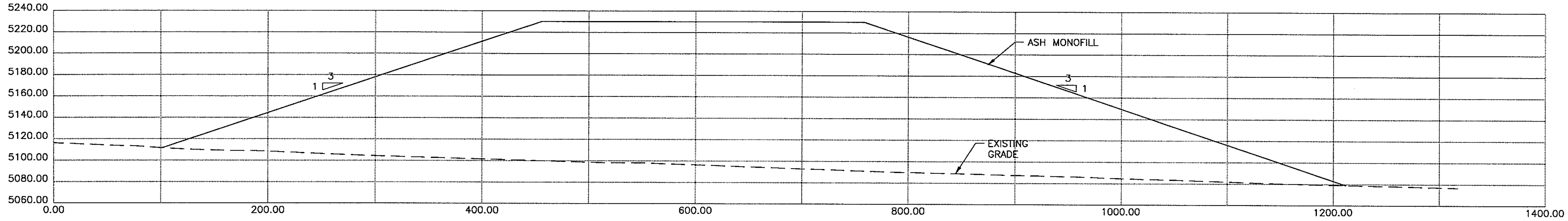

SECTION A 2|3

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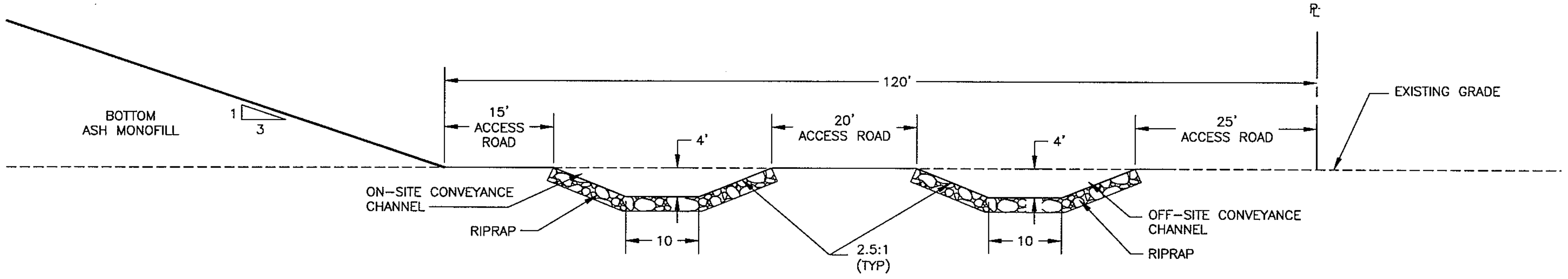

SECTION B 2|3

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Phoenix, Arizona 85020
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PRELIMINARY
NOT FOR
CONSTRUCTION

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CHOLLA GENERATING STATION
ASH MONOFILL APP

SECTION AND DETAILS

APS

SCALE NOTED
DATE 02-09

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W A XXX

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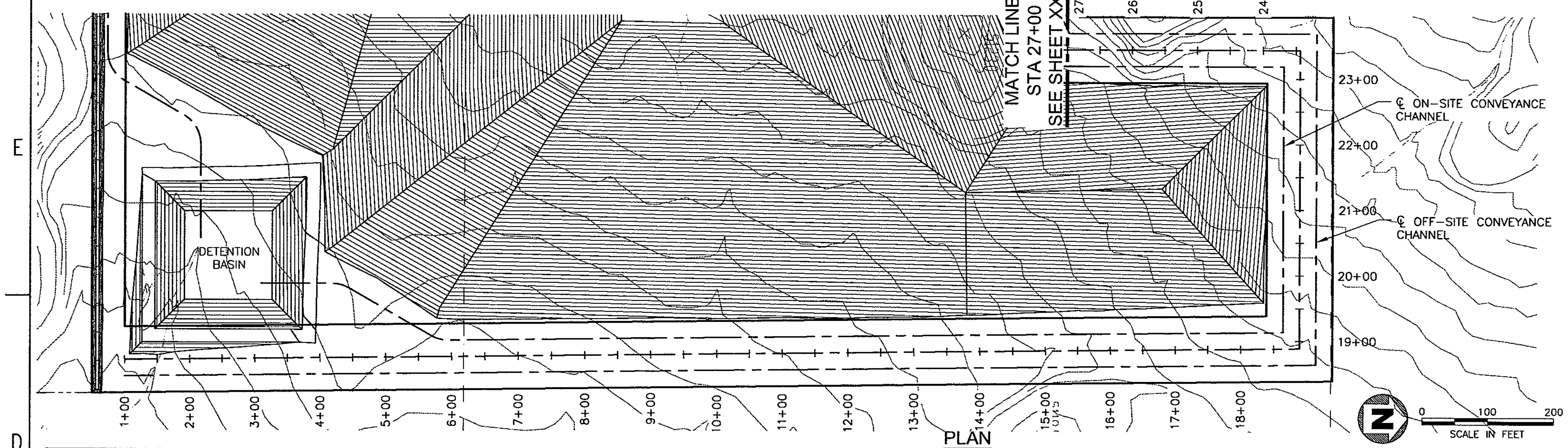
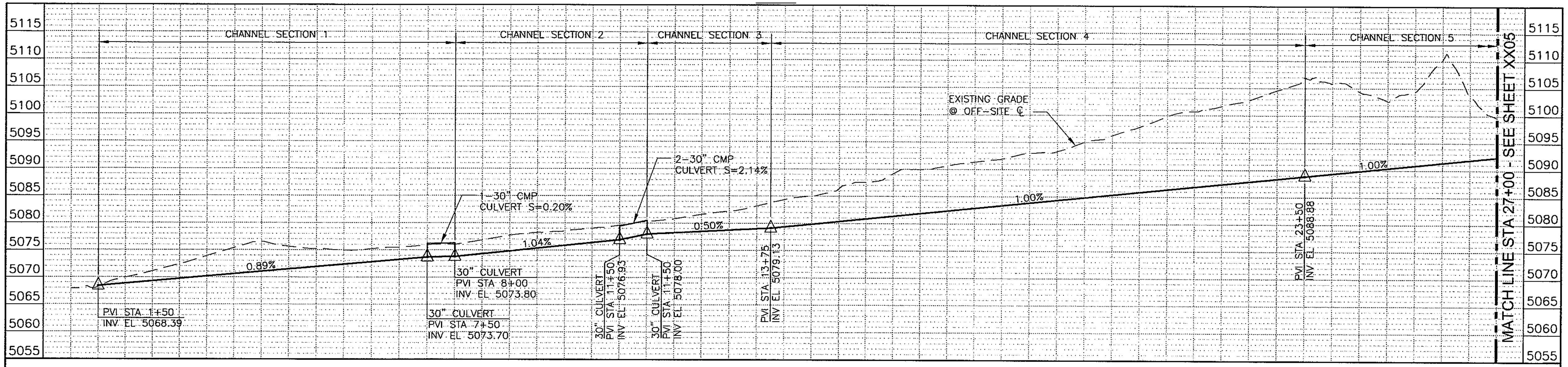
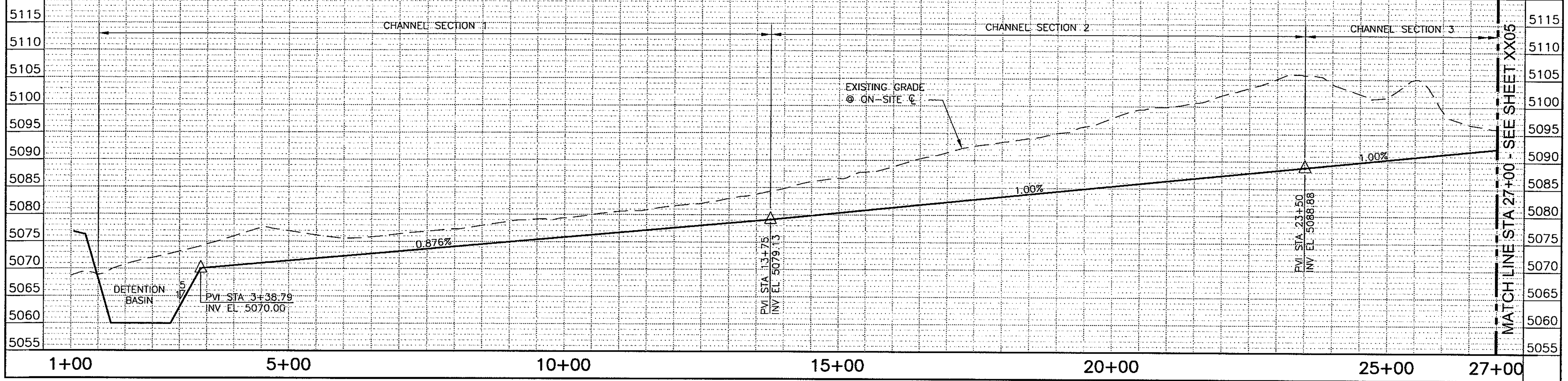


PLAN



OFFSITE CHANNEL PROFILE



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ASH MONOFILL APP

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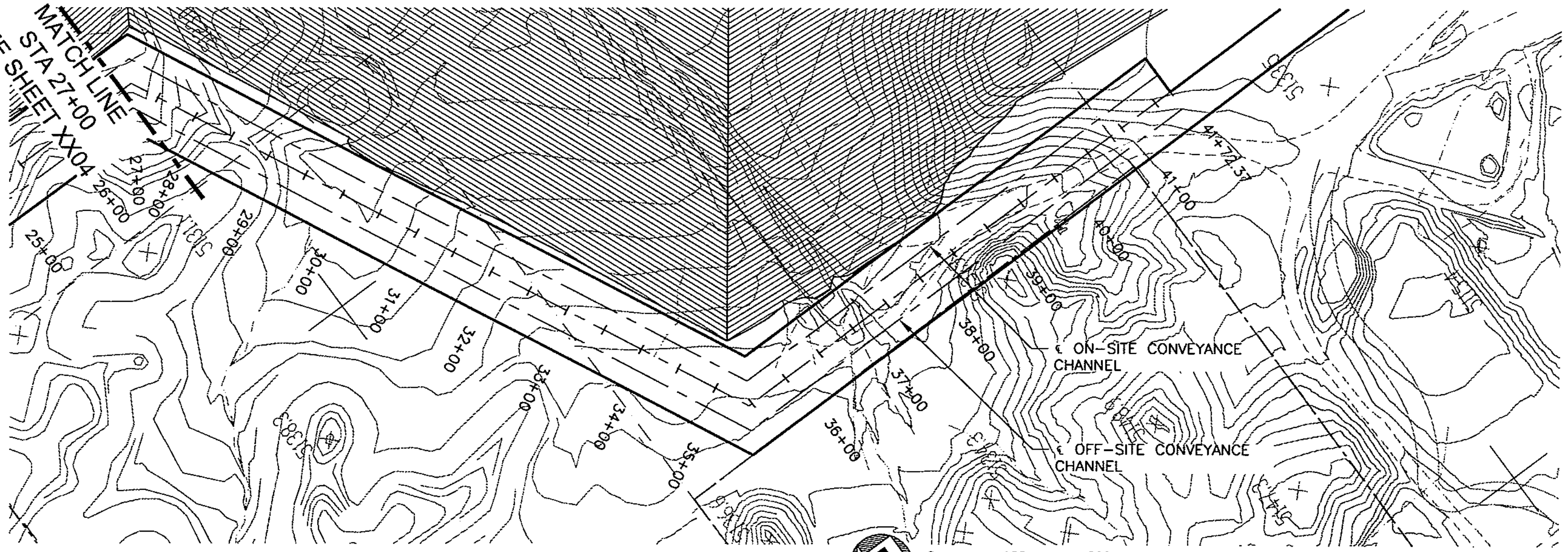

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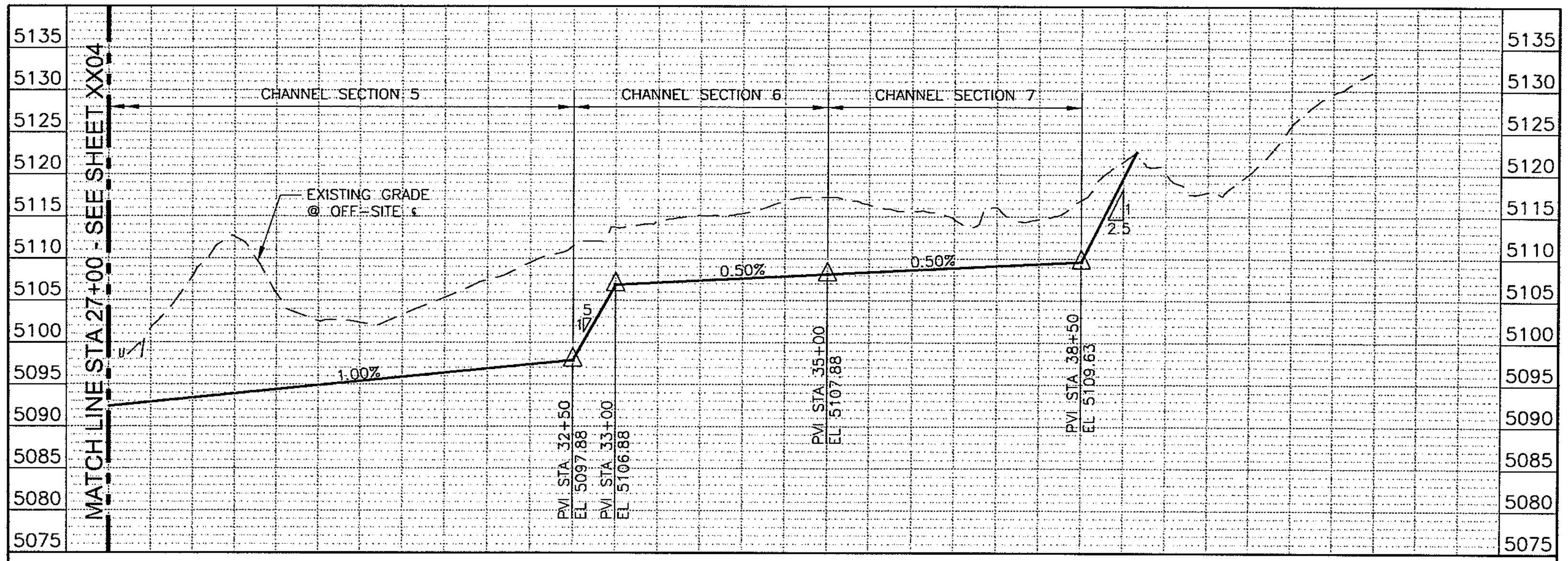

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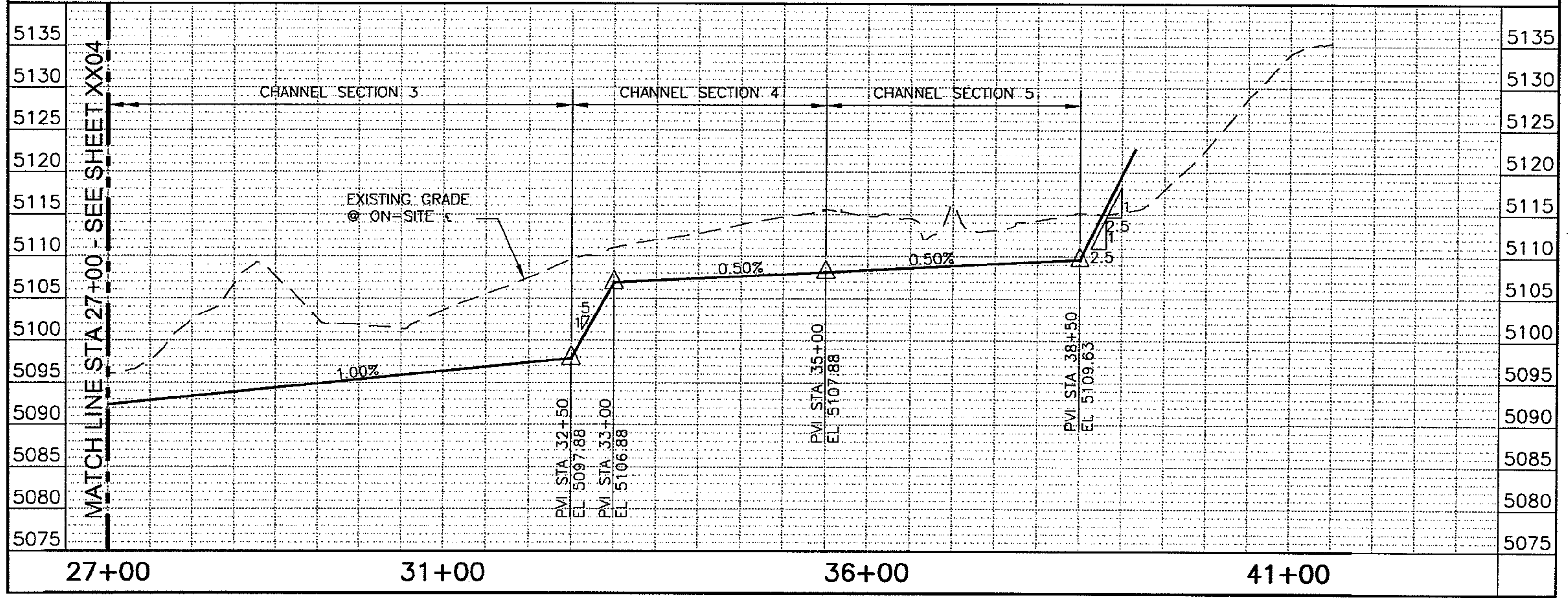

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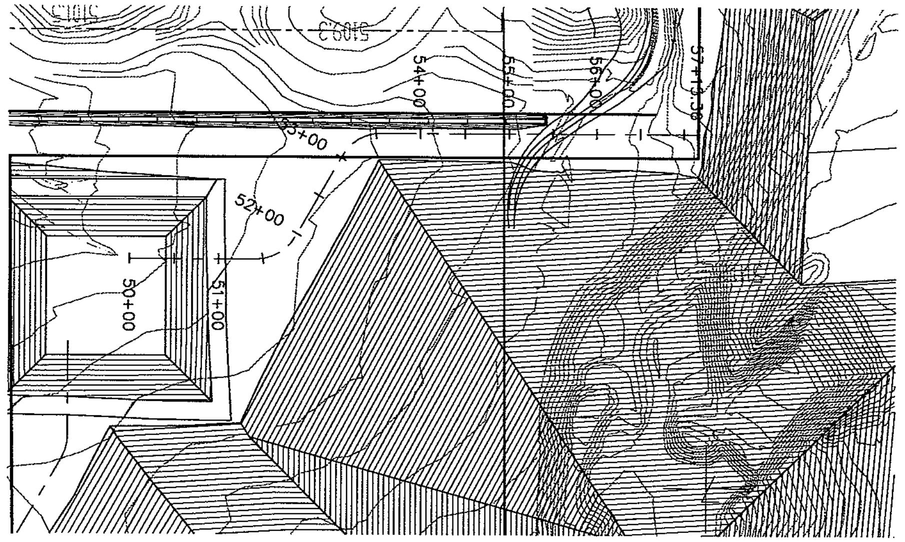

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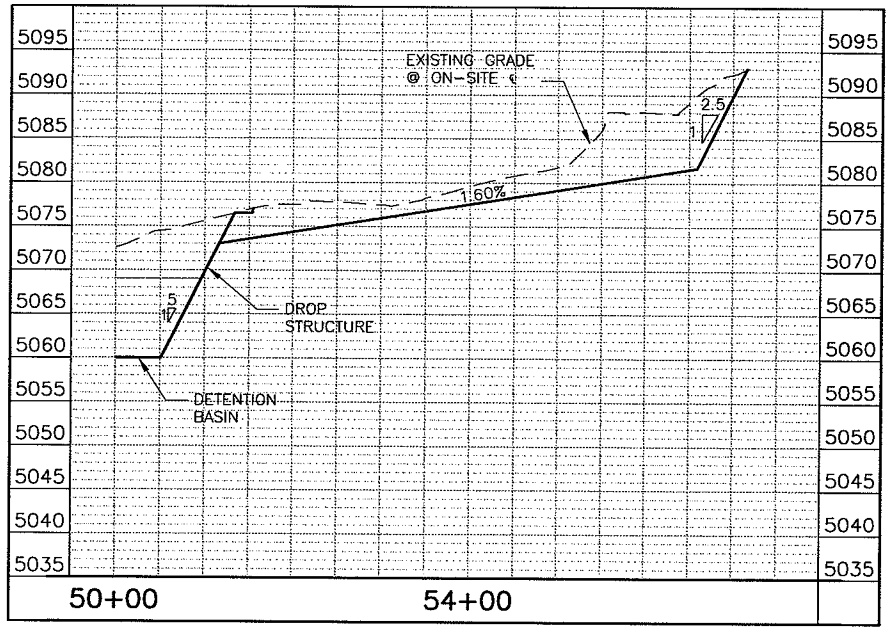

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ON-SITE CHANNEL PROFILE

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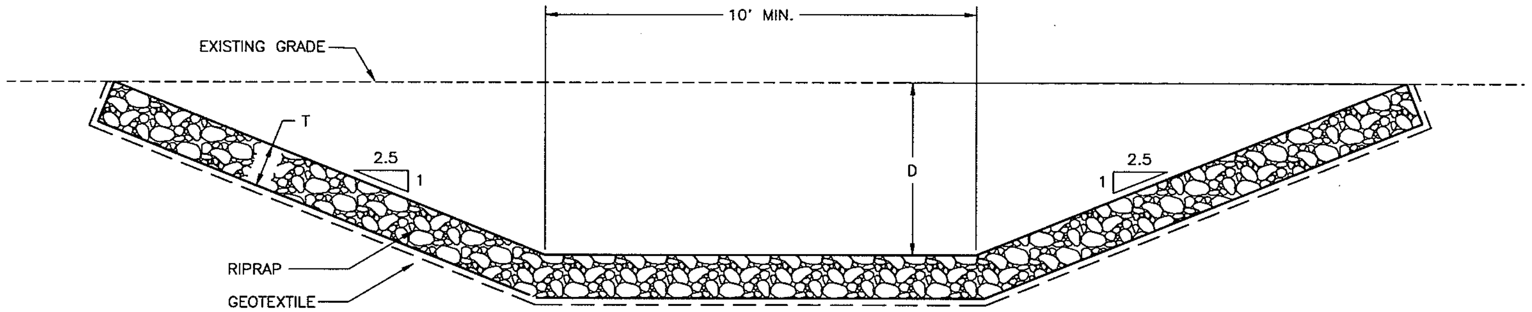


TYPICAL CHANNEL
SECTION A 2|6

0 2 4
SCALE IN FEET

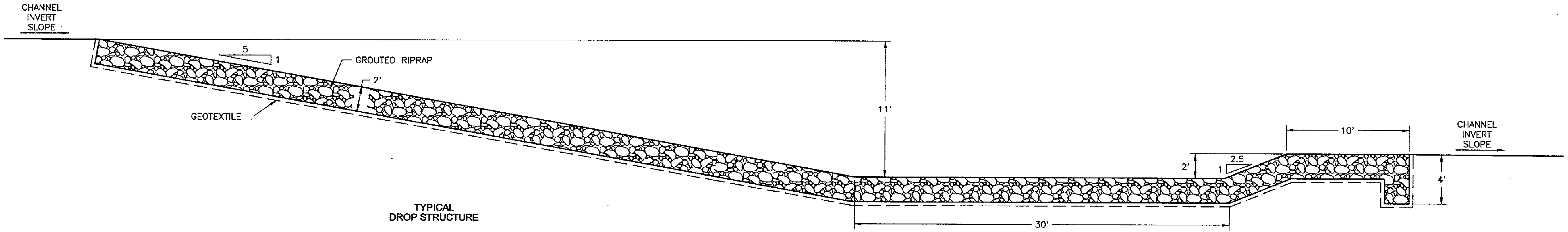
ON-SITE CHANNEL TABLE

CHANNEL SECTION	STA	STA	RIPRAP D50 (IN)	T (FT)	CHANNEL DEPTH	CHANNEL SLOPE
1	1+50	13+75	4	1	3	0.876%
2	13+75	23+50	4	1	4	1.00%
3	23+50	32+50	4	1	4	1.00%
4	33+00	35+00	4	1	4	0.50%
5	35+00	38+50	4	1	4	0.50%
1	50+00	56+58.13	4	1	4	1.60%

OFF-SITE CHANNEL TABLE

CHANNEL SECTION	STA	STA	RIPRAP D50 (IN)	T (FT)	CHANNEL DEPTH	CHANNEL SLOPE
1	1+50	7+50	4	1	3	0.885%
2	8+00	11+00	4	1	4	1.04%
3	11+50	13+75	4	1	4	0.50%
4	13+75	23+50	4/6	1	4	1.00%
5	23+50	32+50	4	1	4	1.00%
6	33+00	35+00	4	1	4	0.5%
7	35+00	38+50	4	1	3	0.5%

NOTE:
1. DROP STRUCTURE D50=1FT, THICKNESS IS 2xD50=2FT AND WILL BE GROUTED.



TYPICAL
DROP STRUCTURE
SECTION B 2|6

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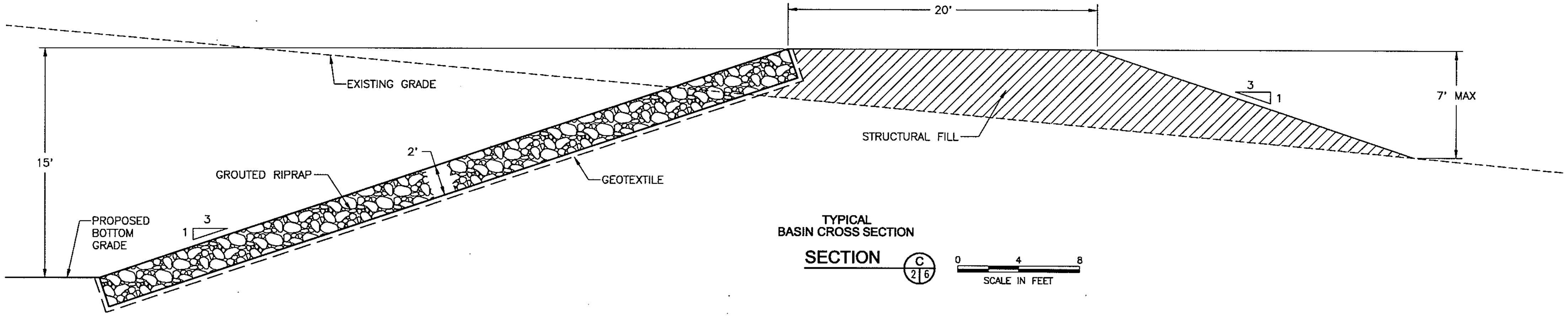
SCALE IN FEET



TYPICAL
BASIN CROSS SECTION
SECTION C 2|6

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CHOLLA GENERATING STATION
ASH MONOFILL APP

SECTION AND DETAILS

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ENGINEERING SUPERVISOR

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APPENDIX 2 - CHOLLA POWER PLANT, ASH MONOFILL DRAINAGE STUDY, PRELIMINARY DRAINAGE REPORT

CHOLLA POWER PLANT
ASH MONOFILL DRAINAGE STUDY
PRELIMINARY DRAINAGE REPORT

Prepared for
NAVAJO COUNTY

URS Job No. 23445548
February 2009

Cholla Power Plant - Ash Monofill

Drainage Study

Preliminary Drainage Report

Prepared for:

Navajo County

This report is based on data, site conditions and other information that are generally applicable as of 2009, and the conclusions and recommendations herein are therefore applicable only to that period.

This report is preliminary and is not to be used as the sole basis for final design or for construction or as a basis for major capital decisions. Further analysis of the study area should be performed prior to any designs or decisions.

February 2009

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1.0 INTRODUCTION

This drainage report presents the hydrologic and hydraulic analysis completed for the proposed expansion to the Cholla Generating Station Ash Monofill for the Arizona Public Service (APS). This report will be included as a portion of the revised Aquifer Protection Permit that will be submitted to the Arizona Department of Environmental Quality (ADEQ). The purpose of this analysis was to calculate the pre-development and post-development flows to ensure the proposed design would not increase historic flow amounts and discharge points.

1.1 SITE LOCATION AND DESCRIPTION

The Ash Monofill area is in eastern Arizona located on the Arizona Public Service (APS) Cholla Generating Station property, approximately 2.5 miles east of the town of Joseph City, Arizona, as shown in Figure 1. The site covers approximately 50 acres and is north of Interstate 40. The study area encompasses all of the off-site drainage areas for the proposed Ash Monofill, which covers approximately 100 acres.

2.0 FEDERAL EMERGENCY MANAGEMENT AGENCY FLOODPLAIN CLASSIFICATION

The project site is located in the flood hazard area represented by Zone X of the National Flood Insurance Program, based on Flood Insurance Rate Map Number 04017C3308E and 04017C3310E, revised September 26, 2008 (see Figure 3). The Zone X classification indicates the following:

> *Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1-foot with drainage area less than one square mile.*

3.0 HYDROLOGY

3.1 METHODOLOGY

The hydrologic analysis for the Ash Monofill site was computed using the Rational Method based on the *Arizona Department of Transportation Highway Drainage Design Manual, Hydrology* (*ADOT Drainage Manual*) (ADOT 1993). This methodology can be used to estimate peak discharges and runoff volumes for small, uniform drainage areas that are less than 160 acres in size. The largest existing or developed drainage basin for this proposed expansion project is approximately 60 acres, which is much less than the 160 acre maximum threshold. The peak discharges and runoff volumes were used to design the offsite and onsite collection system. The topographic and soil data information were collected to assist in the analysis.

3.2 TOPOGRAPHY

Topography was provided by APS at 2-foot contour intervals and by United Stated Geological Survey's topographic maps at 5-foot contour intervals. All topographic data was generated in North American Vertical Datum (NAVD) 1988 for the vertical dimension and in North American Datum 1983, Arizona State Plane East, for the horizontal. The combined survey data were used as guidance for delineating drainage basins (see Figure 4).

3.3 SOILS

Soil data was obtained from the Natural Resources Conservation Service (NRCS) online soil survey site (NRCS 2008). There are two existing soil types in the vicinity of the proposed development. The first soil is Gypsiorthids-Torriothents, 5 to 60 percent slopes and the second soil is Brunswick Sandy Clay Loam, 1 to 5 percent slopes. The two soils belong to Hydrologic Soil Group B and this information was used to determine coefficient values for the Rational Method calculations. This information has been included in Appendix B.

3.4 HYDROLOGIC MODELING PARAMETERS

The *ADOT Drainage Manual* was used to determine the hydrologic parameters to be used in the Rational Method. A detailed discussion of the hydrologic parameter calculations is provided in the following sections.

3.4.1 Rainfall

The 100-year, 24-hour storm event was used as the design storm for the offsite collection system and the 25-year, 24-hour storm was used for the onsite collection system and retention basin. These are the design storms specified for use by ADEQ. The rainfall depths were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 (NOAA 2008). This information was used to create a site-specific intensity-duration-frequency (I-D-F) curve that was used in the Rational Method. The 100-year, 24-hour rainfall amount used in the analysis is 2.77 inches and the 25-year, 24-hour rainfall is 2.22 inches. The rainfall information and I-D-F calculation is included in Appendix A.

3.4.2 Drainage Areas

The existing drainage area basin boundaries for the study area are shown in Figure 4. The watershed delineations were performed using the 2-foot and 5-foot contours. The existing information was used to determine the pre-development discharges and historic outfall locations. The design of the proposed expansion will maintain the historic outfall locations and will ensure the post-development flows are below the pre-development flows.

The post-development drainage areas were delineated based on the proposed improvements within the APS property. The post-development drainage basins are shown on Figure 5. The onsite basins will be conveyed by channels to a retention basin and the offsite basins will be routed around the property to their historic outfall locations.

3.4.3 Rational Coefficient

The rational coefficients were selected based on the land use and vegetation cover using Figure 2-5 from the *ADOT Drainage Manual* (ADOT 1993). The study area was considered to be Upland Rangeland with a vegetation cover of approximately 10 percent. The soil in the vicinity of the project site belongs to the Hydrologic Soil Type B. Based on this information, the study area was considered to have a rational coefficient of 0.30 for existing conditions. The soil that will be used for the landfill cover will be a clay soil with little or no vegetation. This soil type was selected to minimize rainfall infiltratration into the landfill and will have a rational coefficient of 0.60. This information has been included in Appendix B.

3.4.4 Time of Concentration

The time of concentrations for each of the sub-basins was calculated based on Equation 2-2, below, and following parameters from the Rational Method in the *ADOT Drainage Manual* (ADOT 1993):

$$T_c = 11.4 L^{0.5} {K_b}^{0.52} S^{-0.31} i^{-0.38}$$

Where T_c = time of concentration in hours

L = length of the longest flow path in feet per mile

K_b = watershed resistance coefficient

S= slope of the longest flow path in feet per mile

i = average rainfall intensity, in inches per hour, for a duration of rainfall equal to T_c, unless T_c is less than 10 minutes, in which case (i) is for a 10-minute duration

A summary of the time of concentration is provided in Table 1 below and in Appendix B.

Table 1

Time of Concentration Summary[1]

Sub-Basin	L (miles)	Area (ac)	H (feet) (change in elevation along L)	S (feet/mile)	i (inches/ hour)	T_c (min)
OFF-1 (Pre-Development)	0.56	39.6	129.0	229.9	4.60	16
OFF-2 (Pre-Development)	0.63	49.3	135.0	215.4	4.30	18
OFF-3 (Pre-Development)	0.85	59.7	166.0	194.9	3.80	22
OFF-1 (Post-Development)	0.26	14.1	71.0	276.3	5.73	10
OFF-2 (Post-Development)	0.39	34.4	92.0	234.0	5.00	13
OFF-3 (Post-Development)	0.66	49.2	126.0	189.8	4.20	19
ON-4	0.16	8.9	144.0	928.6	4.48	10
ON-5	0.12	13.7	127.0	1065.4	4.48	10
ON-6	0.16	19.9	153.0	967.5	4.48	10
ON-7	0.09	4.7	112.0	1246.0	4.48	10

SOURCE: Arizona Department of Transportation 1993

NOTE: [1] Based on the *Arizona Department of Transportation Highway Drainage Design Manual, Hydrology*, Equation 2-2, Time of Concentration Estimation

3.5 HYDROLOGIC MODELING RESULTS

The Rational Method model provides the 100-year, 24-hour peak discharges for the offsite basins and the 25-year, 24-hour peak discharges for the onsite drainage basin. The hydrology calculations and Rational Method model are provided in Appendix B, along with the total volume of runoff calculated for each on-site drainage basin. The peak discharge summary is provided Table 2 and in Appendix B. This table confirms that the existing peak flow amounts for basin OFF-1, OFF-2, and OFF-3 will be decreased in the developed condition. The on-site runoff volume is shown in Table 3.

Table 2

Peak Discharge Summary Table

Sub-Basin	Rainfall	Area (acre)	Peak Discharge (cubic feet per second)
OFF-1 (Pre-Development)	100-yr, 24-hour	39.6	54
OFF-2 (Pre-Development)	100-yr, 24-hour	49.3	63
OFF-3 (Pre-Development)	100-yr, 24-hour	59.7	67
OFF-1 (Post-Development)	100-yr, 24-hour	14.1	24
OFF-2 (Post-Development)	100-yr, 24-hour	34.4	51
OFF-3 (Post-Development)	100-yr, 24-hour	49.2	61
ON-4	25-year, 24-hour	8.9	24
ON-5	25-year, 24-hour	13.7	37
ON-6	25-year, 24-hour	19.9	54
ON-7	25-year, 24-hour	4.7	13

Table 3

Volume Summary Table

Sub-Basin	P (inches)	Area (acres)	C	Volume (acre-feet)
ON-4	2.22	8.9	0.60	0.99
ON-5	2.22	13.7	0.60	1.52
ON-6	2.22	19.9	0.60	2.21
ON-7	2.22	4.7	0.60	0.52
			Total Volume:	5.23

NOTES: P = 25-year, 24-hour rainfall event; C = rational coefficient

4.0 DRAINAGE DESIGN

4.1 OFFSITE COLLECTION SYSTEM

The offsite collection system was designed to capture the offsite flows and route them around the proposed improvements to their historic outlet points. There are three historic outfall points for the existing drainage basins, which are displayed on Figure 4. The offsite collection system consists of rip-rap lined channels, culverts, weirs, and a drop structure.

4.1.1 Offsite Perimeter Channel

The offsite perimeter channel is located within the APS property adjacent to the property line. It has a 10-foot bottom width with 2 ½ to 1 side slopes (H:V). URS field investigation of the proposed site revealed evidence of scour and sediment deposits in existing collection channels due to the nature of the contributing soils. The size and depth of the proposed perimeter channel is small enough that rip-rap can be used for the entire channel cross sectional area. The sizing calculations for the rip-rap channel are located in Appendix C.

The perimeter channel consists of seven sections based on the offsite inflow and historic outflow locations. The normal depth calculations for the channel sections are located in Appendix C. A drop structure along the channel alignment is necessary because the channel was designed to minimize the amount of excavation. The elevation drops nine feet in this structure over a length of fifty feet. The calculation for this drop structure is included in Appendix C.

4.1.2 Historic Outflow Points

Offsite flows in the channels will outlet at the historic outflow locations and the peak flow at these locations will be maintained. Due to the topography of the area, the proposed site layout, and the location of the historic outfalls, culverts were placed in the channel. These culverts reduce the flow in the downstream channel section by allowing excess flows to overtop the channel on the east side maintaining the historic outfall location. A lateral weir is located on the east bank of the channel which allows flow to overtop the channel section. The design of the culverts and weir is located in Appendix C.

4.2 ONSITE COLLECTION SYSTEM

The onsite collection system was designed based on the ultimate developed condition. This design parameter was selected because the peak flows and volumes would be maximized, resulting in a conservative design that eliminates the necessity of an interim design and construction. The onsite collection system consists of channels, drop structures, and a storage basin. There is a portion of the project site within the proposed improvements that will not drain into the onsite collection system, but will be collected by an existing pond located south of this project.

4.2.1 Onsite Channels

The layout of the onsite channel system parallels the offsite collection system and is shown on Figure 5. The offsite and onsite channels were aligned based on the offset from landfill as well as the property line, which is shown on Figure 6. The onsite channel system will collect and convey the runoff from the 25-year, 24-hour storm to the storage basin located in the southeast corner of the project site. The channel alignments near the onsite storage basin were modified so that they would not flow into the basin at the corners. The channels will empty into the storage basin thru drop structures and a stilling basin. The stilling basin will protect the storage basin floor by dissipating the flow energy from the drop structure. The hydraulic design calculations are included in Appendix C.

4.2.2 Onsite Storage Basin

The onsite storage basin was designed to collect the runoff volume generated by a 25-year, 24-hour storm. That volume is shown in Table 3 as 5.2 acre-feet. The basin depth was increased by 2-feet to account for sediment and the basin will have 2-feet of freeboard. The overall proposed depth of the basin is 12-feet with 3 to 1 side slopes (H:V). An overflow spillway is located on the east side of the basin that will allow the basin to overtop during storms greater than the 25-year, 24-hour storm. The actual storage volume provided by the basin is 8.2 acre-feet. That calculation is provided in Appendix C. Any runoff volume collected in this storage basin will be pumped within 36-hours to the existing pond located south of the project site.

4.3 CONCLUSIONS

The offsite drainage system was design to collect and convey the 100-year, 24-hour peak flow around the project site to the historic outlet points. The post-development peak flow at these discharge points is less than the pre-development flows. The onsite collection system was designed to collect and convey the 25-year, 24-hour peak flow to a storage basin that has the volume capacity for that design storm. The drainage design drawings for the proposed improvements are included in this report.

5.0 REFERENCES

Arizona Department of Transportation (ADOT). 1993. *Highway Drainage Design Manual, Hydrology*. Revision 8-11-94. Report FHWA-AZ93-281. Prepared for the Arizona Department of Transportation by NBS/Lowry Engineers & Planners, Phoenix, Arizona, and George V. Sabol Consulting Engineers, Brighton, Colorado.
Available at:
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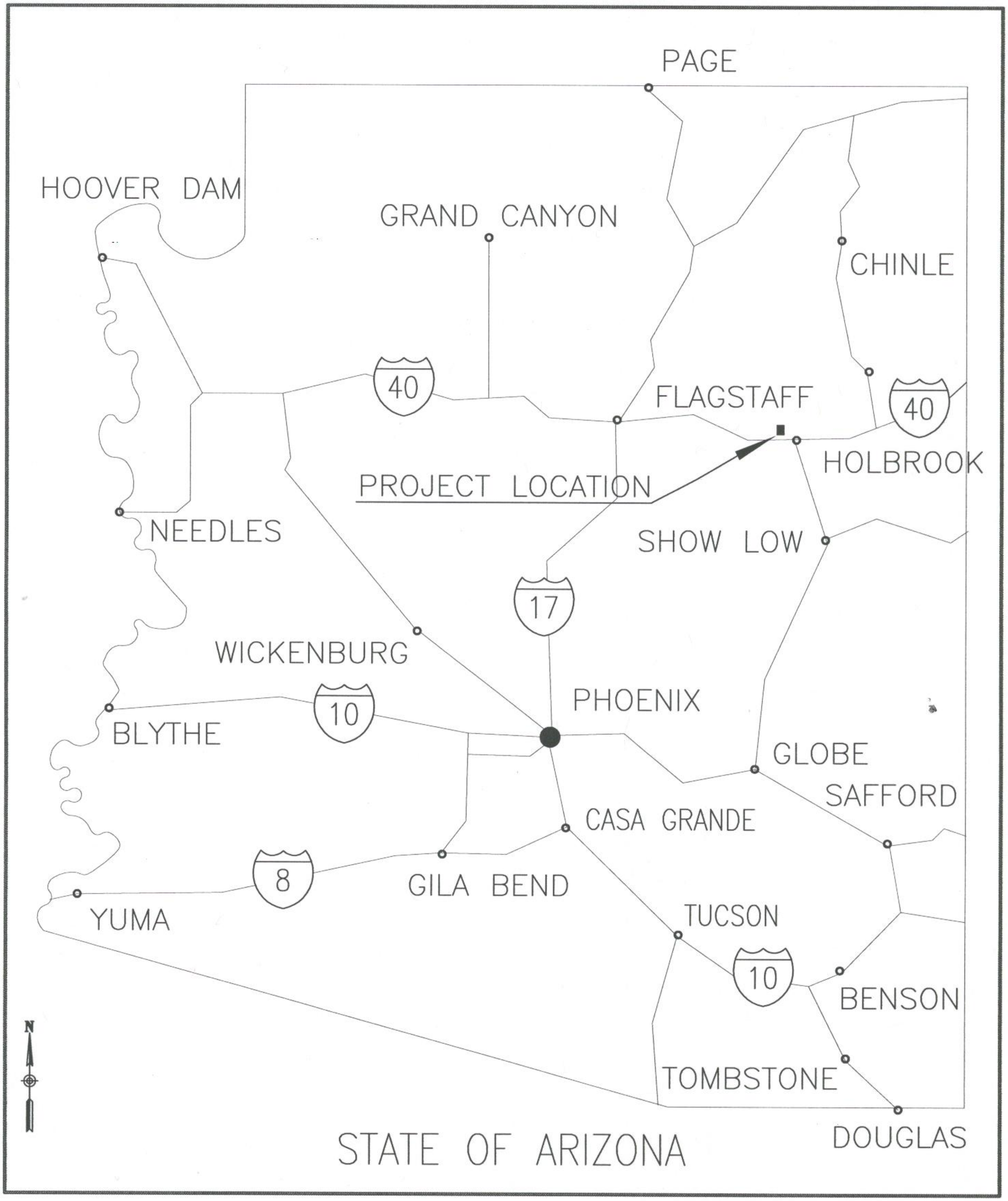
FIGURES



Site Location Map

Figure 1

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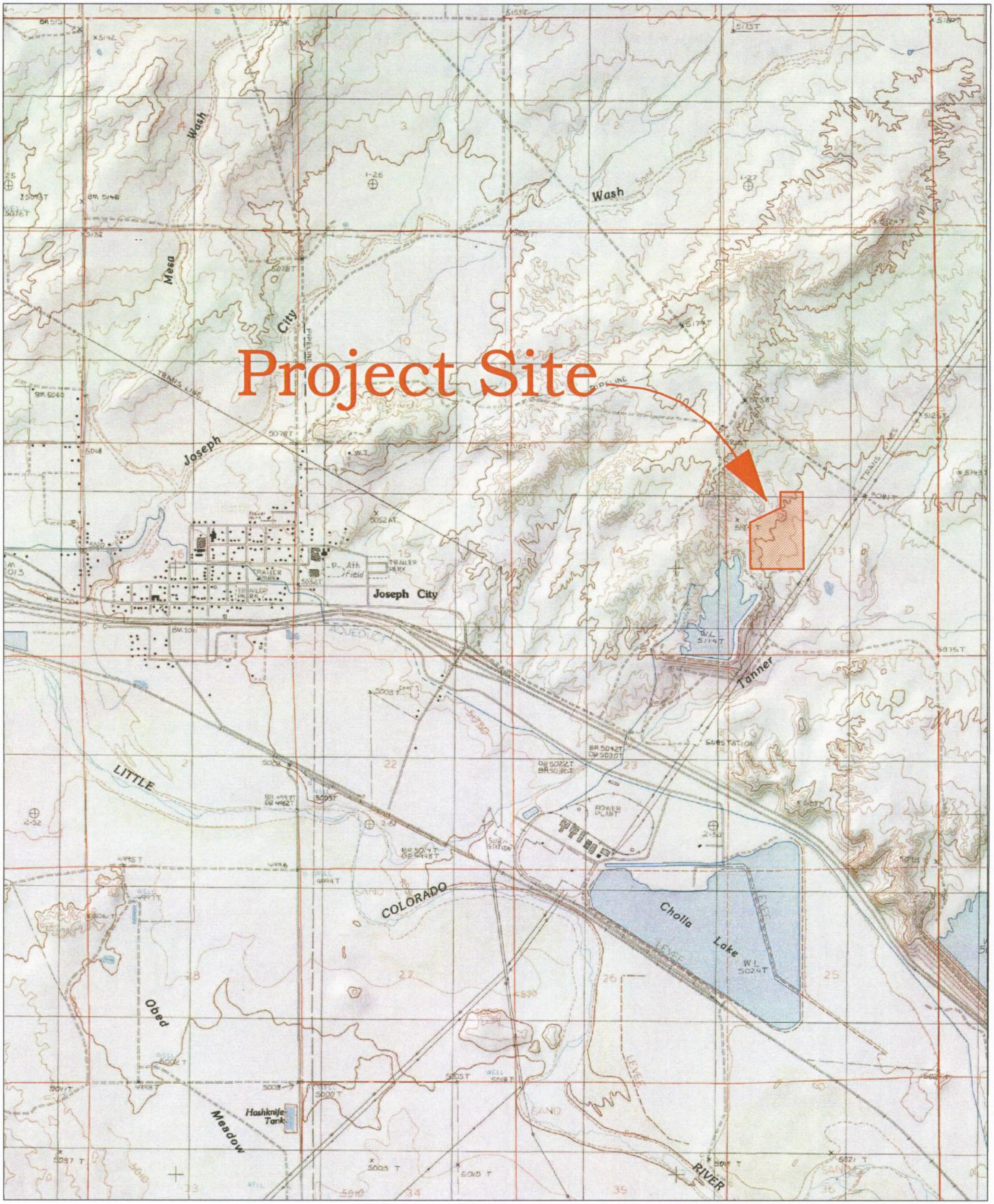
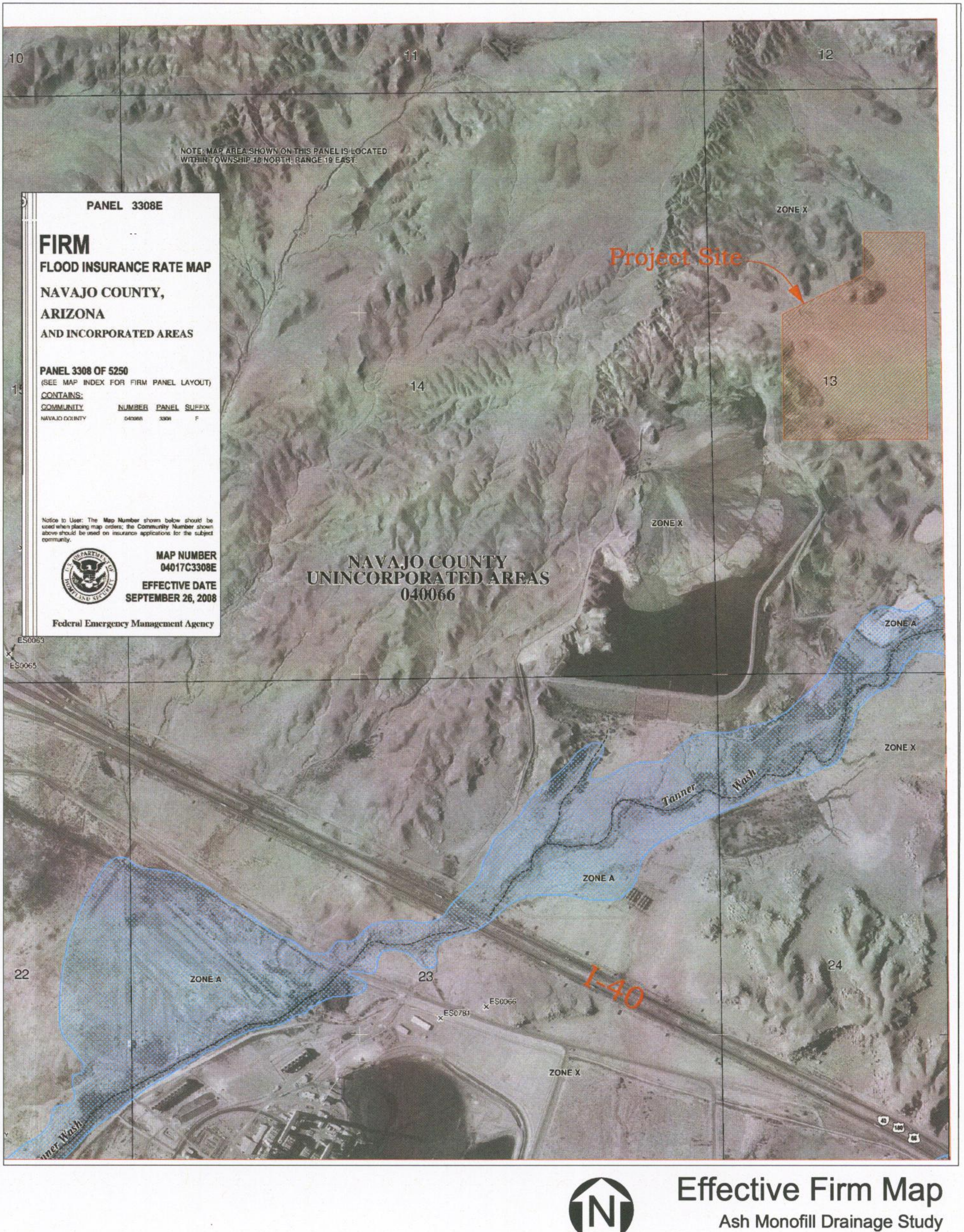


Site Location Map

Ash Monofill Drainage Study

Navajo County

Figure 2

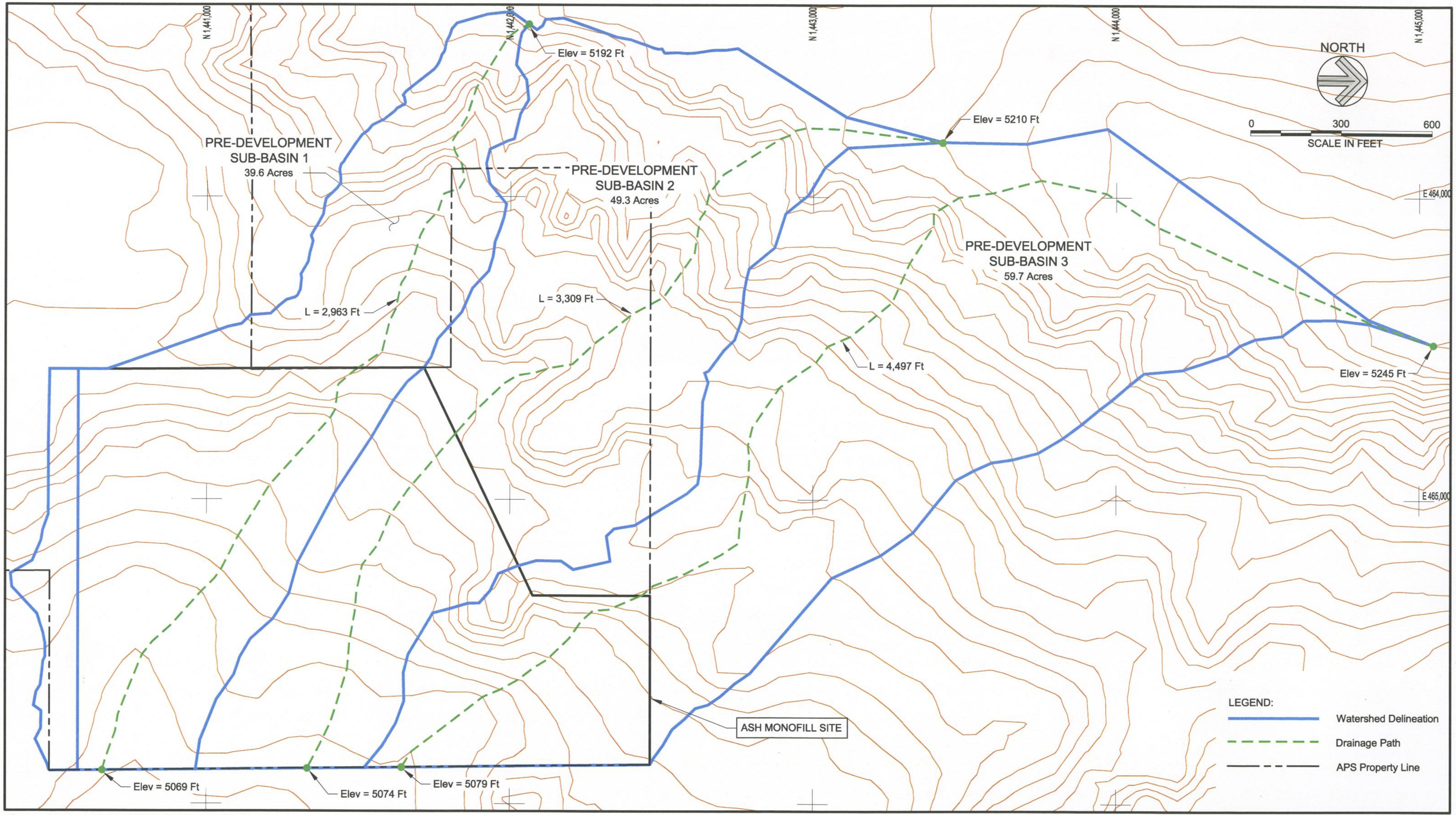


Effective Firm Map

Ash Monofill Drainage Study

Navajo County

Figure 3



Source: Topo provided by USGS 5-Ft Topographic Map

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PRE-DEVELOPMENT DELINEATION

Figure 4

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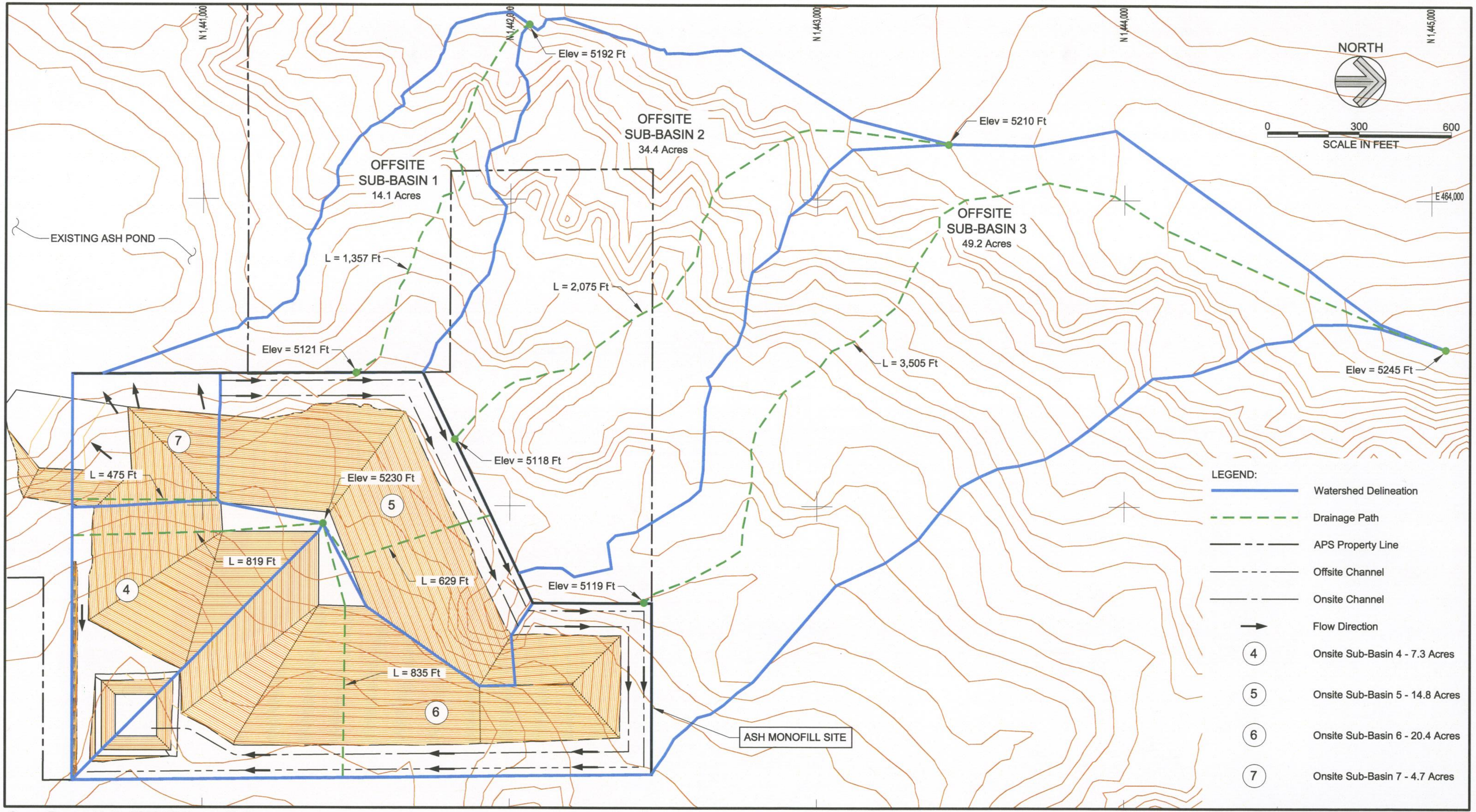

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2-Ft Topographic Map Provided by Arizona Public Service

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POST-DEVELOPMENT DELINEATION

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Figure 5

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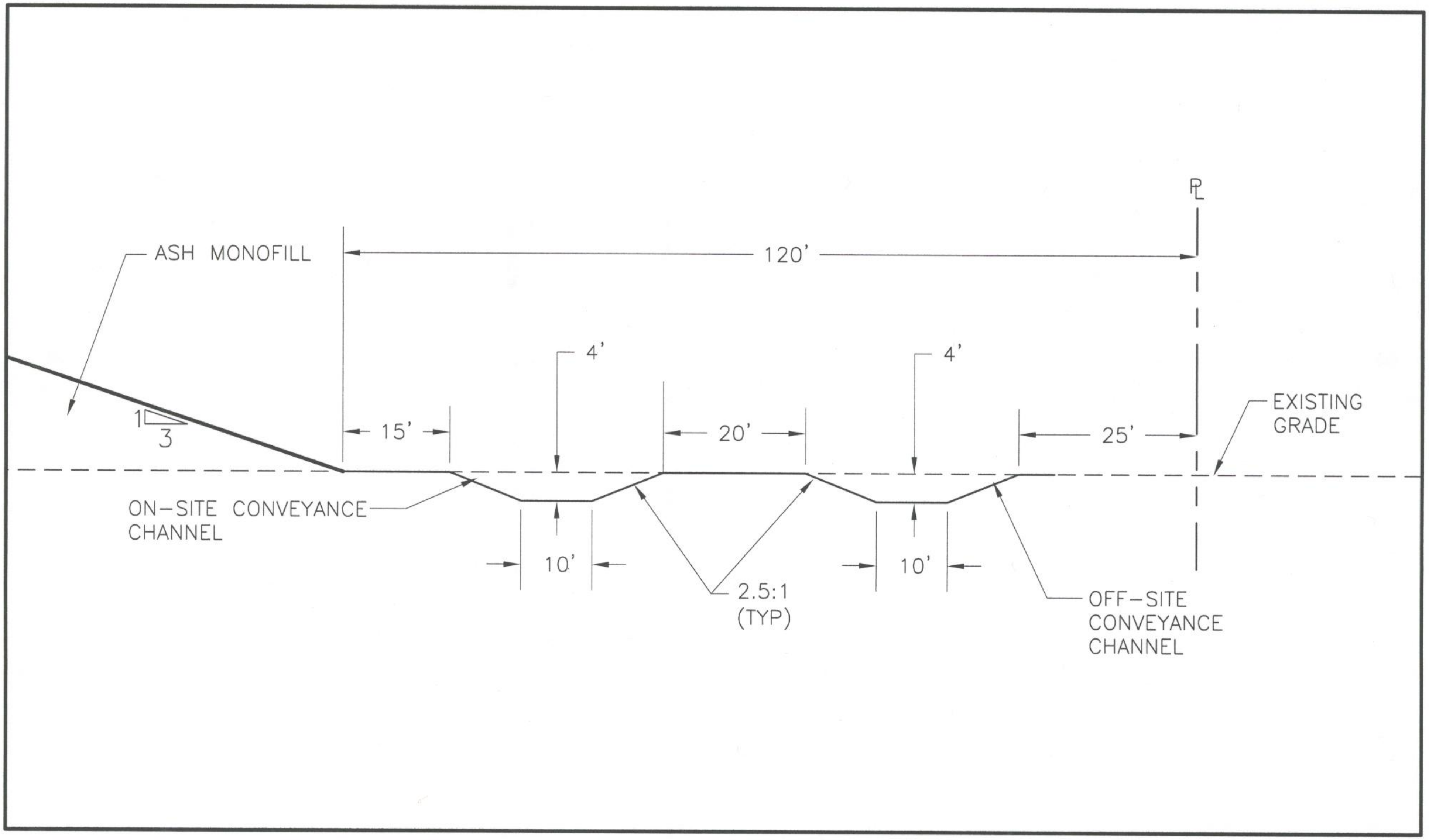

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CHOLLA ASH MONOFILL
OFFSITE AND ONSITE PERIMETER CHANNELS

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Figure 6

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DRAINAGE DRAWINGS

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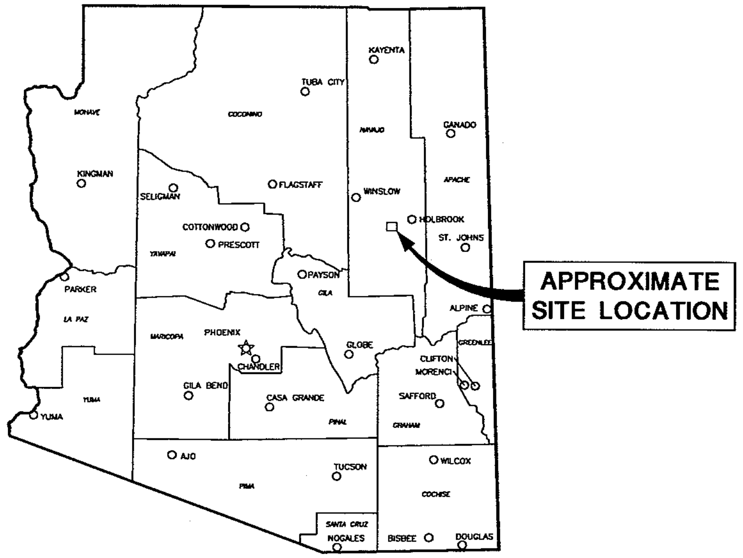
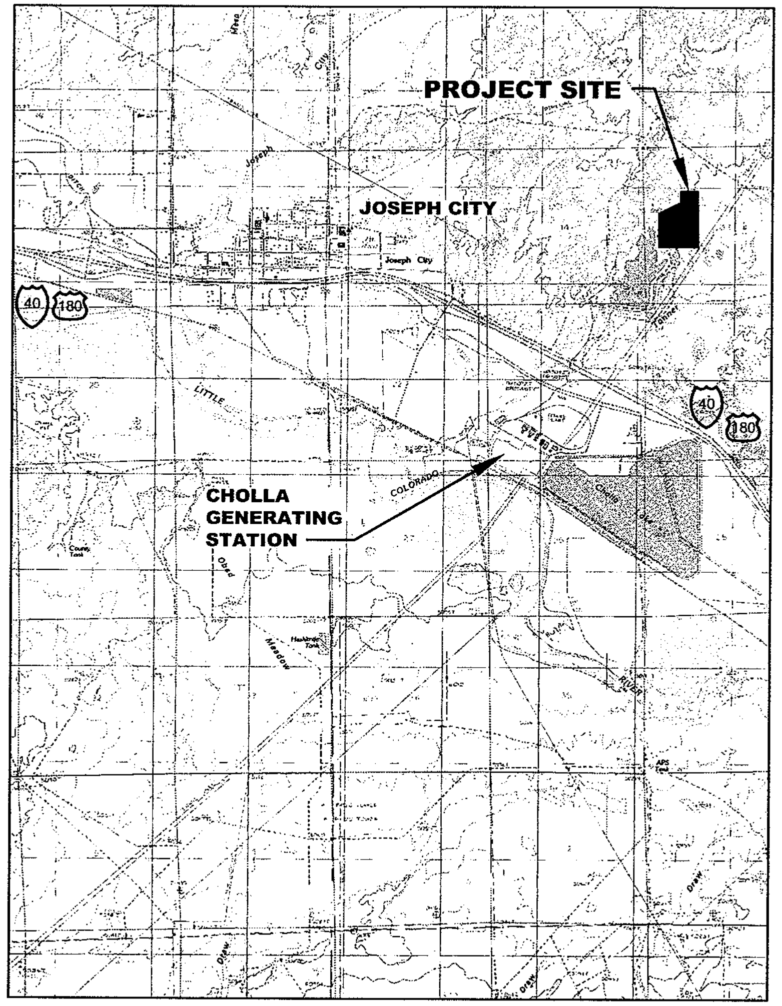
CHOLLA GENERATING STATION
CHOLLA ASH MONOFILL APP
JOSEPH CITY, ARIZONA



LOCATION MAP

NTS



VICINITY MAP

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SCALE IN FEET

DRAWING INDEX

DRAWING NO.	REV.	DRAWING TITLE
5548-CHOLLA-ASH-XX01	A	COVER SHEET
5548-CHOLLA-ASH-XX02	A	GENERAL SITE PLAN
5548-CHOLLA-ASH-XX03	A	SECTION AND DETAILS
5548-CHOLLA-ASH-XX04	A	PLAN AND PROFILES
5548-CHOLLA-ASH-XX05	A	PLAN AND PROFILES
5548-CHOLLA-ASH-XX06	A	SECTION AND DETAILS

OWNER: ARIZONA PUBLIC SERVICE COMPANY
CHOLLA GENERATION STATION
JOSEPH CITY, AZ 85XXX

A.P.S. PROJECT MANAGER:
PROJECT MANAGER PERSON
(602) XXX-XXXX
(602) XXX-XXXX FAX

ENGINEER: URS CORPORATION
7720 N. 16TH STREET, SUITE 100
PHOENIX, AZ 85020

ENGINEER OF RECORD
TODD RINGSMUTH, P.E.
(602) 371-1100
(602) 371-1615 FAX

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CHOLLA GENERATING STATION
ASH MONOFILL APP

COVER SHEET

APS

SCALE NOTED
DATE 02-09

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EXD CDW
RVWD TER

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UNIT	DISC	TYPE	SYS	NUMBER	SHEET
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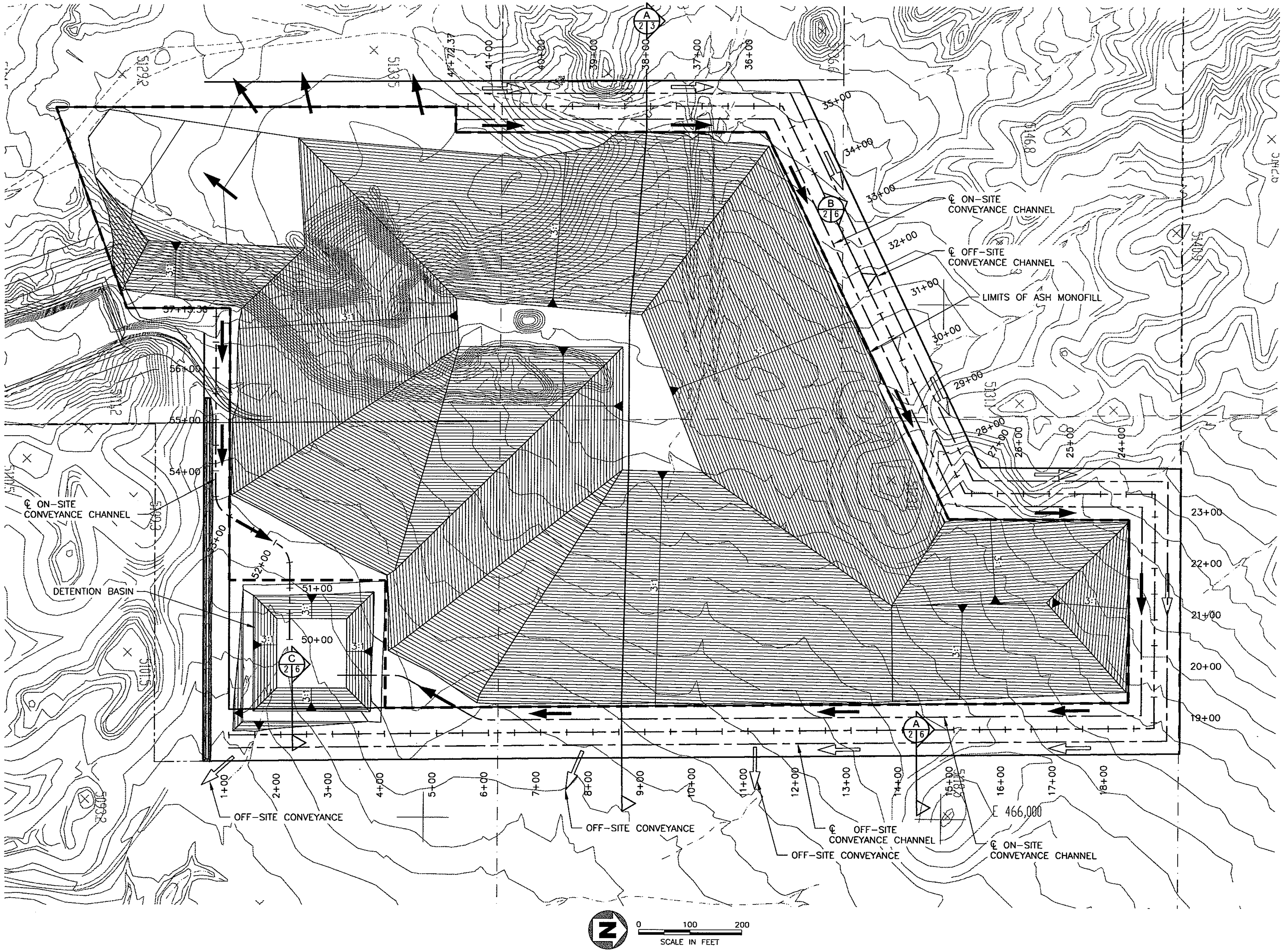

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CHOLLA GENERATING STATION
ASH MONOFILL APP

GENERAL SITE PLAN

APS

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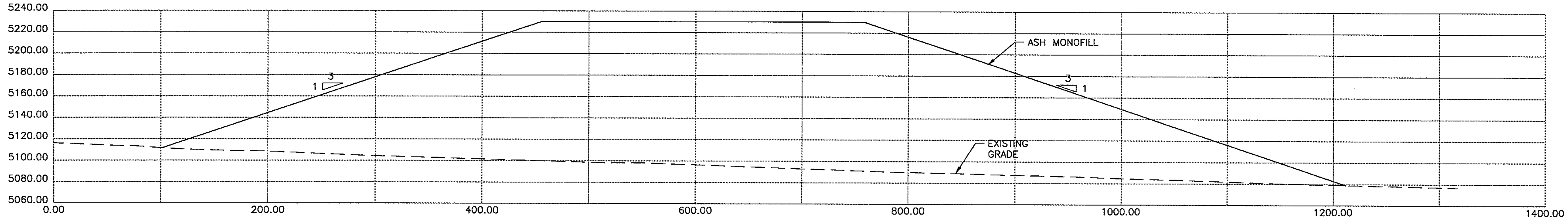
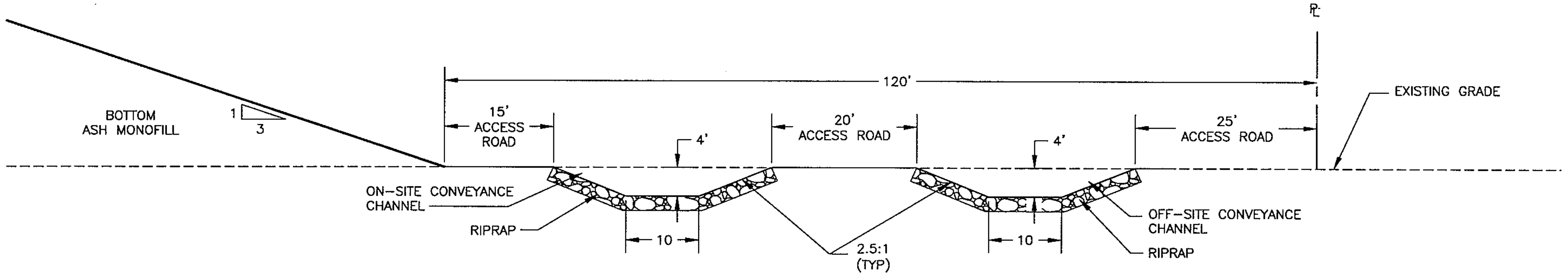


SECTION A 2|3

0 50 100
SCALE IN FEET



SECTION B 2|3

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SCALE IN FEET

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ASH MONOFILL APP

SECTION AND DETAILS

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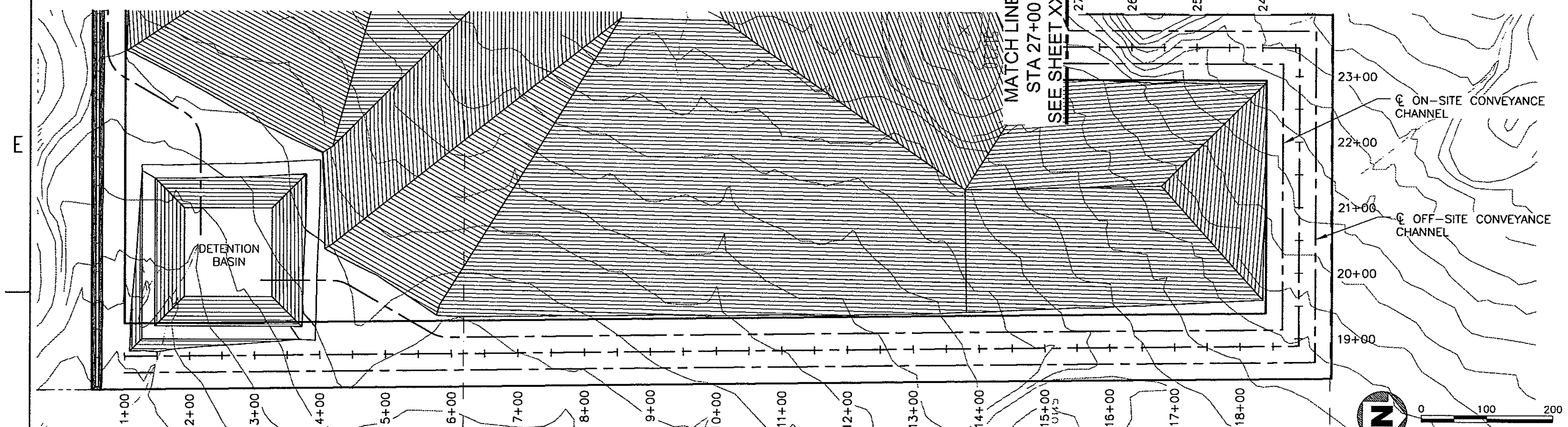
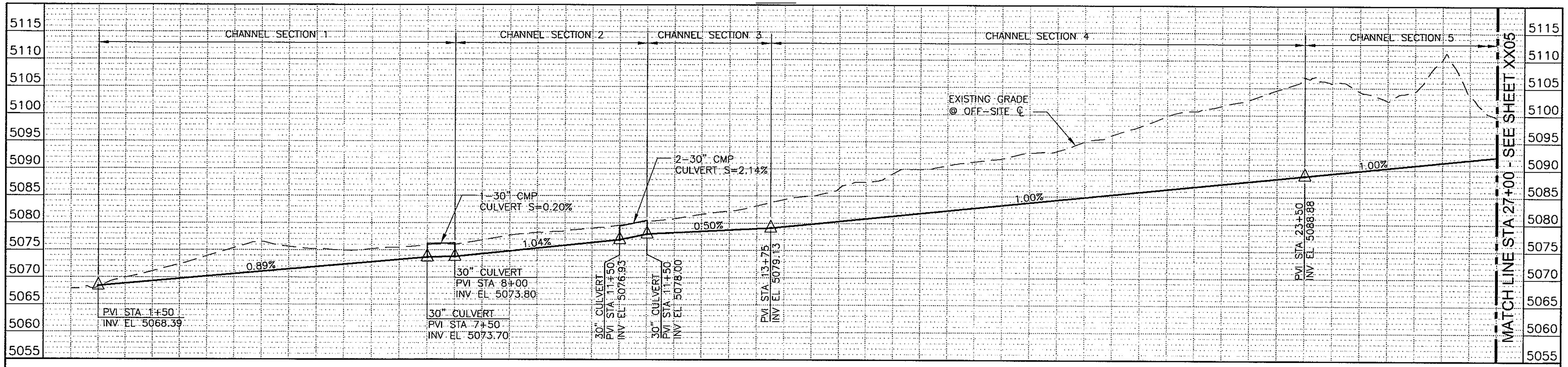
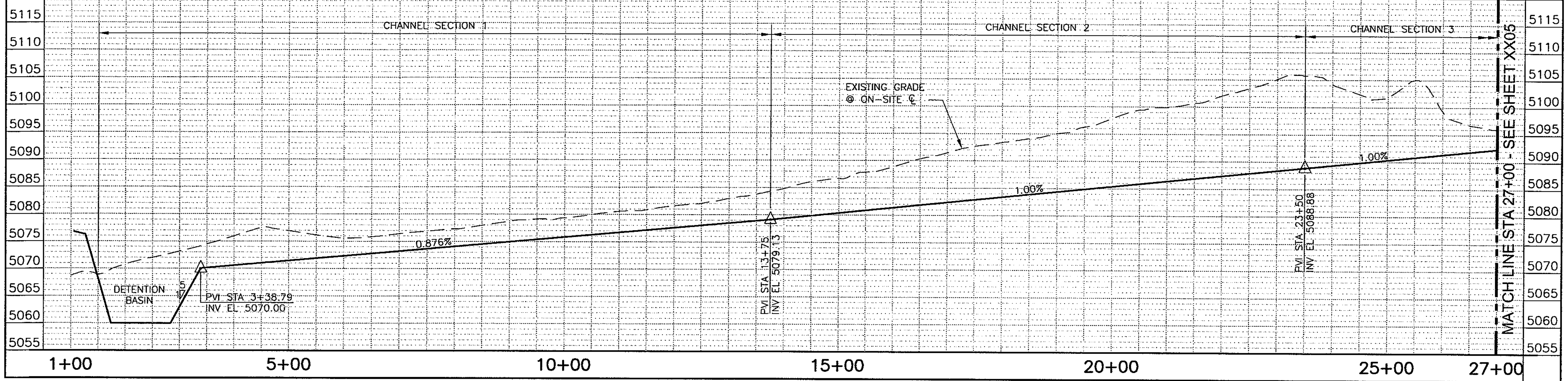


PLAN



OFFSITE CHANNEL PROFILE



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HORIZONTAL 0 100 200 SCALE IN FEET

VERTICAL 0 10 20 SCALE IN FEET

ON-SITE CHANNEL PROFILE

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CHOLLA GENERATING STATION
ASH MONOFILL APP

PLAN AND PROFILE

APS

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UNIT	DISC	TYPE	SYS	NUMBER	SHEET
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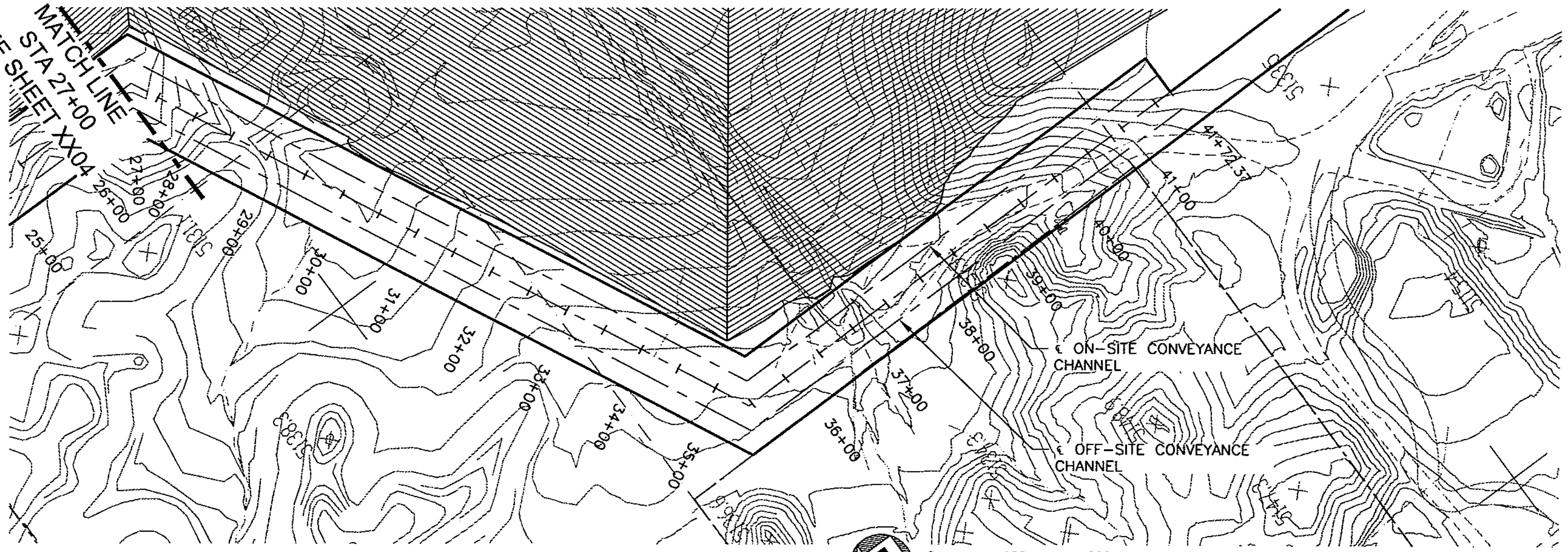

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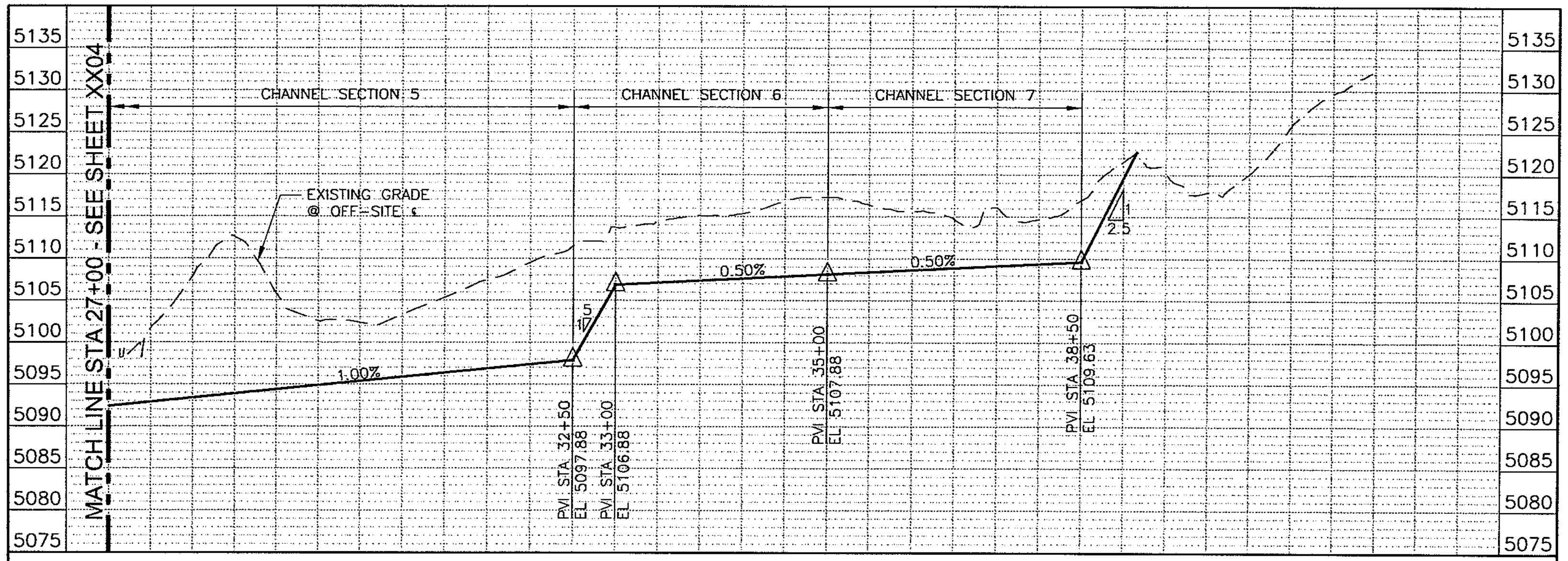
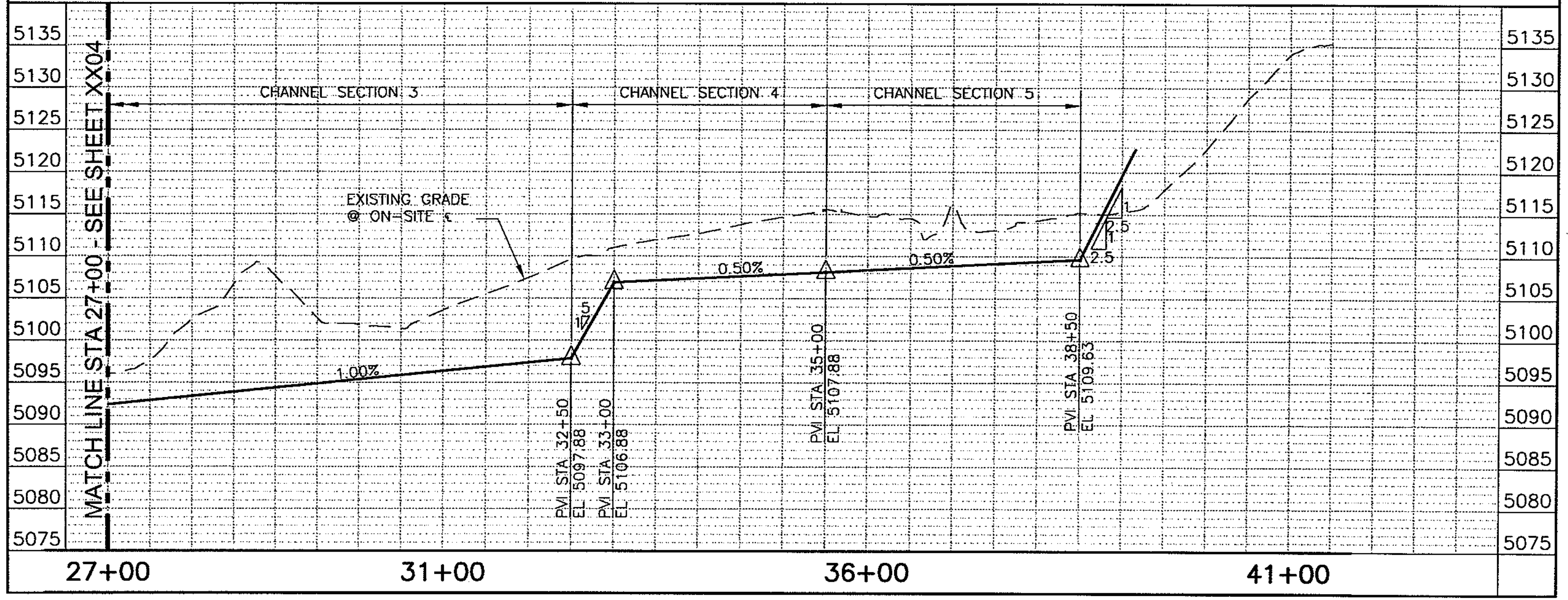


OFF-SITE CHANNEL PROFILE



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VERTICAL 0 10 20 SCALE IN FEET

ON-SITE CHANNEL PROFILE

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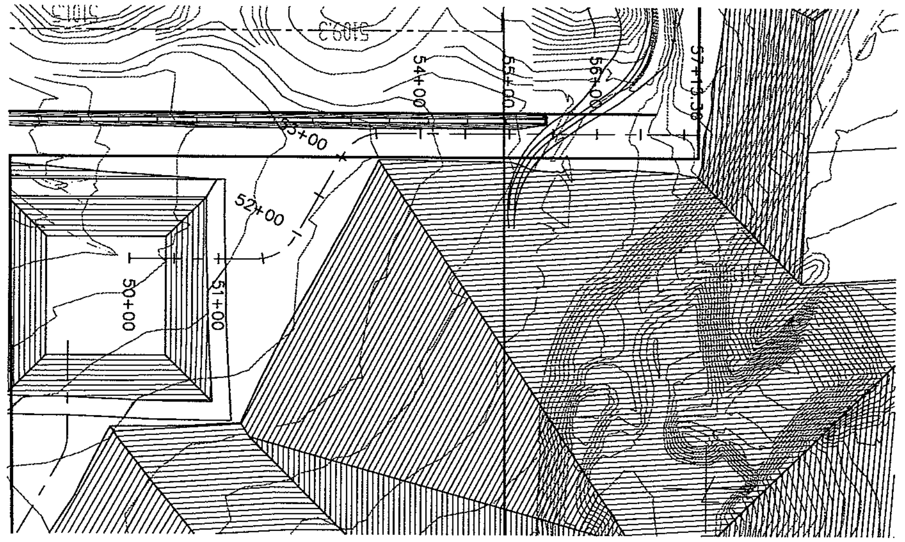
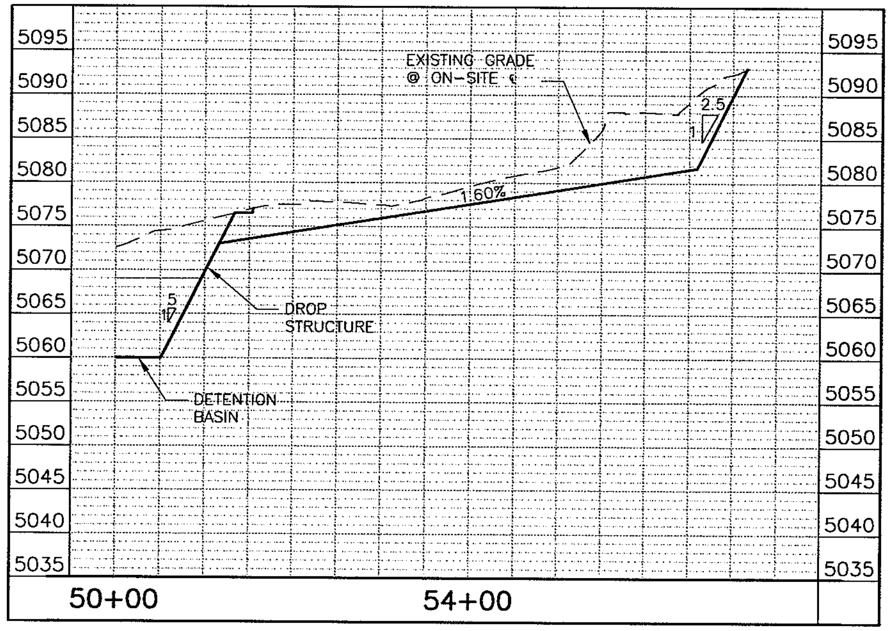


PLAN



HORIZONTAL 0 100 200 SCALE IN FEET

VERTICAL 0 10 20 SCALE IN FEET

ON-SITE CHANNEL PROFILE

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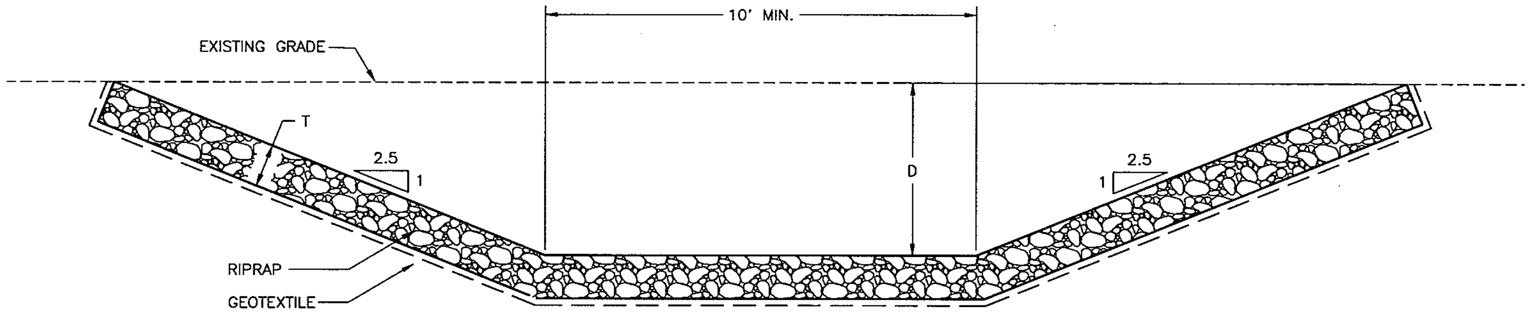


TYPICAL CHANNEL

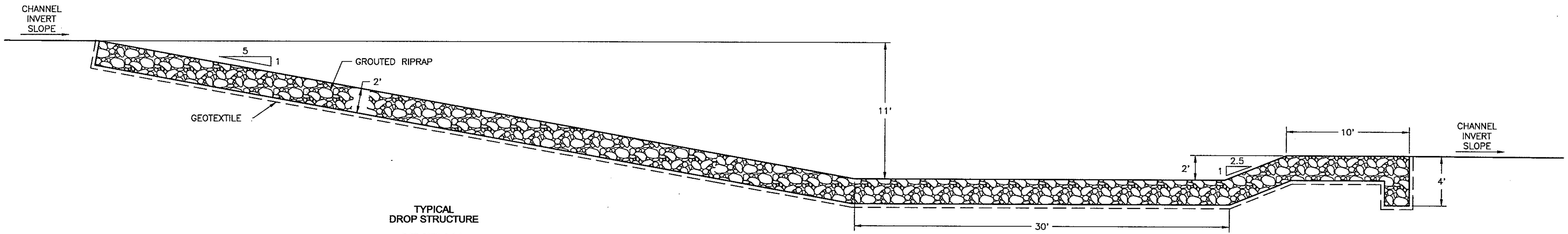
SECTION A 2|6

0 2 4 SCALE IN FEET

ON-SITE CHANNEL TABLE						
CHANNEL SECTION	STA	STA	RIPRAP D_{50} (IN)	T (FT)	CHANNEL DEPTH	CHANNEL SLOPE
1	1+50	13+75	4	1	3	0.876%
2	13+75	23+50	4	1	4	1.00%
3	23+50	32+50	4	1	4	1.00%
4	33+00	35+00	4	1	4	0.50%
5	35+00	38+50	4	1	4	0.50%
1	50+00	56+58.13	4	1	4	1.60%

OFF-SITE CHANNEL TABLE						
CHANNEL SECTION	STA	STA	RIPRAP D_{50} (IN)	T (FT)	CHANNEL DEPTH	CHANNEL SLOPE
1	1+50	7+50	4	1	3	0.885%
2	8+00	11+00	4	1	4	1.04%
3	11+50	13+75	4	1	4	0.50%
4	13+75	23+50	4/6	1	4	1.00%
5	23+50	32+50	4	1	4	1.00%
6	33+00	35+00	4	1	4	0.5%
7	35+00	38+50	4	1	3	0.5%

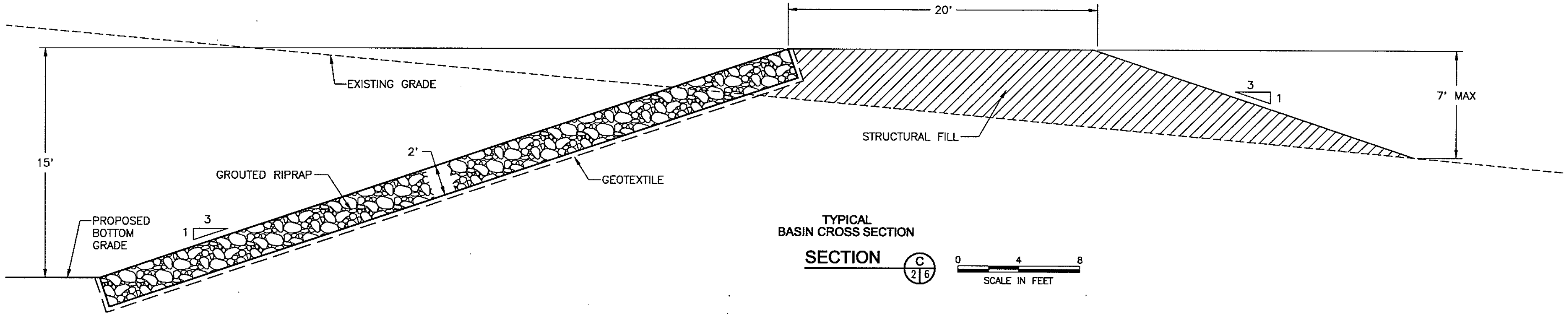
NOTE:
1. DROP STRUCTURE D_{50}=1FT, THICKNESS IS 2xD_{50}=2FT AND WILL BE GROUTED.



TYPICAL
DROP STRUCTURE

SECTION B 2|6

0 4 8 SCALE IN FEET



TYPICAL
BASIN CROSS SECTION

SECTION C 2|6

0 4 8 SCALE IN FEET

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CHOLLA GENERATING STATION
ASH MONOFILL APP

SECTION AND DETAILS

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UNIT	DISC	TYPE	SYS	NUMBER	SHEET
XX	X	XX	XXX	XXXXXX	XX06

APPENDIX A

RAINFALL CALCULATIONS

URS **EXHIBIT 4.7-2**

CALCULATION COVER SHEET

Client: Arizona Public Service Project Name: Cholla Ash Monofill

Project/Calculation Number: 23445548

Title: Rainfall Data for the Rational Method

Total Number of Pages (including cover sheet): 24

Total Number of Computer Runs:

Prepared by: Michelle C. West, EIT Michelle C. West Date: 2/3/2009

Checked by: Danette Lucas, EIT Danette Lucas Date: 2/5/2009

Description and Purpose:
The purpose of this calculation was to determine the rainfall data required in the Rational Method calculation package.
Included in this package is the rainfall data including I-D-F worksheets required for the ADOT method as well as the I-D-F curves.

Design Basis/References/Assumptions
The rainfall data was based on NOAA Atlas 14, and the rainfall AZ zone map has been included.
The NOAA data was located based on Latitude and Longitude coordinates for the Cholla Bottom Ash Dam near the project area.
The I-D-F worksheet and I-D-F curve printouts were generated from an excel spreadsheet located:
P:\WRES\Arizona_Public_Service\23445548_Cholla_Ash Monofill APP\Channel Design\Hydrology\ADOT IDF-Rainfall-Data.xls

---

Remarks/Conclusions/Results:
See attached worksheets

Calculation Approved by:
Project Manager/Date

Revision No.:	Description of Revision:	Approved by:
		Project Manager/Date

RAINFALL DATA CALCULATION
CHOLLA ASH MONOFILL HYDROLOGY ANALYSIS
CHOLLA GENERATING STATION
ARIZONA PUBLIC SERVICE

Problem Statement

The object of this calculation is to determine the rainfall data required in the Rational Method calculation package for the hydrology analysis of the proposed Cholla Ash Monofill.

The Rainfall Data was calculated using the procedure outlined in the Arizona Department of Transportation (ADOT) Highway Drainage Design Manual Hydrology.

Required Deliverables

- I-D-F worksheets and I-D-F curves for use with the Rational Method as required by the ADOT method.
- Rainfall intensity and depth for 100-year storm event, 24-hour duration.

Data Available

- Cholla Bottom Ash Dam location (Latitude 34.97 N, Longitude 110.29 W)
- NOAA Atlas 14 Rainfall Data for site specific latitude and longitude
- Arizona Zone Rainfall Map

Results

The printout I-D-F worksheets and I-D-F curves were generated from the following Excel spreadsheet are attached:

P:\WRES\Arizona_Public_Service\23445548_Cholla_Ash Monofill APP\Channel Design\Hydrology\ADOT IDF-Rainfall-Data.xls

REFERENCES

NOAA Atlas 14 Point Precipitation Frequency Estimates. www.noaa.gov.

ADOT Highway Drainage Design Manual Hydrology. March 1993.

WORKSHEETS

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

Project No.	23445548		
Project Name	Cholla Power Plant - Ash Fill	Date	2/3/2009
Location/Station	Joseph City, AZ		
Designer	MCW	Checker	DRL

Figure 1-2
RAINFALL DEPTH-DURATION-FREQUENCY (D-D-F) WORKSHEET

PART A

Determine rainfall depths from Precipitation Data (NOAA Atlas 14):

2-year, 6-hour	$P_{2,6'}=$	0.96
2-year, 24-hour	$P_{2,24'}=$	1.25
100-year, 6-hour	$P_{100,6'}=$	2.28
100-year, 24-hour	$P_{100,24'}=$	2.77

PART B

Compute the following:

2-year, 1-hour	$-0.011+\frac{0.942(P_{2,6'})^2}{(P_{2,24'})}$	$P_{2,1'}=$	0.68
100-year, 1-hour	$0.494+\frac{0.755(P_{100,6'})^2}{(P_{100,24'})}$	$P_{100,1'}=$	1.91
2-year, 2-hour	$0.341(P_{2,6'})+0.659(P_{2,1'})$	$P_{2,2'}=$	0.78
2-year, 3-hour	$0.569(P_{2,6'})+0.431(P_{2,1'})$	$P_{2,3'}=$	0.84
2-year, 12-hour	$0.500(P_{2,6'})+0.500(P_{2,24'})$	$P_{2,12'}=$	1.11
100-year, 2-hour	$0.341(P_{100,6'})+0.659(P_{100,1'})$	$P_{100,2'}=$	2.04
100-year, 3-hour	$0.569(P_{100,6'})+0.431(P_{100,1'})$	$P_{100,3'}=$	2.12
100-year, 12-hour	$0.500(P_{100,6'})+0.500(P_{100,24'})$	$P_{100,12'}=$	2.53

5

	A	B	C	D	E	F	G	H	I

1
ARIZONA DEPARTMENT OF TRANSPORTATION
2
HYDROLOGIC DESIGN DATA
3

4	Project No.	23445548			
5	Project Name	Cholla Power Plant - Ash Fill	Date	39847
6	Location/Station	Joseph City, AZ		
7	Location/Station	MCW	Checker	DRL

8
9
Figure 1-2
10
RAINFALL DEPTH-DURATION-FREQUENCY (D-D-F) WORKSHEET
11

12
PART A - FORMULAS
13

14 Determine rainfall depths from isopluvial maps (ADOT Highway Drainage Design Manual, **Appendix B**):

15

16	2-year, 6-hour	$P_{2,6'}$=	0.96
17	2-year, 24-hour	$P_{2,24'}$=	1.25
18	100-year, 6-hour	$P_{100,6'}$=	2.28
19	100-year, 24-hour	$P_{100,24'}$=	2.77

20

21
PART B - FORMULAS
22

23 Compute the following:

24

25 26	2-year, 1-hour	$-0.011+\frac{0.942(P_{2,6'})^2}{(P_{2,24'})}$	$P_{2,1'}$=	=(-0.011+(0.942*I16^2)/I17)
27 28	100-year, 1-hour	$0.494+\frac{0.755(P_{100,6'})^2}{(P_{100,24'})}$	$P_{100,1'}$=	=0.494+(0.755*I18^2)/I19
29	2-year, 2-hour	$0.341(P_{2,6'})+0.659(P_{2,1'})$	$P_{2,2'}$=	=0.341*$I$16+0.659*$I$25
30	2-year, 3-hour	$0.569(P_{2,6'})+0.431(P_{2,1'})$	$P_{2,3'}$=	=0.569*$I$16+0.431*$I$25
31	2-year, 12-hour	$0.500(P_{2,6'})+0.500(P_{2,24'})$	$P_{2,12'}$=	=0.5*$I$16+0.5*$I$17
32	100-year, 2-hour	$0.341(P_{100,6'})+0.659(P_{100,1'})$	$P_{100,2'}$=	=0.341*$I$18+0.659*$I$27
33	100-year, 3-hour	$0.569(P_{100,6'})+0.431(P_{100,1'})$	$P_{100,3'}$=	=0.569*$I$18+0.431*$I$27
34	100-year, 12-hour	$0.500(P_{100,6'})+0.500(P_{100,24'})$	$P_{100,12'}$=	=0.5*$I$18+0.5*$I$19

Figure 1-2
RAINFALL DEPTH-DURATION-FREQUENCY (D-D-F) WORKSHEET

PART C

Determine the short-duration rainfall zone (**Figure 1-1**):

Zone = 6

Determine the short duration rainfall ratios (**Table 1-1**):

Duration (Minutes)	**Ratio**			
	2-Year		**100-Year**	
5	A=	0.35	E=	0.32
10	B=	0.54	F=	0.50
15	C=	0.65	G=	0.62
30	D=	0.83	H=	0.81

Compute the following:

2-year, 5-min	(A)($P_{2,1'}$)=	$P_{2,5''}$=	0.24
2-year, 10-min	(B)($P_{2,1'}$)=	$P_{2,10''}$=	0.37
2-year, 15-min	(C)($P_{2,1'}$)=	$P_{2,15''}$=	0.44
2-year, 30-min	(D)($P_{2,1'}$)=	$P_{2,30''}$=	0.57
100-year, 5-min	(E)($P_{100,1'}$)=	$P_{100,5''}$=	0.61
100-year, 10-min	(F)($P_{100,1'}$)=	$P_{100,10''}$=	0.96
100-year, 15-min	(G)($P_{100,1'}$)=	$P_{100,15''}$=	1.18
100-year, 30-min	(H)($P_{100,1'}$)=	$P_{100,30''}$=	1.55

Figure 1-2

RAINFALL DEPTH-DURATION-FREQUENCY (D-D-F) WORKSHEET

PART C - FORMULAS

Determine the short-duration rainfall zone (**Figure 1-1**):

Zone = 6

Determine the short duration rainfall ratios (**Table 1-1**):

Duration (Minutes)	**Ratio**			
	2-Year		**100-Year**	
5	A=	`=IF($E$9=6,0.35,IF($E$9=8,0.34,"NG"))`	E=	`=IF($E$9=6,0.32,IF($E$9=8,0.3,"NG"))`
10	B=	`=IF($E$9=6,0.54,IF($E$9=8,0.51,"NG"))`	F=	`=IF($E$9=6,0.5,IF($E$9=8,0.46,"NG"))`
15	C=	`=IF($E$9=6,0.65,IF($E$9=8,0.62,"NG"))`	G=	`=IF($E$9=6,0.62,IF($E$9=8,0.59,"NG"))`
30	D=	`=IF($E$9=6,0.83,IF($E$9=8,0.82,"NG"))`	H=	`=IF($E$9=6,0.81,IF($E$9=8,0.8,"NG"))`

Compute the following:

2-year, 5-min (A)($P_{2,1'}$)= $P_{2,5"}$= `=E15*'Parts A & B'!I25`

2-year, 10-min (B)($P_{2,1'}$)= $P_{2,10"}$= `=E16*'Parts A & B'!$I$25`

2-year, 15-min (C)($P_{2,1'}$)= $P_{2,15"}$= `=E17*'Parts A & B'!$I$25`

2-year, 30-min (D)($P_{2,1'}$)= $P_{2,30"}$= `=E18*'Parts A & B'!$I$25`

100-year, 5-min (E)($P_{100,1'}$)= $P_{100,5"}$= `='Parts A & B'!I27*'Part C'!G15`

100-year, 10-min (F)($P_{100,1'}$)= $P_{100,10"}$= `='Parts A & B'!$I$27*'Part C'!G16`

100-year, 15-min (G)($P_{100,1'}$)= $P_{100,15"}$= `='Parts A & B'!$I$27*'Part C'!G17`

100-year, 30-min (H)($P_{100,1'}$)= $P_{100,30"}$= `='Parts A & B'!$I$27*'Part C'!G18`

Figure 1-2

RAINFALL DEPTH-DURATION-FREQUENCY (D-D-F) WORKSHEET

PART D

For any flood frequency (T-yr) other than the 2-year or 100-year, calculate the rainfall depth for each rainfall duration (t) by the following equation:

$$P_{T,t}=(X)(P_{2,t})+(Y)(P_{100,t})$$

Frequency (T-yr)	**X**	**Y**
5-year	0.674	0.278
10-year	0.496	0.449
25-year	0.293	0.669
50-year	0.146	0.835
500-year	-0.337	1.381

Selected Frequency (T-year)

5 yr X= 0.674 Y= 0.278

5-min	$(X)(P_{2,5''})+(Y)(P_{100,5''})=$	$(P_{5,5''})=$	0.33
10-min	$(X)(P_{2,10''})+(Y)(P_{100,10''})=$	$(P_{5,10''})=$	0.51
15-min	$(X)(P_{2,15''})+(Y)(P_{100,15''})=$	$(P_{5,15''})=$	0.63
30-min	$(X)(P_{2,30''})+(Y)(P_{100,30''})=$	$(P_{5,30''})=$	0.81
1-hour	$(X)(P_{2,1'})+(Y)(P_{100,1'})=$	$(P_{5,1'})=$	0.99
2-hour	$(X)(P_{2,2'})+(Y)(P_{100,2'})=$	$(P_{5,2'})=$	1.09
3-hour	$(X)(P_{2,3'})+(Y)(P_{100,3'})=$	$(P_{5,3'})=$	1.16
6-hour	$(X)(P_{2,6'})+(Y)(P_{100,6'})=$	$(P_{5,6'})=$	1.28
12-hour	$(X)(P_{2,12'})+(Y)(P_{100,12'})=$	$(P_{5,12'})=$	1.45
24-hour	$(X)(P_{2,24'})+(Y)(P_{100,24'})=$	$(P_{5,24'})=$	1.61

NOTE: $P_{5,5''}$: 5 = flood frequency Year, 5" = rainfall duration
"stands for minutes, ' stands for hours.

Figure 1-2
RAINFALL DEPTH-DURATION-FREQUENCY (D-D-F) WORKSHEET

PART D

For any flood frequency (T-yr) other than the 2-year or 100-year, calculate the rainfall depth for each rainfall duration (t) by the following equation:

$$P_{T,t}=(X)(P_{2,t})+(Y)(P_{100,t})$$

Frequency (T-yr)	X	Y
5-year	0.674	0.278
10-year	0.496	0.449
25-year	0.293	0.669
50-year	0.146	0.835
500-year	-0.337	1.381

Selected Frequency (T-year)

10 yr X= 0.496 Y= 0.449

5-min	$(X)(P_{2,5''})+(Y)(P_{100,5''})=$	$(P_{10,5''})=$	0.39
10-min	$(X)(P_{2,10''})+(Y)(P_{100,10''})=$	$(P_{10,10''})=$	0.61
15-min	$(X)(P_{2,15''})+(Y)(P_{100,15''})=$	$(P_{10,15''})=$	0.75
30-min	$(X)(P_{2,30''})+(Y)(P_{100,30''})=$	$(P_{10,30''})=$	0.98
1-hour	$(X)(P_{2,1'})+(Y)(P_{100,1'})=$	$(P_{10,1'})=$	1.20
2-hour	$(X)(P_{2,2'})+(Y)(P_{100,2'})=$	$(P_{10,2'})=$	1.30
3-hour	$(X)(P_{2,3'})+(Y)(P_{100,3'})=$	$(P_{10,3'})=$	1.37
6-hour	$(X)(P_{2,6'})+(Y)(P_{100,6'})=$	$(P_{10,6'})=$	1.50
12-hour	$(X)(P_{2,12'})+(Y)(P_{100,12'})=$	$(P_{10,12'})=$	1.68
24-hour	$(X)(P_{2,24'})+(Y)(P_{100,24'})=$	$(P_{10,24'})=$	1.86

Figure 1-2
RAINFALL DEPTH-DURATION-FREQUENCY (D-D-F) WORKSHEET

PART D

For any flood frequency (T-yr) other than the 2-year or 100-year, calculate the rainfall depth for each rainfall duration (t) by the following equation:

$$P_{T,t}=(X)(P_{2,t})+(Y)(P_{100,t})$$

Frequency (T-yr)	**X**	**Y**
5-year	0.674	0.278
10-year	0.496	0.449
25-year	0.293	0.669
50-year	0.146	0.835
500-year	-0.337	1.381

Selected Frequency (T-year)

25 yr X= 0.293 Y= 0.669

5-min	$(X)(P_{2,5"})+(Y)(P_{100,5"})=$	$(P_{25,5"})=$	0.48
10-min	$(X)(P_{2,10"})+(Y)(P_{100,10"})=$	$(P_{25,10"})=$	0.75
15-min	$(X)(P_{2,15"})+(Y)(P_{100,15"})=$	$(P_{25,15"})=$	0.92
30-min	$(X)(P_{2,30"})+(Y)(P_{100,30"})=$	$(P_{25,30"})=$	1.20
1-hour	$(X)(P_{2,1'})+(Y)(P_{100,1'})=$	$(P_{25,1'})=$	1.48
2-hour	$(X)(P_{2,2'})+(Y)(P_{100,2'})=$	$(P_{25,2'})=$	1.59
3-hour	$(X)(P_{2,3'})+(Y)(P_{100,3'})=$	$(P_{25,3'})=$	1.67
6-hour	$(X)(P_{2,6'})+(Y)(P_{100,6'})=$	$(P_{25,6'})=$	1.81
12-hour	$(X)(P_{2,12'})+(Y)(P_{100,12'})=$	$(P_{25,12'})=$	2.01
24-hour	$(X)(P_{2,24'})+(Y)(P_{100,24'})=$	$(P_{25,24'})=$	2.22

Figure 1-2
RAINFALL DEPTH-DURATION-FREQUENCY (D-D-F) WORKSHEET

PART D

For any flood frequency (T-yr) other than the 2-year or 100-year, calculate the rainfall depth for each rainfall duration (t) by the following equation:

$$P_{T,t}=(X)(P_{2,t})+(Y)(P_{100,t})$$

Frequency (T-yr)	X	Y
5-year	0.674	0.278
10-year	0.496	0.449
25-year	0.293	0.669
50-year	0.146	0.835
500-year	-0.337	1.381

Selected Frequency (T-year)

50 yr X= 0.146 Y= 0.835

5-min	$(X)(P_{2,5''})+(Y)(P_{100,5''})=$	$(P_{50,5''})=$	0.55
10-min	$(X)(P_{2,10''})+(Y)(P_{100,10''})=$	$(P_{50,10''})=$	0.85
15-min	$(X)(P_{2,15''})+(Y)(P_{100,15''})=$	$(P_{50,15''})=$	1.05
30-min	$(X)(P_{2,30''})+(Y)(P_{100,30''})=$	$(P_{50,30''})=$	1.38
1-hour	$(X)(P_{2,1'})+(Y)(P_{100,1'})=$	$(P_{50,1'})=$	1.70
2-hour	$(X)(P_{2,2'})+(Y)(P_{100,2'})=$	$(P_{50,2'})=$	1.81
3-hour	$(X)(P_{2,3'})+(Y)(P_{100,3'})=$	$(P_{50,3'})=$	1.89
6-hour	$(X)(P_{2,6'})+(Y)(P_{100,6'})=$	$(P_{50,6'})=$	2.04
12-hour	$(X)(P_{2,12'})+(Y)(P_{100,12'})=$	$(P_{50,12'})=$	2.27
24-hour	$(X)(P_{2,24'})+(Y)(P_{100,24'})=$	$(P_{50,24'})=$	2.50

Figure 1-2
RAINFALL DEPTH-DURATION-FREQUENCY (D-D-F) WORKSHEET

PART D

For any flood frequency (T-yr) other than the 2-year or 100-year, calculate the rainfall depth for each rainfall duration (t) by the following equation:

$$P_{T,t}=(X)(P_{2,t})+(Y)(P_{100,t})$$

Frequency (T-yr)	X	Y
5-year	0.674	0.278
10-year	0.496	0.449
25-year	0.293	0.669
50-year	0.146	0.835
500-year	-0.337	1.381

Selected Frequency (T-year)

500 yr X= -0.337 Y= 1.381

5-min	$(X)(P_{2,5"})+(Y)(P_{100,5"})=$	$(P_{500,5"})=$	0.76
10-min	$(X)(P_{2,10"})+(Y)(P_{100,10"})=$	$(P_{500,10"})=$	1.20
15-min	$(X)(P_{2,15"})+(Y)(P_{100,15"})=$	$(P_{500,15"})=$	1.49
30-min	$(X)(P_{2,30"})+(Y)(P_{100,30"})=$	$(P_{500,30"})=$	1.95
1-hour	$(X)(P_{2,1'})+(Y)(P_{100,1'})=$	$(P_{500,1'})=$	2.41
2-hour	$(X)(P_{2,2'})+(Y)(P_{100,2'})=$	$(P_{500,2'})=$	2.55
3-hour	$(X)(P_{2,3'})+(Y)(P_{100,3'})=$	$(P_{500,3'})=$	2.65
6-hour	$(X)(P_{2,6'})+(Y)(P_{100,6'})=$	$(P_{500,6'})=$	2.83
12-hour	$(X)(P_{2,12'})+(Y)(P_{100,12'})=$	$(P_{500,12'})=$	3.11
24-hour	$(X)(P_{2,24'})+(Y)(P_{100,24'})=$	$(P_{500,24'})=$	3.40

Figure 1-2

RAINFALL DEPTH-DURATION-FREQUENCY (D-D-F) WORKSHEET

PART D - FORMULAS

For any flood frequency (T-yr) other than the 2-year or 100-year, calculate the rainfall depth for each rainfall duration (t) by the following equation:

$$P_{T,t}=(X)(P_{2,t})+(Y)(P_{100,t})$$

Frequency (T-yr)	X	Y
5-year	0.674	0.278
10-year	0.496	0.449
25-year	0.293	0.669
50-year	0.146	0.835
500-year	-0.337	1.381

Selected Frequency (T-year)

500 yr X= =IF($B$24=5,D15,IF($B$24=10,D16,IF($B$24=25,D17,IF($B$24=50,D18,IF($B$24=500,D19,"NG"))))) Y= =IF($B$24=5,E15,IF($B$24=10,E16,IF($B$24=25,E17,IF($B$24=50,E18,IF($B$24=500,E19,"NG")))))

5-min	$(X)(P_{2,5''})+(Y)(P_{100,5''})=$	$(P_{=\$B\$24,5''})=$	=$D$24*'Part C'!G25+'Part D'!$F$24*'Part C'!G33
10-min	$(X)(P_{2,10''})+(Y)(P_{100,10''})=$	$(P_{=\$B\$24,10''})=$	=$D$24*'Part C'!G27+'Part D'!$F$24*'Part C'!G35
15-min	$(X)(P_{2,15''})+(Y)(P_{100,15''})=$	$(P_{=\$B\$24,15''})=$	=$D$24*'Part C'!G29+'Part D'!$F$24*'Part C'!G37
30-min	$(X)(P_{2,30''})+(Y)(P_{100,30''})=$	$(P_{=\$B\$24,30''})=$	=$D$24*'Part C'!G31+'Part D'!$F$24*'Part C'!G39
1-hour	$(X)(P_{2,1'})+(Y)(P_{100,1'})=$	$(P_{=\$B\$24,1'})=$	=$D$24*'Parts A & B'!I25+'Part D'!$F$24*'Parts A & B'!I27
2-hour	$(X)(P_{2,2'})+(Y)(P_{100,2'})=$	$(P_{=\$B\$24,2'})=$	=$D$24*'Parts A & B'!I29+'Part D'!$F$24*'Parts A & B'!I32
3-hour	$(X)(P_{2,3'})+(Y)(P_{100,3'})=$	$(P_{=\$B\$24,3'})=$	=$D$24*'Parts A & B'!I30+'Part D'!$F$24*'Parts A & B'!I33
6-hour	$(X)(P_{2,6'})+(Y)(P_{100,6'})=$	$(P_{=\$B\$24,6'})=$	=$D$24*'Parts A & B'!I16+'Part D'!$F$24*'Parts A & B'!I18
12-hour	$(X)(P_{2,12'})+(Y)(P_{100,12'})=$	$(P_{=\$B\$24,12'})=$	=$D$24*'Parts A & B'!I31+'Part D'!$F$24*'Parts A & B'!I34
24-hour	$(X)(P_{2,24'})+(Y)(P_{100,24'})=$	$(P_{=\$B\$24,24'})=$	=$D$24*'Parts A & B'!I17+'Part D'!$F$24*'Parts A & B'!I19

Figure 1-2
RAINFALL DEPTH-DURATION-FREQUENCY (D-D-F) WORKSHEET

PART E

Tabulate the rainfall Depth-Duration-Frequency statistics below:

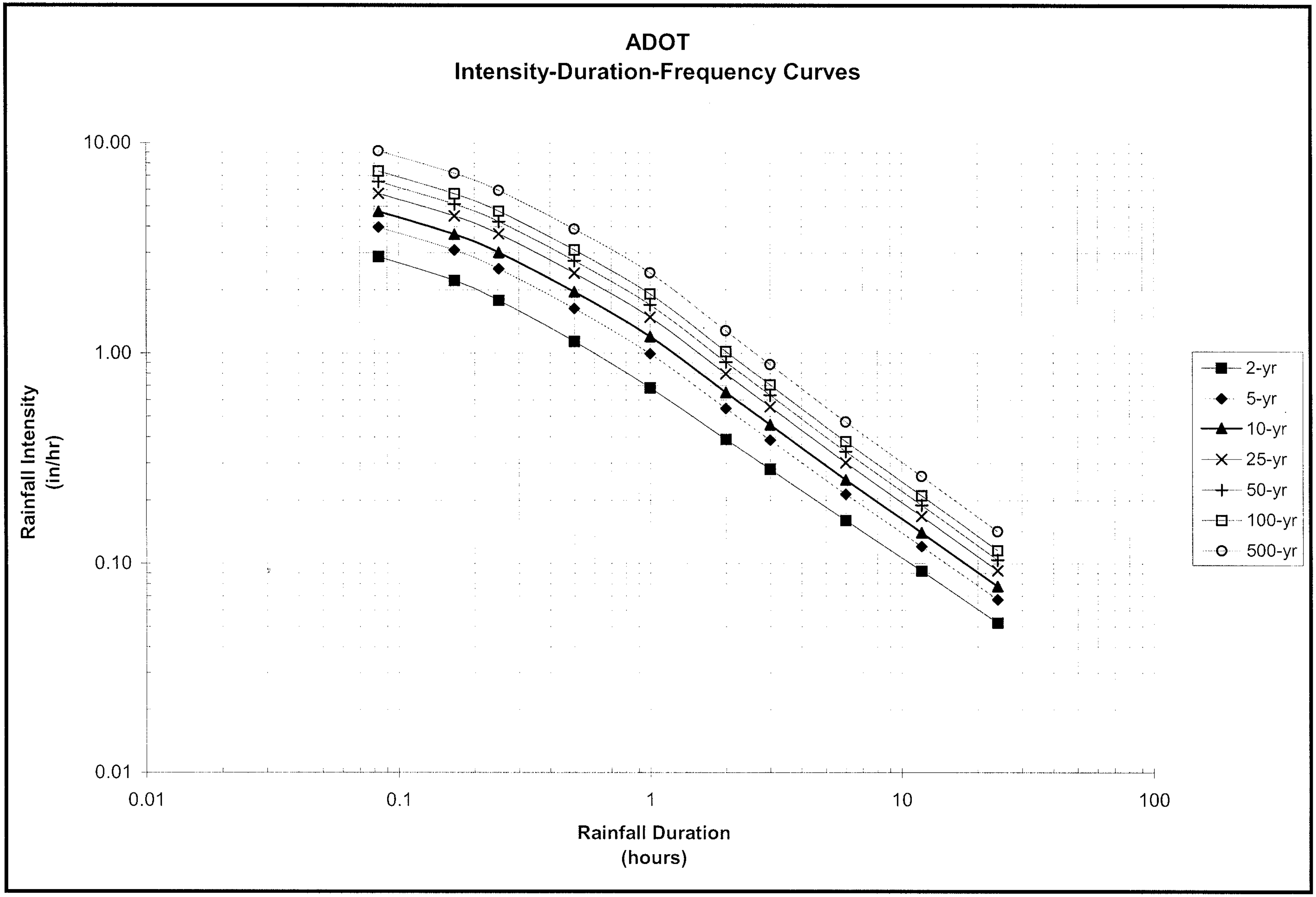
	Rainfall Depth, In Inches						
	Frequency, In Years						
Duration	2	5	10	25	50	100	500
5-min	0.24	0.33	0.39	0.48	0.55	0.61	0.76
10-min	0.37	0.51	0.61	0.75	0.85	0.96	1.20
15-min	0.44	0.63	0.75	0.92	1.05	1.18	1.49
30-min	0.57	0.81	0.98	1.20	1.38	1.55	1.95
1-hour	0.68	0.99	1.20	1.48	1.70	1.91	2.41
2-hour	0.78	1.09	1.30	1.59	1.81	2.04	2.55
3-hour	0.84	1.16	1.37	1.67	1.89	2.12	2.65
6-hour	0.96	1.28	1.50	1.81	2.04	2.28	2.83
12-hour	1.11	1.45	1.68	2.01	2.27	2.53	3.11
24-hour	1.25	1.61	1.86	2.22	2.50	**2.77**	3.40

Figure 1-2
RAINFALL DEPTH-DURATION-FREQUENCY (D-D-F) WORKSHEET

PART E - FORMULAS

Tabulate the rainfall Depth-Duration-Frequency statistics below:

	Rainfall Depth, In Inches						
	Frequency, In Years						
Duration	2	5	10	25	50	100	500
5-min	='Part C'!G25	='Part D, 5-yr'!J26	='Part D, 10-yr'!$J26	='Part D, 25-yr'!$J26	='Part D, 50-yr'!$J26	='Part C'!G33	='Part D, 500-yr '!J26
10-min	='Part C'!G27	='Part D, 5-yr'!J28	='Part D, 10-yr'!$J28	='Part D, 25-yr'!$J28	='Part D, 50-yr'!$J28	='Part C'!G35	='Part D, 500-yr '!J28
15-min	='Part C'!G29	='Part D, 5-yr'!J30	='Part D, 10-yr'!$J30	='Part D, 25-yr'!$J30	='Part D, 50-yr'!$J30	='Part C'!G37	='Part D, 500-yr '!J30
30-min	='Part C'!G31	='Part D, 5-yr'!J32	='Part D, 10-yr'!$J32	='Part D, 25-yr'!$J32	='Part D, 50-yr'!$J32	='Part C'!G39	='Part D, 500-yr '!J32
1-hour	='Parts A & B'!I25	='Part D, 5-yr'!J34	='Part D, 10-yr'!$J34	='Part D, 25-yr'!$J34	='Part D, 50-yr'!$J34	='Parts A & B'!I27	='Part D, 500-yr '!J34
2-hour	='Parts A & B'!I29	='Part D, 5-yr'!J36	='Part D, 10-yr'!$J36	='Part D, 25-yr'!$J36	='Part D, 50-yr'!$J36	='Parts A & B'!I32	='Part D, 500-yr '!J36
3-hour	='Parts A & B'!I30	='Part D, 5-yr'!J38	='Part D, 10-yr'!$J38	='Part D, 25-yr'!$J38	='Part D, 50-yr'!$J38	='Parts A & B'!I33	='Part D, 500-yr '!J38
6-hour	='Parts A & B'!I16	='Part D, 5-yr'!J40	='Part D, 10-yr'!$J40	='Part D, 25-yr'!$J40	='Part D, 50-yr'!$J40	='Parts A & B'!I18	='Part D, 500-yr '!J40
12-hour	='Parts A & B'!I31	='Part D, 5-yr'!J42	='Part D, 10-yr'!$J42	='Part D, 25-yr'!$J42	='Part D, 50-yr'!$J42	='Parts A & B'!I34	='Part D, 500-yr '!J42
24-hour	='Parts A & B'!I17	='Part D, 5-yr'!J44	='Part D, 10-yr'!$J44	='Part D, 25-yr'!$J44	='Part D, 50-yr'!$J44	='Parts A & B'!I19	='Part D, 500-yr '!J44

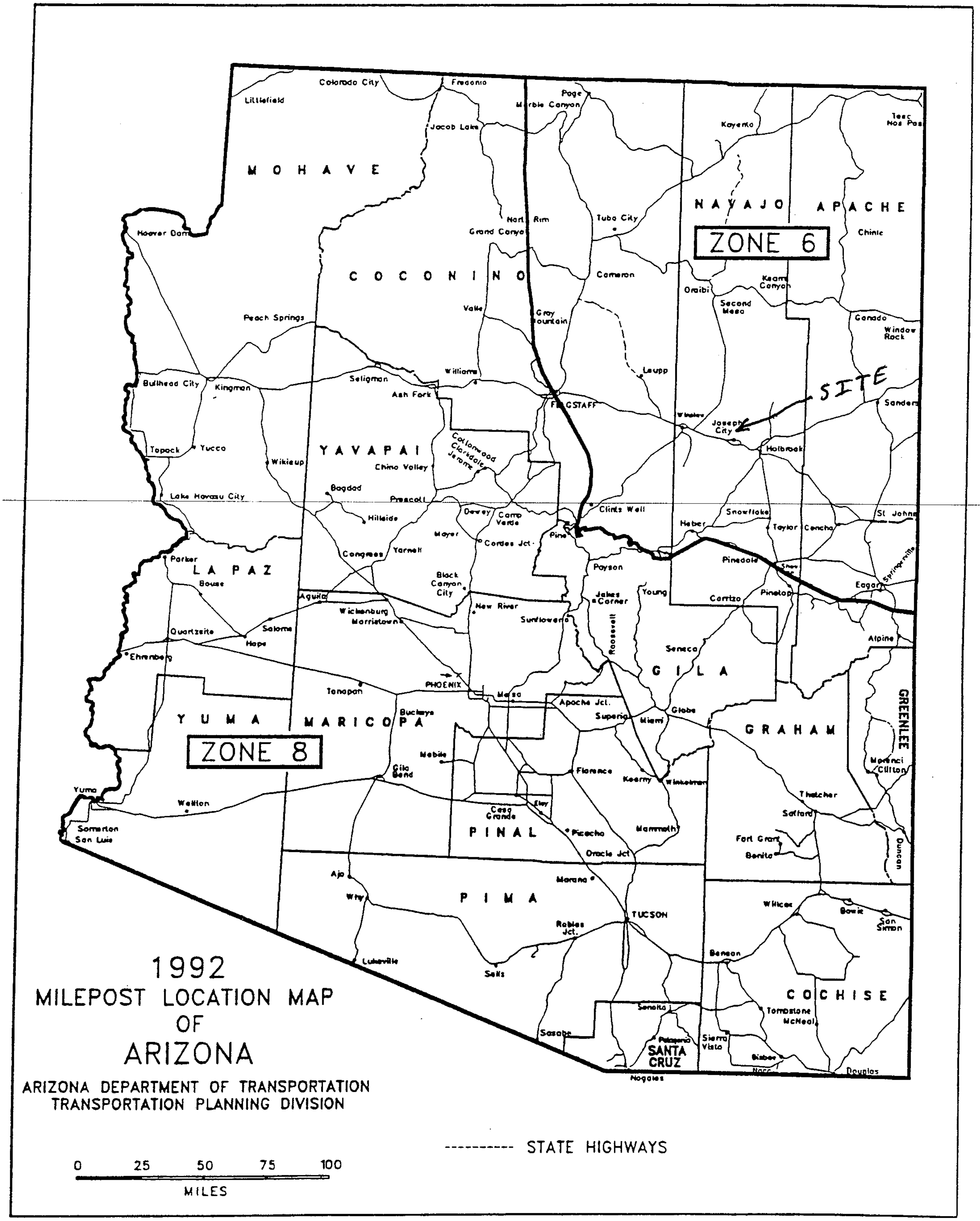


P:\WRES\Arizona_Public_Service\23445548_Cholla_Ash Monofill APP\Channel Design\Hydrology\Calculations\Rainfall Data\ADOT IDF-Rainfall-Data

REFERENCES

FIGURE 1-1

SHORT-DURATION RAINFALL RATIO ZONES FOR ARIZONA



Navajo

Abitibi Consolidated Snowflake Division

State ID	NID	Dam Name	Hazard Class	Location	Dam Type	Height	Capacity	Dam Size	Req. IDF
09.35	AZ00227	Ash Lagoons	Low	S21,T13N,R19E	Earth	25	451	Small	100-year
09.36	AZ00231	Mill Pond	Low	S17,T13N,R19E	Earth	30	2200	Intermediate	

Arizona Game & Fish Department

State ID	NID	Dam Name	Hazard Class	Location	Dam Type	Height	Capacity	Dam Size	Req. IDF
09.20	AZ00042	Black Canyon	High	S24,T11N,R15E	Earth	60	1581	Intermediate	0.5 PMF
09.19	AZ00051	Fool Hollow	High	S12,T10N,R21E	Earthrock	60	3217	Intermediate	0.5 PMF

Arizona Public Service Company, Cholla Power Plant

State ID	NID	Dam Name	Hazard Class	Location	Dam Type	Height	Capacity	Dam Size	Req. IDF
09.27	AZ00178	Cholla Bottom Ash Pond	High	S13,T18N,R19E	Earth	73	2200	Intermediate	
09.28	AZ00179	Cholla Fly Ash Pond	High	S30,T18N,R20E	Earth	80	18000	Intermediate	

Arizona Public Service Company, Phoenix Office

State ID	NID	Dam Name	Hazard Class	Location	Dam Type	Height	Capacity	Dam Size	Req. IDF
09.29	AZ00180	Cholla Cooling Pond	Significant	S26,T18N,R19E	Earth	13	2200	Small	

City of Show Low

State ID	NID	Dam Name	Hazard Class	Location	Dam Type	Height	Capacity	Dam Size	Req. IDF
09.13	AZ00023	Jaques	High	S10,T9N,R22E	Earth	65	6000	Intermediate	

City of Winslow

State ID	NID	Dam Name	Hazard Class	Location	Dam Type	Height	Capacity	Dam Size	Req. IDF
09.03	AZ00057	Clear Creek #1	Low	S10,T18N,R16E	Masonry	7	350	Small	

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Graphical Locater
Home Page
USA map
XY- data
TRS- data

Montana State University
Environmental Statistics Group

USF&WS

USDOE

The selected location is:

Latitude/Longitude 34.9584°N, 110.2784°W (34°, 57', 30.4" N; 110°, 16', 42.3" W)
The legal description is: Arizona, Gila & Salt River Meridian T18N,R19E,sec13. sec's 11,12,13,&14
UTM zone 12 (X,Y) 565879 , 3868672

The elevation is 1554 m (5098 ft)
The gradient is: 0.0 percent
There is no aspect direction.
The local roughness is: 0.0 or flat
The location as decimal degrees (X,Y;Z) = -110.2784, 34.9584; 1554 m

The state and county are Arizona: Navajo County 4017
The HUC is Middle Little Colorado 15020008; Place point in HUC
The Omernik ecoregion is Arizona/New Mexico Plateau (less typical) 22
The 1:100,000 map (if available); Switch to TerraServer
Zoom on that location with radius = 2 km; 5 km ; 10 km ; 20 km ; 30 km ; custom.

Nearby named places (in order by distance)

1. Cholla Cooling Pond Dam; Arizona: Navajo Co. -110.2774, 34.9550 at a distance of 391 m
2. Cholla Fly Ash Pond; Arizona: Navajo Co. -110.2674, 34.9600 at a distance of 1023 m
3. Cholla Fly Ash Pond Dam; Arizona: Navajo Co. -110.2674, 34.9600 at a distance of 1023 m
4. Cholla Bottom Ash Pond; Arizona: Navajo Co. -110.2890, 34.9667 at a distance of 1332 m
5. Cholla Bottom Ash Pond Dam; Arizona: Navajo Co. -110.2890, 34.9667 at a distance of 1332 m
6. Cholla Power Generating Plant; Arizona: Navajo Co. -110.2979, 34.9394 at a distance of 2759 m
7. Cholla Lake; Arizona: Navajo Co. -110.2838, 34.9306 at a distance of 3125 m
8. The Old Fort Historical Monument; Arizona: Navajo Co. -110.3210, 34.9558 at a distance of 3898 m
9. Joseph City Elementary School; Arizona: Navajo Co. -110.3318, 34.9647 at a distance of 4923 m
10. Joseph City High School; Arizona: Navajo Co. -110.3318, 34.9653 at a distance of 4933 m

The 7.5 minute series topographic maps for that area

Humpy Camp Well	Blairs Spring	Lee Mountain
Apache Butte	**Joseph City**	Holbrook
Chimney Canyon	Saunders Draw	Porter Canyon

NOAA 14 TABLES

21

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Arizona 34.9667 N 110.289 W 5200 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006

Extracted: Thu Jan 22 2009

Confidence Limits | Seasonality | Location Maps | Other Info. | GIS data | Maps | Docs | Return to Sta

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day	
1	0.18	0.27	0.33	0.45	0.55	0.63	0.68	0.77	0.88	1.00	1.12	1.25	1.43	1.57	2.04	2.39	2.87	3.30	
2	0.23	0.34	0.43	0.58	0.71	0.81	0.86	0.96	1.09	1.25	1.40	1.55	1.77	1.96	2.54	2.97	3.56	4.09	←
5	0.31	0.47	0.58	0.78	0.96	1.07	1.11	1.21	1.36	1.57	1.74	1.92	2.18	2.40	3.09	3.61	4.32	4.92	
10	0.37	0.57	0.70	0.94	1.17	1.29	1.33	1.43	1.57	1.83	2.01	2.22	2.51	2.74	3.52	4.08	4.89	5.54	
25	0.47	0.71	0.88	1.19	1.47	1.62	1.65	1.74	1.87	2.19	2.39	2.63	2.95	3.20	4.07	4.68	5.60	6.31	
50	0.55	0.83	1.03	1.38	1.71	1.89	1.91	2.00	2.10	2.47	2.68	2.95	3.29	3.54	4.48	5.12	6.11	6.85	
100	0.63	0.96	1.19	1.60	1.99	2.18	2.20	2.28	2.34	2.77	2.98	3.29	3.63	3.88	4.88	5.54	6.59	7.35	←
200	0.72	1.10	1.36	1.84	2.27	2.50	2.52	2.59	2.61	3.07	3.29	3.62	3.98	4.21	5.26	5.94	7.03	7.81	
500	0.85	1.30	1.61	2.17	2.69	2.97	2.99	3.04	3.08	3.49	3.70	4.08	4.44	4.66	5.75	6.43	7.56	8.35	
1000	0.96	1.46	1.81	2.44	3.02	3.35	3.38	3.43	3.47	3.81	4.02	4.43	4.79	4.99	6.11	6.78	7.91	8.70	

* These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

* Upper bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.20	0.31	0.38	0.51	0.64	0.73	0.77	0.86	0.97	1.09	1.22	1.35	1.54	1.70	2.19	2.56	3.08	3.53
2	0.26	0.40	0.49	0.66	0.82	0.93	0.98	1.08	1.22	1.36	1.52	1.67	1.91	2.11	2.73	3.18	3.82	4.37
5	0.35	0.54	0.67	0.90	1.11	1.23	1.27	1.36	1.51	1.70	1.88	2.07	2.35	2.58	3.32	3.85	4.62	5.25
10	0.43	0.65	0.81	1.09	1.34	1.48	1.51	1.60	1.74	1.98	2.18	2.39	2.70	2.94	3.77	4.35	5.21	5.89
25	0.54	0.82	1.01	1.36	1.69	1.85	1.87	1.94	2.07	2.37	2.58	2.83	3.18	3.43	4.36	4.99	5.95	6.70
50	0.62	0.95	1.18	1.59	1.96	2.15	2.17	2.23	2.32	2.67	2.90	3.17	3.54	3.79	4.80	5.46	6.49	7.27
100	0.73	1.10	1.37	1.84	2.28	2.49	2.50	2.55	2.60	2.99	3.22	3.53	3.91	4.16	5.22	5.91	7.00	7.80
200	0.83	1.27	1.57	2.12	2.62	2.87	2.88	2.91	2.91	3.32	3.56	3.90	4.29	4.53	5.64	6.34	7.46	8.30
500	0.99	1.51	1.87	2.52	3.12	3.42	3.43	3.44	3.48	3.78	4.02	4.41	4.80	5.01	6.18	6.88	8.04	8.89
1000	1.12	1.71	2.12	2.85	3.52	3.88	3.90	3.91	3.95	4.15	4.38	4.81	5.20	5.39	6.58	7.26	8.43	9.27

* The **upper** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **greater** than.
** These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval.

Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

* Lower bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.15	0.23	0.29	0.39	0.48	0.56	0.60	0.69	0.80	0.93	1.04	1.16	1.33	1.47	1.90	2.24	2.69	3.09
2	0.20	0.30	0.37	0.50	0.62	0.71	0.76	0.86	0.99	1.16	1.29	1.44	1.65	1.82	2.36	2.78	3.34	3.83

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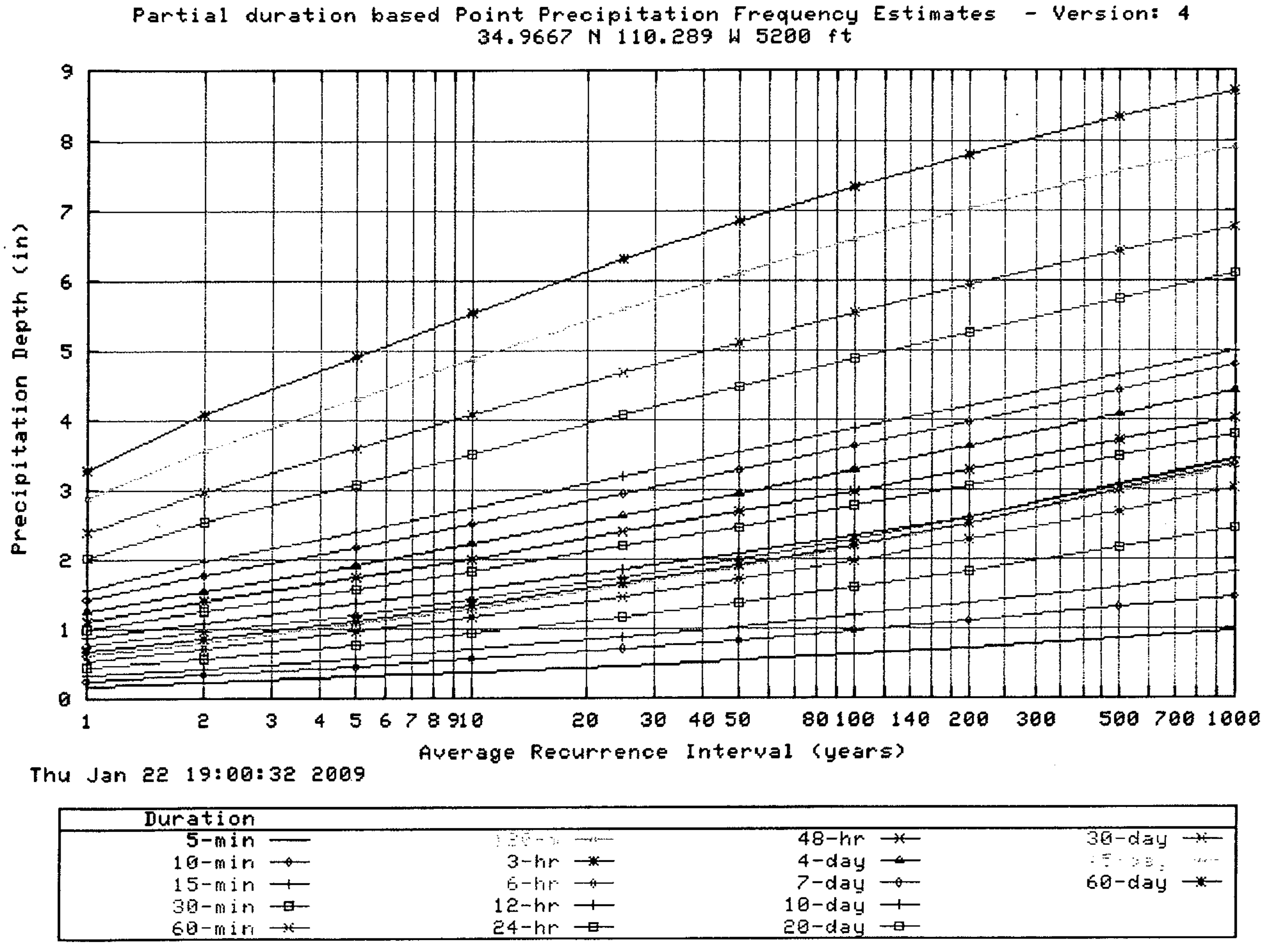
5	0.27	0.41	0.51	0.68	0.84	0.94	0.98	1.09	1.23	1.45	1.61	1.79	2.03	2.24	2.88	3.38	4.05	4.62
10	0.32	0.49	0.61	0.82	1.01	1.13	1.17	1.27	1.42	1.69	1.86	2.07	2.33	2.56	3.28	3.82	4.58	5.19
25	0.40	0.61	0.75	1.01	1.25	1.39	1.43	1.54	1.67	2.01	2.20	2.44	2.74	2.97	3.79	4.38	5.24	5.91
50	0.46	0.70	0.87	1.17	1.45	1.60	1.64	1.75	1.86	2.26	2.46	2.73	3.04	3.28	4.16	4.78	5.71	6.41
100	0.53	0.80	0.99	1.34	1.65	1.83	1.86	1.97	2.05	2.51	2.72	3.02	3.35	3.58	4.51	5.16	6.15	6.87
200	0.59	0.90	1.12	1.51	1.87	2.06	2.09	2.19	2.26	2.77	2.98	3.31	3.65	3.88	4.86	5.52	6.56	7.29
500	0.69	1.04	1.29	1.74	2.15	2.39	2.42	2.52	2.56	3.12	3.33	3.68	4.05	4.26	5.27	5.94	7.04	7.78
1000	0.76	1.15	1.43	1.93	2.38	2.64	2.69	2.78	2.81	3.38	3.59	3.97	4.34	4.54	5.58	6.25	7.37	8.10

* The **lower** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **less** than.

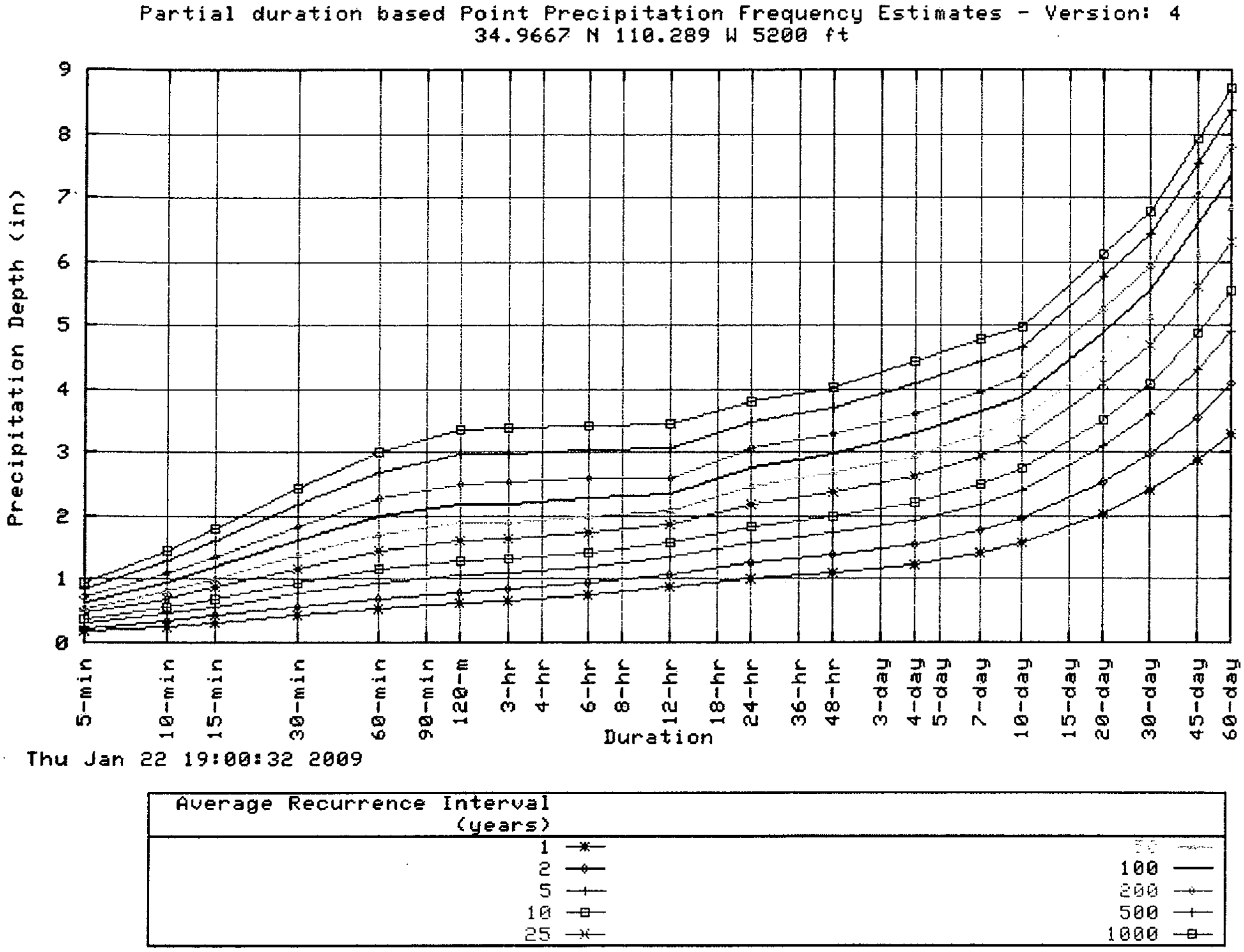
** These precipitation frequency estimates are based on a partial duration maxima series. **ARI** is the Average Recurrence Interval.

Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

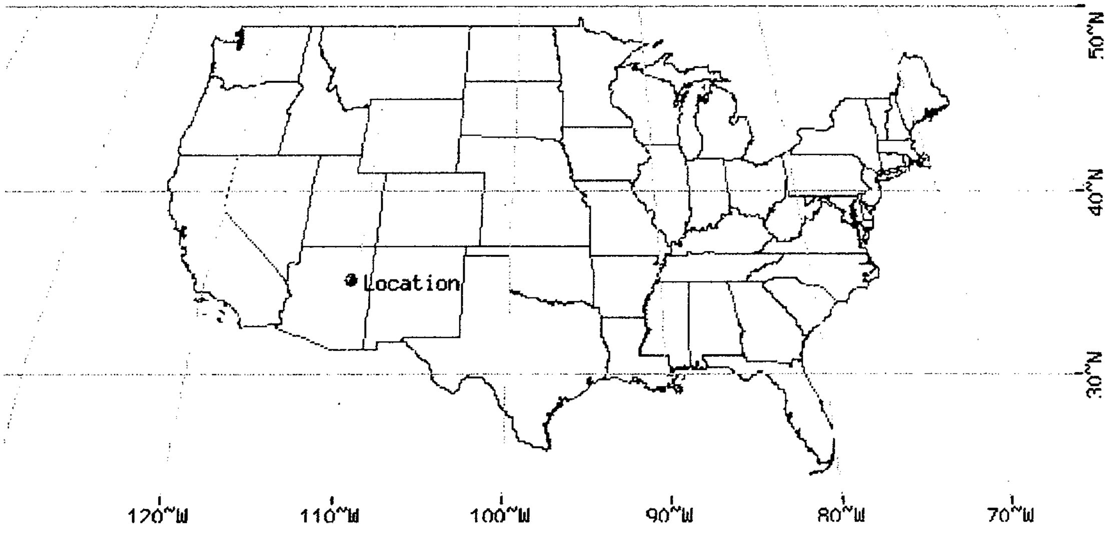
Text version of tables



23

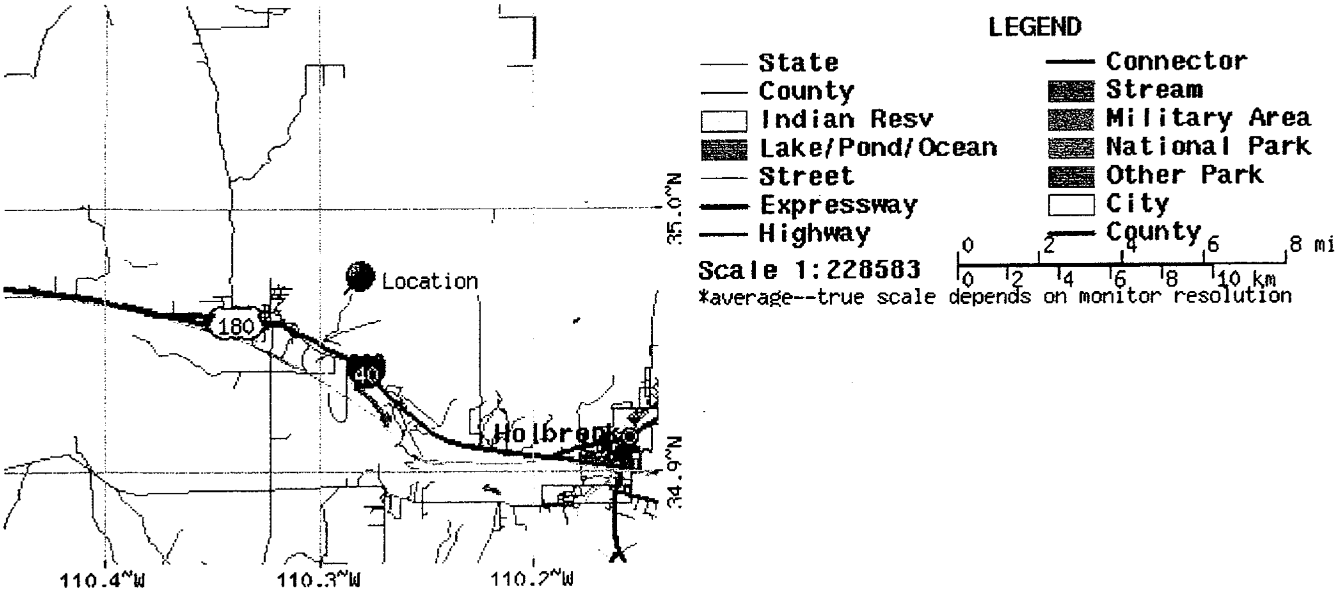


Maps -



These maps were produced using a direct map request from the
U.S. Census Bureau Mapping and Cartographic Resources
Tiger Map Server.

Please read disclaimer for more information.



Other Maps/Photographs -

View USGS digital orthophoto quadrangle (DOQ) covering this location from TerraServer; **USGS Aerial Photograph** may also be available
from this site. A DOQ is a computer-generated image of an aerial photograph in which image displacement caused by terrain relief and camera tilts has been removed. It combines the image characteristics of a photograph with the geometric qualities of a map. Visit the USGS for more information.

Watershed/Stream Flow Information -

Find the Watershed for this location using the U.S. Environmental Protection Agency's site.

Climate Data Sources -

*Precipitation frequency results are based on data from a variety of sources, but largely NCDC. The following links provide general information
about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study,
please refer to NOAA Atlas 14 Document.*

Using the **National Climatic Data Center's (NCDC)** station search engine, locate other climate stations within:

[+/-30 minutes] ...OR... [+/-1 degree] of this location (34.9667/-110.2890). Digital ASCII data can be obtained directly from **NCDC**.

Find Natural Resources Conservation Service (NRCS) SNOTEL (SNOwpack TELemetry) stations by visiting the
Western Regional Climate Center's state-specific SNOTEL station maps.

Hydrometeorological Design Studies Center
DOC/NOAA/National Weather Service
1325 East-West Highway
Silver Spring, MD 20910
(301) 713-1669
Questions?: HDSC.Questions@noaa.gov

Disclaimer

APPENDIX B

HYDROLOGY

ON-SITE HYDROLOGY

URS **EXHIBIT 4.7-2**

CALCULATION COVER SHEET

Client: Arizona Public Service Project Name: Cholla Ash Monofill

Project/Calculation Number: 23445548

Title: Rational Method Calculations/Inputs

Total Number of Pages (including cover sheet): ____________

Total Number of Computer Runs: ____________

Prepared by: Michelle C. West, EIT Michelle C. West Date: 2/3/2009

Checked by: Danette Lucas, EIT Danette Lucas Date: 2/9/2009

Description and Purpose:
The purpose of this calculation is to estimate the peak flows required for the offsite and onsite drainage channel design, and to calculate the runoff volume for the onsite drainage detention basin.
The Rational Method and inputs were calculated in an excel spreadsheet. This package contains the input calculations and reference material used to determine C values, K_b values and T_c values. The Rainfall data included in this package is provided in the Rainfall Data calculation package.
The Peak Flow printouts were generated from an excel spreadsheet located:
P:\WRES\Arizona_Public_Service\23445548_Cholla_Ash Monofill APP\Channel Design\Hydrology\Calculations\Rational Method\ADOT-IDF-Cholla-Ash-Monofill_2-9-09.xls

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Design Basis/References/Assumptions
The drainage basins and flow paths that the rational method calculation are based on are located in the following CADD files:
P:\WRES\Arizona_Public_Service\23445548_Cholla_Ash Monofill APP\Channel Design\Hydrology\Topo_Base_mcw_working.dwg
P:\WRES\Arizona_Public_Service\23445548_Cholla_Ash Monofill APP\Channel Design\Hydrology\X-5548-SitePlan_onsite_mcw_working.dwg
Figures are included which show the proposed development area, the offsite and onsite drainage basin delineations, and the longest flowpaths for each basin.

Remarks/Conclusions/Results:
See attached printouts.
Calculation Approved by: ______________________________
Project Manager/Date

Revision No.:	Description of Revision:	Approved by:

Project Manager/Date

RATIONAL METHOD CALCULATION

CHOLLA ASH MONOFILL HYDROLOGY ANALYSIS
CHOLLA GENERATING STATION
ARIZONA PUBLIC SERVICE

Problem Statement

The object of this calculation is to calculate the peak flows required for the onsite and offsite drainage channel design of the proposed Cholla Ash Monofill, and to calculate the volume required for the detention basin for the onsite drainage.

The peak flows for the drainage basins were calculated using the procedure outlined in the Arizona Department of Transportation (ADOT) Highway Drainage Design Manual Hydrology.

Required Deliverables

- Times of Concentration and Peak flows for each drainage basin, both offsite pre-development (100-year, 24-hour storm event) and onsite post-development (25-year, 24-hour storm event).
- Volume of runoff for onsite post-development detention basin.

Data Available

- Rainfall Data provided in Rainfall Data Calculation package
- I-D-F Data and Curves provided in Rainfall Data Calculation package
- Drainage Area (Total pre-development drainage area is approximately 150 acres, total post-development offsite drainage area is approximately 98 acres, see Fig 1)
- USDA NRCS web soil survey report for hydrologic soil group ratings by soil map unit to provide basis for C value.
- Tables from ADOT Highway Drainage Design Manual Hydrology providing C values and K_b values for the calculation
- Contour Data provided by USGS (5-foot contours) and Arizona Public Service (2-foot contours)
- Proposed Ash Monofill contour data.

Results

The printouts of the offsite and onsite peak flows were generated from the following Excel spreadsheet are attached:

P:\WRES\Arizona_Public_Service\23445548_Cholla_Ash Monofill APP\Channel Design\Hydrology\Calculations\Rational Method\ADOT-IDF-Cholla-Ash-Monofill_2-9-09.xls

The total runoff volume for the onsite post-development drainage basins is 5.5 acre feet, including the proposed area of the detention basin itself.

REFERENCES

ADOT Highway Drainage Design Manual Hydrology. March 1993.

URS Corporation. Rainfall Data Calculation Package. Cholla Ash Monofill. 2009.

USDA NRCS. Web Soil Survey. Soil Properties and Qualities, Hydrologic Soil Group. Accessed February 4, 2009. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

WORKSHEETS

Cholla Ash Monofill
Cholla Generating Station
Arizona Public Service

7

Return Frequency	Rainfall Depth (inches)
2-year, 6-hour	0.96
2-year, 24-hour	1.25
100-year, 6-hour	2.28
100-year, 24-hour	2.77

Short-Duration Rainfall Zone = 6

ADOT RAINFALL INTENSITY-DURATION-FREQUENCY
SITE SPECIFIC I-D-F TABLE

Duration	**Rainfall Intensity (inches/hour) Frequency (N-year)**						
	2	**5**	**10**	**25**	**50**	**100**	**500**
5-min	2.87	3.97	4.72	5.75	6.55	7.34	9.17
10-min	2.21	3.09	3.67	4.48	5.11	5.73	7.17
15-min	1.78	2.52	3.01	3.69	4.22	4.74	5.95
30-min	1.13	1.63	1.95	2.40	2.75	3.10	3.89
1-hour	0.68	0.99	1.20	**1.48**	1.70	**1.91**	2.41
2-hour	0.39	0.55	0.65	0.80	0.91	1.02	1.28
3-hour	0.28	0.39	0.46	0.56	0.63	0.71	0.88
6-hour	0.16	0.21	0.25	0.30	0.34	0.38	0.47
12-hour	0.09	0.12	0.14	0.17	0.19	0.21	0.26
24-hour	0.05	0.07	0.08	**0.09**	0.10	**0.12**	0.14

ADOT RAINFALL DEPTH-DURATION-FREQUENCY
SITE SPECIFIC D-D-F TABLE

Duration	**Rainfall Depth (inches) Frequency (N-year)**						
	2	**5**	**10**	**25**	**50**	**100**	**500**
5-min	0.24	0.33	0.39	0.48	0.55	0.61	0.76
10-min	0.37	0.51	0.61	0.75	0.85	0.96	1.20
15-min	0.44	0.63	0.75	0.92	1.05	1.18	1.49
30-min	0.57	0.81	0.98	1.20	1.38	1.55	1.95
1-hour	0.68	0.99	1.20	1.48	1.70	1.91	2.41
2-hour	0.78	1.09	1.30	1.59	1.81	2.04	2.55
3-hour	0.84	1.16	1.37	1.67	1.89	2.12	2.65
6-hour	0.96	1.28	1.50	1.81	2.04	2.28	2.83
12-hour	1.11	1.45	1.68	2.01	2.27	2.53	3.11
24-hour	1.25	1.61	1.86	**2.22**	2.50	**2.77**	3.40

Cholla Ash Monofill
Cholla Generating Station
Arizona Public Service

	A	C	D	E	F	G	H	I
45								
46	**Procedure Intermediate Calculations:**							
47								
48			Rainfall Depth (inches)				Rainfall Depth (inches)	
49	2-year, 1-hour		0.68		2-year, 5-min		0.24	
50	2-year, 2-hour		0.78		2-year, 10-min		0.37	
51	2-year, 3-hour		0.84		2-year, 15-min		0.44	
52	2-year, 6-hour		0.96		2-year, 30-min		0.57	
53	2-year, 12-hour		1.11		100-year, 5-min		0.61	
54	2-year, 24-hour		1.25		100-year, 10-min		0.96	
55	100-year, 1-hour		1.91		100-year, 15-min		1.18	
56	100-year, 2-hour		2.04		100-year, 30-min		1.55	
57	100-year, 3-hour		2.12					
58	100-year, 6-hour		2.28					
59	100-year, 12-hour		2.53					
60	100-year, 24-hour		2.77					
61								
62	**Procedure Look-up Tables:**							
63								
64		Duration	Zone Ratio			Frequency	Adjustment Ratio	
65		(Minutes)	6	8		(N-yr)	X	Y
66		5	0.35	0.34		5	0.674	0.278
67		10	0.54	0.51		10	0.496	0.449
68		15	0.65	0.62		25	0.293	0.669
69		30	0.83	0.82		50	0.146	0.835
70		5	0.32	0.30		500	-0.337	1.381
71		10	0.50	0.46				
72		15	0.62	0.59				
73		30	0.81	0.80				
74								

Cholla Ash Monofill
Cholla Generating Station
Arizona Public Service
IDF DATA FORMULAS

Return Frequency	Rainfall Depth (inches)
2-year, 6-hour	0.96
2-year, 24-hour	1.25
100-year, 6-hour	2.28
100-year, 24-hour	2.77

Short-Duration Rainfall Zone = 6

Duration	2	5	10	25	50	100	500
5-min	=C35/$B18	=D35/$B18	=E35/$B18	=F35/$B18	=G35/$B18	=H35/$B18	=I35/$B18
10-min	=C36/$B19	=D36/$B19	=E36/$B19	=F36/$B19	=G36/$B19	=H36/$B19	=I36/$B19
15-min	=C37/$B20	=D37/$B20	=E37/$B20	=F37/$B20	=G37/$B20	=H37/$B20	=I37/$B20
30-min	=C38/$B21	=D38/$B21	=E38/$B21	=F38/$B21	=G38/$B21	=H38/$B21	=I38/$B21
1-hour	=C39/$B22	=D39/$B22	=E39/$B22	=F39/$B22	=G39/$B22	=H39/$B22	=I39/$B22
2-hour	=C40/$B23	=D40/$B23	=E40/$B23	=F40/$B23	=G40/$B23	=H40/$B23	=I40/$B23
3-hour	=C41/$B24	=D41/$B24	=E41/$B24	=F41/$B24	=G41/$B24	=H41/$B24	=I41/$B24
6-hour	=C42/$B25	=D42/$B25	=E42/$B25	=F42/$B25	=G42/$B25	=H42/$B25	=I42/$B25
12-hour	=C43/$B26	=D43/$B26	=E43/$B26	=F43/$B26	=G43/$B26	=H43/$B26	=I43/$B26
24-hour	=C44/$B27	=D44/$B27	=E44/$B27	=F44/$B27	=G44/$B27	=H44/$B27	=I44/$B27

Duration	2	5	10	25	50	100	500
5-min	=H48	=(VLOOKUP(D$34,$G$65:$I$69,2)*$H48)+(VLOOKUP(D$34,$G$65:$I$69,3)*$H52)	=(VLOOKUP(E$34,$G$65:$I$69,2)*$H48)+(VLOOKUP(E$34,$G$65:$I$69,3)*$H52)	=(VLOOKUP(F$34,$G$65:$I$69,2)*$H48)+(VLOOKUP(F$34,$G$65:$I$69,3)*$H52)	=(VLOOKUP(G$34,$G$65:$I$69,2)*$H48)+(VLOOKUP(G$34,$G$65:$I$69,3)*$H52)	=H52	=(VLOOKUP(I$34,$G$65:$I$69,2)*$H48)+(VLOOKUP(I$34,$G$65:$I$69,3)*$H52)
10-min	=H49	=(VLOOKUP(D$34,$G$65:$I$69,2)*$H49)+(VLOOKUP(D$34,$G$65:$I$69,3)*$H53)	=(VLOOKUP(E$34,$G$65:$I$69,2)*$H49)+(VLOOKUP(E$34,$G$65:$I$69,3)*$H53)	=(VLOOKUP(F$34,$G$65:$I$69,2)*$H49)+(VLOOKUP(F$34,$G$65:$I$69,3)*$H53)	=(VLOOKUP(G$34,$G$65:$I$69,2)*$H49)+(VLOOKUP(G$34,$G$65:$I$69,3)*$H53)	=H53	=(VLOOKUP(I$34,$G$65:$I$69,2)*$H49)+(VLOOKUP(I$34,$G$65:$I$69,3)*$H53)
15-min	=H50	=(VLOOKUP(D$34,$G$65:$I$69,2)*$H50)+(VLOOKUP(D$34,$G$65:$I$69,3)*$H54)	=(VLOOKUP(E$34,$G$65:$I$69,2)*$H50)+(VLOOKUP(E$34,$G$65:$I$69,3)*$H54)	=(VLOOKUP(F$34,$G$65:$I$69,2)*$H50)+(VLOOKUP(F$34,$G$65:$I$69,3)*$H54)	=(VLOOKUP(G$34,$G$65:$I$69,2)*$H50)+(VLOOKUP(G$34,$G$65:$I$69,3)*$H54)	=H54	=(VLOOKUP(I$34,$G$65:$I$69,2)*$H50)+(VLOOKUP(I$34,$G$65:$I$69,3)*$H54)
30-min	=H51	=(VLOOKUP(D$34,$G$65:$I$69,2)*$H51)+(VLOOKUP(D$34,$G$65:$I$69,3)*$H55)	=(VLOOKUP(E$34,$G$65:$I$69,2)*$H51)+(VLOOKUP(E$34,$G$65:$I$69,3)*$H55)	=(VLOOKUP(F$34,$G$65:$I$69,2)*$H51)+(VLOOKUP(F$34,$G$65:$I$69,3)*$H55)	=(VLOOKUP(G$34,$G$65:$I$69,2)*$H51)+(VLOOKUP(G$34,$G$65:$I$69,3)*$H55)	=H55	=(VLOOKUP(I$34,$G$65:$I$69,2)*$H51)+(VLOOKUP(I$34,$G$65:$I$69,3)*$H55)
1-hour	=D48	=(VLOOKUP(D$34,$G$65:$I$69,2)*$D48)+(VLOOKUP(D$34,$G$65:$I$69,3)*$D54)	=(VLOOKUP(E$34,$G$65:$I$69,2)*$D48)+(VLOOKUP(E$34,$G$65:$I$69,3)*$D54)	=(VLOOKUP(F$34,$G$65:$I$69,2)*$D48)+(VLOOKUP(F$34,$G$65:$I$69,3)*$D54)	=(VLOOKUP(G$34,$G$65:$I$69,2)*$D48)+(VLOOKUP(G$34,$G$65:$I$69,3)*$D54)	=D54	=(VLOOKUP(I$34,$G$65:$I$69,2)*$D48)+(VLOOKUP(I$34,$G$65:$I$69,3)*$D54)
2-hour	=D49	=(VLOOKUP(D$34,$G$65:$I$69,2)*$D49)+(VLOOKUP(D$34,$G$65:$I$69,3)*$D55)	=(VLOOKUP(E$34,$G$65:$I$69,2)*$D49)+(VLOOKUP(E$34,$G$65:$I$69,3)*$D55)	=(VLOOKUP(F$34,$G$65:$I$69,2)*$D49)+(VLOOKUP(F$34,$G$65:$I$69,3)*$D55)	=(VLOOKUP(G$34,$G$65:$I$69,2)*$D49)+(VLOOKUP(G$34,$G$65:$I$69,3)*$D55)	=D55	=(VLOOKUP(I$34,$G$65:$I$69,2)*$D49)+(VLOOKUP(I$34,$G$65:$I$69,3)*$D55)
3-hour	=D50	=(VLOOKUP(D$34,$G$65:$I$69,2)*$D50)+(VLOOKUP(D$34,$G$65:$I$69,3)*$D56)	=(VLOOKUP(E$34,$G$65:$I$69,2)*$D50)+(VLOOKUP(E$34,$G$65:$I$69,3)*$D56)	=(VLOOKUP(F$34,$G$65:$I$69,2)*$D50)+(VLOOKUP(F$34,$G$65:$I$69,3)*$D56)	=(VLOOKUP(G$34,$G$65:$I$69,2)*$D50)+(VLOOKUP(G$34,$G$65:$I$69,3)*$D56)	=D56	=(VLOOKUP(I$34,$G$65:$I$69,2)*$D50)+(VLOOKUP(I$34,$G$65:$I$69,3)*$D56)
6-hour	=D51	=(VLOOKUP(D$34,$G$65:$I$69,2)*$D51)+(VLOOKUP(D$34,$G$65:$I$69,3)*$D57)	=(VLOOKUP(E$34,$G$65:$I$69,2)*$D51)+(VLOOKUP(E$34,$G$65:$I$69,3)*$D57)	=(VLOOKUP(F$34,$G$65:$I$69,2)*$D51)+(VLOOKUP(F$34,$G$65:$I$69,3)*$D57)	=(VLOOKUP(G$34,$G$65:$I$69,2)*$D51)+(VLOOKUP(G$34,$G$65:$I$69,3)*$D57)	=D57	=(VLOOKUP(I$34,$G$65:$I$69,2)*$D51)+(VLOOKUP(I$34,$G$65:$I$69,3)*$D57)
12-hour	=D52	=(VLOOKUP(D$34,$G$65:$I$69,2)*$D52)+(VLOOKUP(D$34,$G$65:$I$69,3)*$D58)	=(VLOOKUP(E$34,$G$65:$I$69,2)*$D52)+(VLOOKUP(E$34,$G$65:$I$69,3)*$D58)	=(VLOOKUP(F$34,$G$65:$I$69,2)*$D52)+(VLOOKUP(F$34,$G$65:$I$69,3)*$D58)	=(VLOOKUP(G$34,$G$65:$I$69,2)*$D52)+(VLOOKUP(G$34,$G$65:$I$69,3)*$D58)	=D58	=(VLOOKUP(I$34,$G$65:$I$69,2)*$D52)+(VLOOKUP(I$34,$G$65:$I$69,3)*$D58)
24-hour	=D53	=(VLOOKUP(D$34,$G$65:$I$69,2)*$D53)+(VLOOKUP(D$34,$G$65:$I$69,3)*$D59)	=(VLOOKUP(E$34,$G$65:$I$69,2)*$D53)+(VLOOKUP(E$34,$G$65:$I$69,3)*$D59)	=(VLOOKUP(F$34,$G$65:$I$69,2)*$D53)+(VLOOKUP(F$34,$G$65:$I$69,3)*$D59)	=(VLOOKUP(G$34,$G$65:$I$69,2)*$D53)+(VLOOKUP(G$34,$G$65:$I$69,3)*$D59)	=D59	=(VLOOKUP(I$34,$G$65:$I$69,2)*$D53)+(VLOOKUP(I$34,$G$65:$I$69,3)*$D59)

Procedure Intermediate Calculations:

2-year, 1-hour	=-0.011+(0.942*($F$5^2)/$F$6)
2-year, 2-hour	=0.341*($F$5)+0.659*($D$48)
2-year, 3-hour	=0.569*($F$5)+0.431*($D$48)
2-year, 6-hour	=F5
2-year, 12-hour	=0.5*($F$5)+0.5*($F$6)
2-year, 24-hour	=F6
100-year, 1-hour	=0.494+(0.755*($F$7^2)/$F$8)
100-year, 2-hour	=0.341*($F$7)+0.659*($D$54)
100-year, 3-hour	=0.569*($F$7)+0.431*($D$54)
100-year, 6-hour	=F7
100-year, 12-ho	=0.5*($F$7)+0.5*($F$8)
100-year, 24-ho	=F8

2-year, 5-min	=IF($F$10=6,D65*$D$48,E65*$D$48)
2-year, 10-min	=IF($F$10=6,D66*$D$48,E66*$D$48)
2-year, 15-min	=IF($F$10=6,D67*$D$48,E67*$D$48)
2-year, 30-min	=IF($F$10=6,D68*$D$48,E68*$D$48)
100-year, 5-min	=IF($F$10=6,D69*$D$54,E69*$D$54)
100-year, 10-min	=IF($F$10=6,D70*$D$54,E70*$D$54)
100-year, 15-min	=IF($F$10=6,D71*$D$54,E71*$D$54)
100-year, 30-min	=IF($F$10=6,D72*$D$54,E72*$D$54)

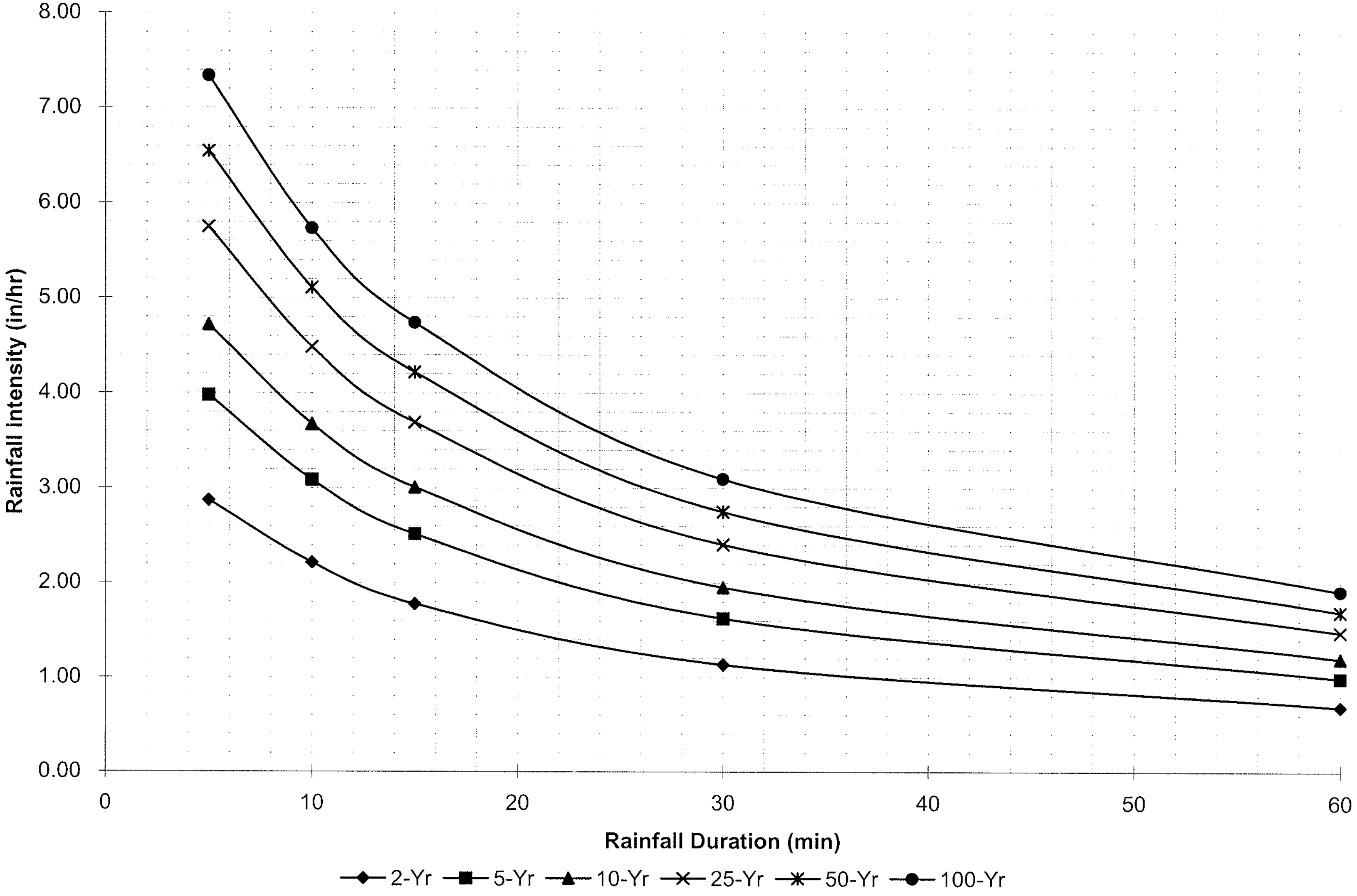
Procedure Look-up Tables:

Duration (Minutes)	Zone Ratio	
	6	8
5	0.35	0.34
10	0.54	0.51
15	0.65	0.62
30	0.83	0.82
5	0.32	0.3
10	0.5	0.46
15	0.62	0.59
30	0.81	0.8

Frequency (N-yr)	X	Y
5	0.674	0.278
10	0.496	0.449
25	0.293	0.669
50	0.146	0.835
500	-0.337	1.381

Cholla Ash Monofill
Cholla Generating Station
Arizona Public Service

Site Specific IDF Graph



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2/10/2009 8:29 AM

Project Name: **Cholla Power Plant- Ash Fill**
Subject: **25-Year Peak Discharge Onsite**
Location: **Joseph City, AZ**

Date: **02/06/09**
Computed By: **MCW**
Checked By:

Ash Fill Channel - On-site Basin 4

25-yr, 24-hr Precipitation = 2.22 in
25-yr, 10 min Intensity = 4.48 in/hr
Hydrologic Zone = 6

Length of Longest Flowpath = 819 feet
0.16 miles
Upper Elevation= 5230.00 feet
Lower Elevation= 5086.00 feet
Slope of Longest Flowpath = 928.58 ft/mi
Kb = 0.08

Q=CIA

C_D= 0.60

I= 4.48 in/hr
Area = 8.89 acres

Total Area = 8.89 acres

Design Peak Flow = **23.9** cfs

$Tc=11.4L^{0.50}K_b^{0.52}S^{-0.31}I^{-0.38}$

Trials

Tc (min)	I(in/hr)	Calculated Tc (min)	
5	5.75	4.5	
10	4.48	4.9	OK*
15	3.69	5.3	
30	2.40	6.2	
60	1.48	7.5	

▨ Denotes information that needs to be entered.
*NOTE: Minimum allowable Tc = 10 minutes per ADOT Manual

Tc = time of concentration (hrs)
L = length of longest flowpath (miles)
Kb = watershed resistance coefficient
S = slope of longest flowpath
I = average rainfall intensity (in/hr)

Project Name:	**Cholla Power Plant- Ash Fill**	Date:	**02/06/09**
Subject:	**25-Year Peak Discharge Onsite**	Computed By:	**MCW**
Location:	**Joseph City, AZ**	Checked By:	

Ash Fill Channel - On-site Basin 5

25-yr, 24-hr Precipitation = 2.22 in
25-yr, 10 min Intensity = 4.48 in/hr
Hydrologic Zone = 6

Length of Longest Flowpath = 629 feet
0.12 miles
Upper Elevation= 5230.00 feet
Lower Elevation= 5103.00 feet
Slope of Longest Flowpath = 1065.40 ft/mi
Kb = 0.08

Q=CIA

C_D= 0.60

I= 4.48 in/hr
Area = 13.72 acres

Total Area = 13.72 acres

Design Peak Flow = **36.9** cfs

$Tc=11.4L^{0.50}K_b^{0.52}S^{-0.31}I^{-0.38}$

Trials

Tc (min)	I(in/hr)	Calculated Tc (min)	
5	5.75	3.8	
10	4.48	4.1	OK*
15	3.69	4.5	
30	2.40	5.2	
60	1.48	6.3	

▨ Denotes information that needs to be entered.
*NOTE: Minimum allowable Tc = 10 minutes per ADOT Manual

Tc =	time of concentration (hrs)
L =	length of longest flowpath (miles)
Kb =	watershed resistance coefficient
S =	slope of longest flowpath
I =	average rainfall intensity (in/hr)

Project Name:	**Cholla Power Plant- Ash Fill**	Date:	**02/06/09**
Subject:	**25-Year Peak Discharge Onsite**	Computed By:	**MCW**
Location:	**Joseph City, AZ**	Checked By:	

Ash Fill Channel - On-site Basin 6

25-yr, 24-hr Precipitation = 2.22 in
25-yr, 10 min Intensity = 4.48 in/hr
Hydrologic Zone = 6

Length of Longest Flowpath = 835 feet
0.16 miles
Upper Elevation= 5230.00 feet
Lower Elevation= 5077.00 feet
Slope of Longest Flowpath = 967.47 ft/mi
Kb = 0.08

Q=CIA

C_D= 0.60

I= 4.48 in/hr
Area = 19.87 acres

Total Area = 19.87 acres

Design Peak Flow = **53.5** cfs

$Tc=11.4L^{0.50}K_b^{0.52}S^{-0.31}I^{-0.38}$

Trials

Tc (min)	I(in/hr)	Calculated Tc (min)	
5	5.75	4.5	
10	4.48	4.9	OK*
15	3.69	5.3	
30	2.40	6.2	
60	1.48	7.5	

▨ Denotes information that needs to be entered.
*NOTE: Minimum allowable Tc = 10 minutes per ADOT Manual

Tc =	time of concentration (hrs)
L =	length of longest flowpath (miles)
Kb =	watershed resistance coefficient
S =	slope of longest flowpath
I =	average rainfall intensity (in/hr)

Project Name: **Cholla Power Plant- Ash Fill**
Subject: **25-Year Peak Discharge Onsite**
Location: **Joseph City, AZ**

Date: **02/06/09**
Computed By: **MCW**
Checked By:

Ash Fill Channel - On-site Basin 7

25-yr, 24-hr Precipitation = 2.22 in
25-yr, 10 min Intensity = 4.48 in/hr
Hydrologic Zone = 6

Length of Longest Flowpath = 475 feet
0.09 miles
Upper Elevation= 5227.00 feet
Lower Elevation= 5115.00 feet
Slope of Longest Flowpath = 1246.02 ft/mi
Kb = 0.08

Q=CIA

C_D= 0.60

I= 4.48 in/hr
Area = 4.67 acres

Total Area = 4.67 acres

Design Peak Flow = **12.6** cfs

$Tc=11.4L^{0.50}K_b^{0.52}S^{-0.31}I^{-0.38}$

Trials

Tc (min)	I(in/hr)	Calculated Tc (min)	
5	5.75	3.1	
10	4.48	3.4	OK*
15	3.69	3.7	
30	2.40	4.3	
60	1.48	5.2	

▨ Denotes information that needs to be entered.
*NOTE: Minimum allowable Tc = 10 minutes per ADOT Manual

Tc =	time of concentration (hrs)
L =	length of longest flowpath (miles)
Kb =	watershed resistance coefficient
S =	slope of longest flowpath
I =	average rainfall intensity (in/hr)

REFERENCES

TABLE 2-1
RESISTANCE COEFFICIENT (K_b) FOR USE WITH THE RATIONAL METHOD T_c EQUATION

Description of Landform	K_b	
	Defined Drainage Network	Overland Flow Only
Mountain, with forest and dense ground cover (overland slopes - 50% or greater)	0.15	0.30
Mountain, with rough rock and boulder cover (overland slopes - 50% or greater)	0.12	0.25
Foothills (overland slopes - 10% to 50%)	0.10	0.20
Alluvial fans, Pediments and Rangeland (overland slopes - 10% or less)	0.05	$\boxed{0.10}$ ← K_b offsite
Irrigated Pasture [a]	—	0.20
Tilled Agricultural Fields [a]	—	0.08
URBAN		
Residential, L is less than 1,000 ft [b]	0.04	—
Residential, L is greater than 1,000 ft [b]	0.025	—
Grass; parks, cemeteries, etc. [a]	—	0.20
Bare ground; playgrounds, etc. [a]	—	0.08
Paved; parking lots, etc. [a]	—	0.02

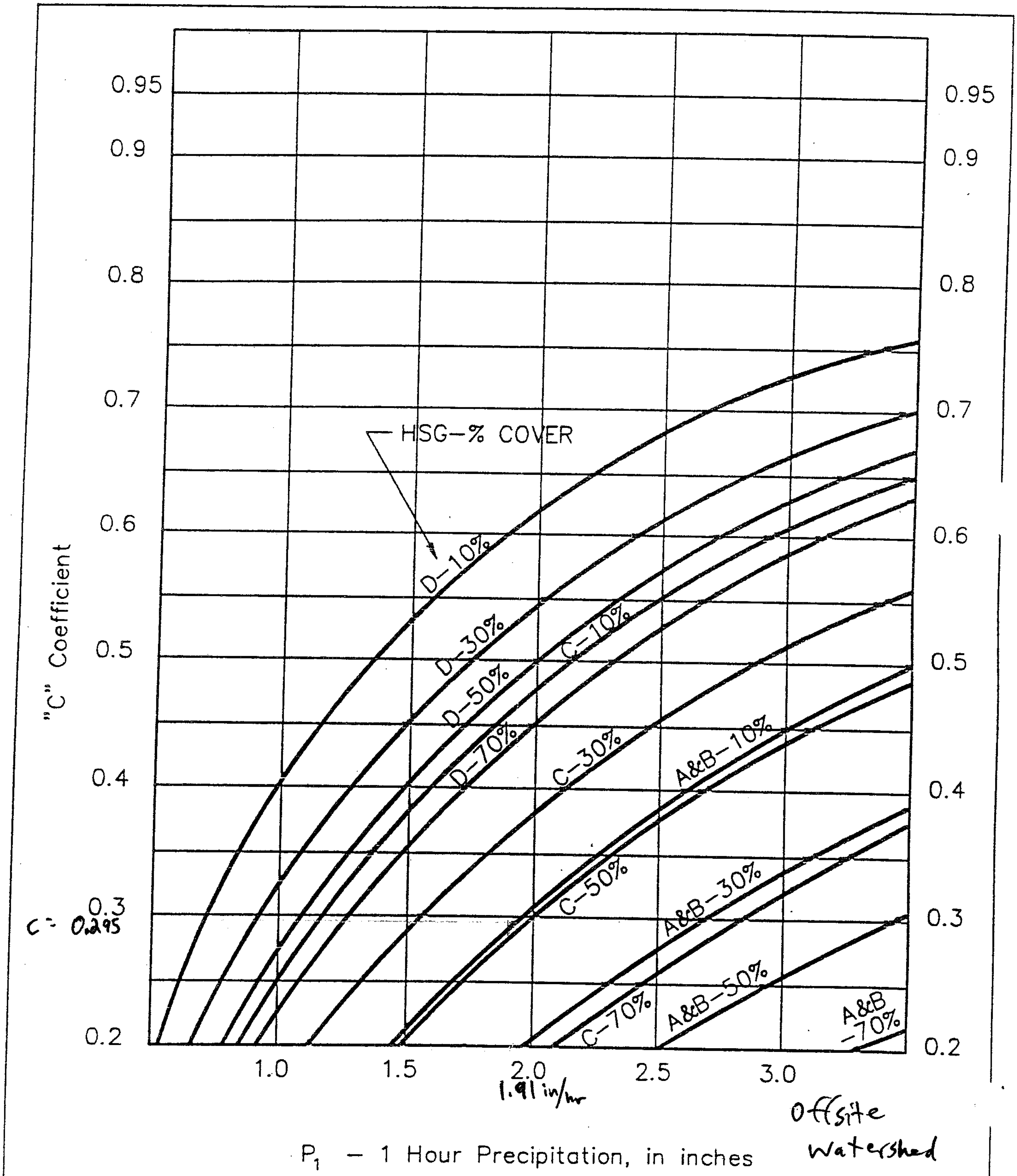
Notes: a - No defined drainage network.
b - L is length in the T_c equation. Streets serve as drainagae network.

Onsite K_b assumed = 0.08

2 6

FIGURE 2-5
RATIONAL "C" COEFFICIENT
UPLAND RANGELAND
(GRASS & BRUSH)

AS A FUNCTION OF RAINFALL DEPTH, HYDROLOGIC SOIL GROUP (HSG), AND % OF VEGETATION COVER



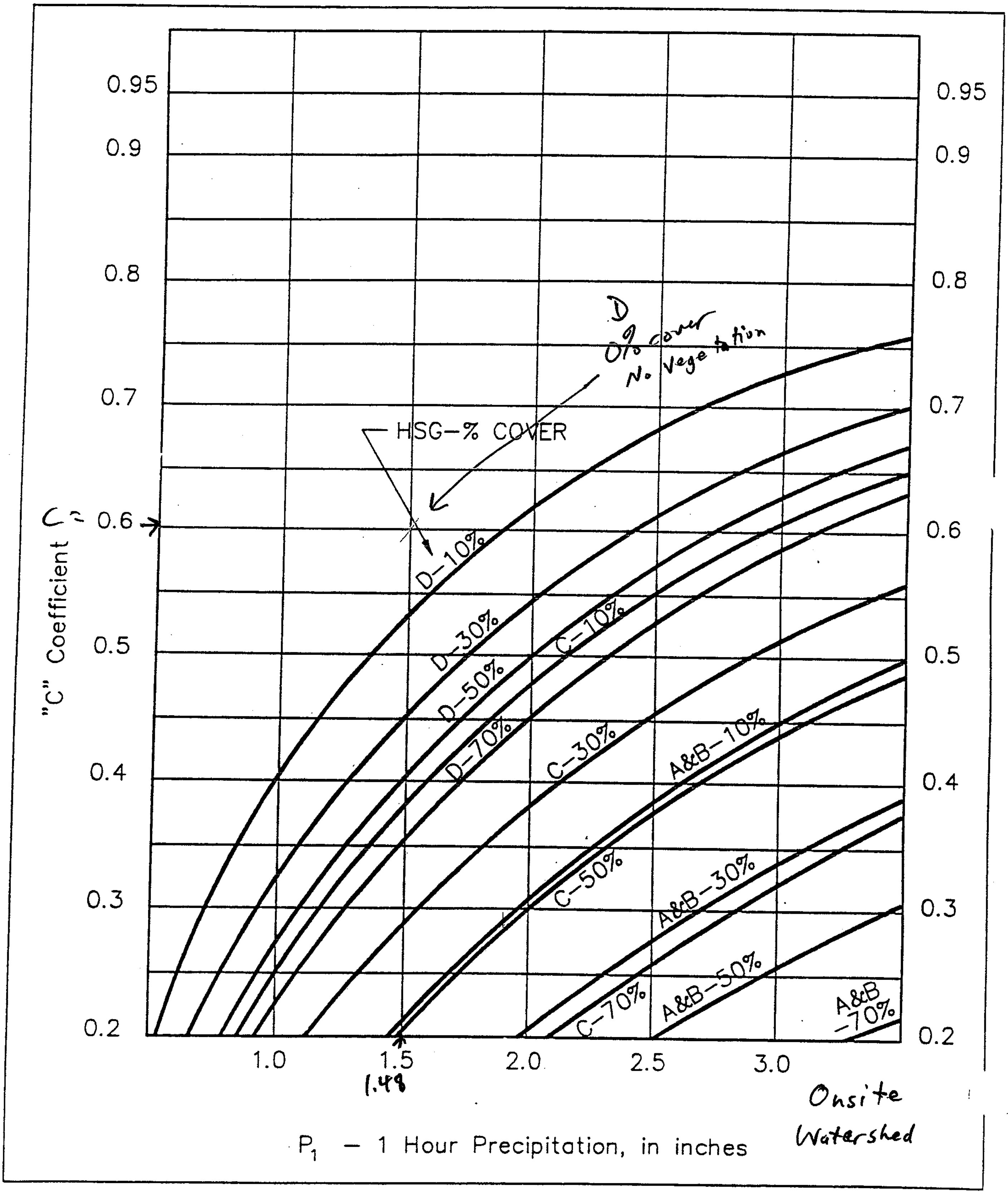
C = 0.295

1.91 in/hr

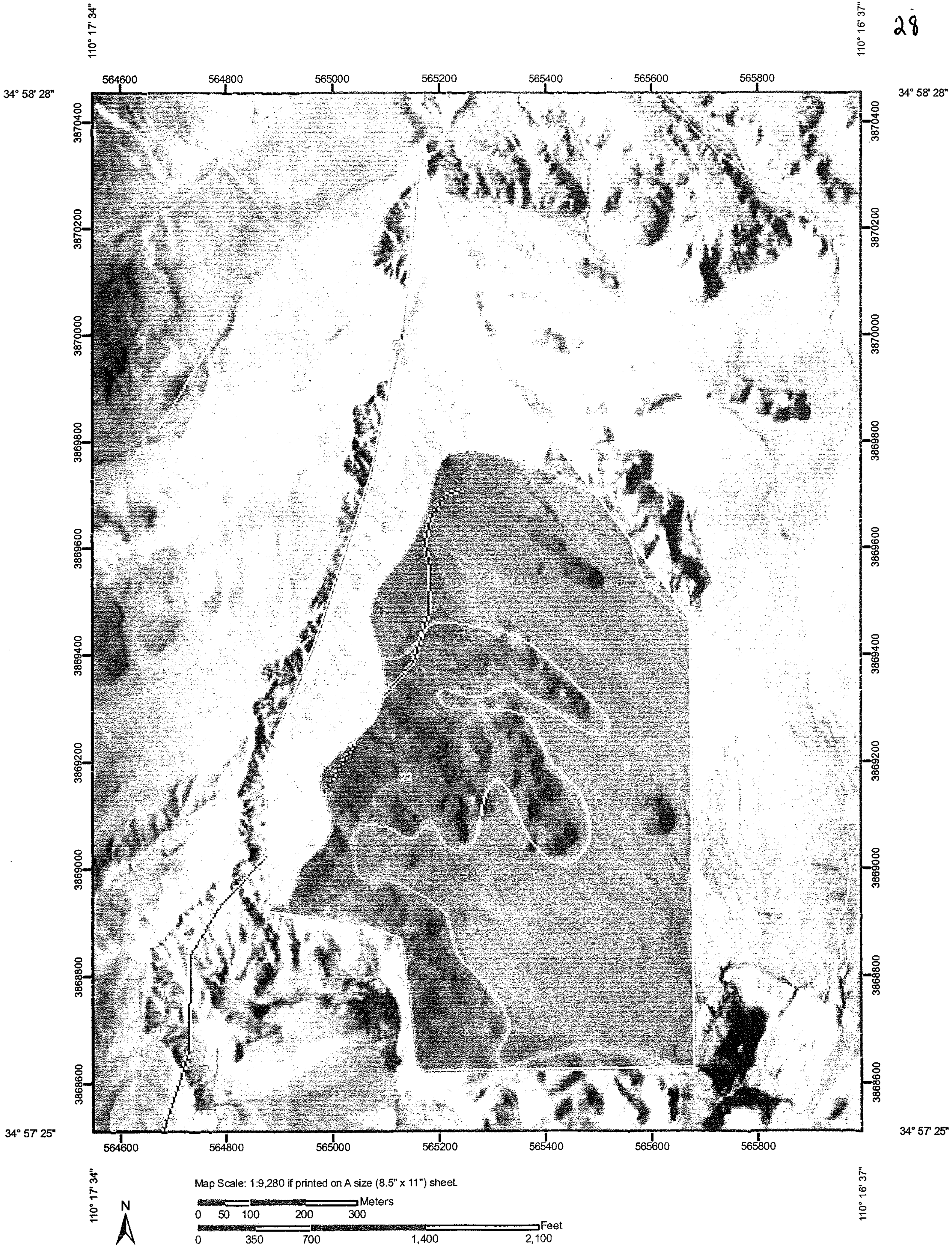
Offsite Watershed

FIGURE 2-5
RATIONAL "C" COEFFICIENT
UPLAND RANGELAND
(GRASS & BRUSH)

AS A FUNCTION OF RAINFALL DEPTH, HYDROLOGIC SOIL GROUP (HSG), AND % OF VEGETATION COVER



Soil Properties and Qualities—Navajo County Area, Arizona, Central Part
(Cholla Ash Monofill Hydrology)



Map Scale: 1:9,280 if printed on A size (8.5" x 11") sheet.

MAP LEGEND

Area of Interest (AOI)

┆ Area of Interest (AOI)

Soils

Soil Map Units

Soil Ratings

░ A

☐ A/D

▨ B

☐ B/D

☐ C

▨ C/D

░ D

Not rated or not available

Political Features

● Cities

Water Features

░ Oceans

Streams and Canals

Transportation

+++ Rails

〰 Interstate Highways

〰 US Routes

Major Roads

〰 Local Roads

MAP INFORMATION

Map Scale: 1:9,280 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 12N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Navajo County Area, Arizona, Central Part
Survey Area Data: Version 10, Sep 11, 2008

Date(s) aerial images were photographed: 6/21/1997

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Soil Properties and Qualities

Soil Properties and Qualities— Summary by Map Unit — Navajo County Area, Arizona, Central Part				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
3	Badland-Torriorthents association, 1 to 30 percent slopes		43.8	21.4%
9	Bumswick sandy clay loam, 1 to 5 percent slopes	B	106.0	51.7%
21	Grieta sandy loam, 3 to 10 percent slopes	B	0.2	0.1%
22	Gypsiorthids-Torriorthents association, 5 to 60 percent slopes	B	55.0	26.8%
Totals for Area of Interest			**205.0**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Pre-Development

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Assumed Post-Development Onsite

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Lower

OFF-SITE HYDROLOGY

Project Name: **Cholla Power Plant- Ash Fill**
Subject: **100-Year Peak Discharge**
Location: **Joseph City, AZ**

Date: **02/03/09**
Computed By: **MCW**
Checked By:

Ash Fill Channel - Pre-development Basin Off-1

100-yr, 24-hr Precipitation = 2.77 in
100-yr, 10 min Intensity = 5.73 in/hr
Hydrologic Zone = 6

Length of Longest Flowpath = 2,963 feet
0.56 miles
Upper Elevation= 5197.00 feet
Lower Elevation= 5068.00 feet
Slope of Longest Flowpath = 229.85 ft/mi
Kb = 0.10

Q=CIA

C_{50B}= 0.30

I= 4.60 in/hr
Area = 39.63 acres

Total Area = 39.63 acres

Design Peak Flow = **53.8** cfs

$Tc=11.4L^{0.50}K_b^{0.52}S^{-0.31}I^{-0.38}$

Trials

Tc (min)	I(in/hr)	Calculated Tc (min)	
5	7.34	13.4	
15	4.74	15.9	
16	4.60	16.1	OK
30	3.10	18.7	
60	1.91	22.4	

▨ Denotes information that needs to be entered.

Tc = time of concentration (hrs)
L = length of longest flowpath (miles)
Kb = watershed resistance coefficient
S = slope of longest flowpath
I = average rainfall intensity (in/hr)

Project Name:	**Cholla Power Plant- Ash Fill**	Date:	**02/03/09**
Subject:	**100-Year Peak Discharge**	Computed By:	**MCW**
Location:	**Joseph City, AZ**	Checked By:	

Ash Fill Channel - Pre-development Basin Off-2

100-yr, 24-hr Precipitation = 2.77 in
100-yr, 10 min Intensity = 5.73 in/hr
Hydrologic Zone = 6

Length of Longest Flowpath = 3,309 feet
0.63 miles
Upper Elevation= 5210.00 feet
Lower Elevation= 5075.00 feet
Slope of Longest Flowpath = 215.44 ft/mi
Kb = 0.10

Q=CIA

C_{50B}= 0.30

I= 4.30 in/hr
Area = 49.27 acres

Total Area = 49.27 acres

Design Peak Flow = **62.5** cfs

$$T_c=11.4L^{0.50}K_b^{0.52}S^{-0.31}I^{-0.38}$$

Trials

Tc (min)	I(in/hr)	Calculated Tc (min)	
5	7.34	14.5	
15	4.74	17.1	
18	4.30	17.8	OK
30	3.10	20.1	
60	1.91	24.2	

▨ Denotes information that needs to be entered.

Tc = time of concentration (hrs)
L = length of longest flowpath (miles)
Kb = watershed resistance coefficient
S = slope of longest flowpath
I = average rainfall intensity (in/hr)

Project Name: **Cholla Power Plant- Ash Fill**
Subject: **100-Year Peak Discharge**
Location: **Joseph City, AZ**

Date: **02/03/09**
Computed By: **MCW**
Checked By:

Ash Fill Channel - Pre-development Basin Off- 3

100-yr, 24-hr Precipitation = 2.77 in
100-yr, 10 min Intensity = 5.73 in/hr
Hydrologic Zone = 6

Length of Longest Flowpath = 4,497 feet
0.85 miles
Upper Elevation= 5245.00 feet
Lower Elevation= 5079.00 feet
Slope of Longest Flowpath = 194.89 ft/mi
Kb = 0.10

Q=CIA

C_{50B}= 0.30

I= 3.80 in/hr
Area = 59.65 acres

Total Area = 59.65 acres

Design Peak Flow = **66.9** cfs

$T_c=11.4L^{0.50}K_b^{0.52}S^{-0.31}I^{-0.38}$

Trials

Tc (min)	I(in/hr)	Calculated Tc (min)	
5	7.34	17.4	
15	4.74	20.6	
22	3.80	22.4	OK
30	3.10	24.2	
60	1.91	29.1	

▨ Denotes information that needs to be entered.

Tc = time of concentration (hrs)
L = length of longest flowpath (miles)
Kb = watershed resistance coefficient
S = slope of longest flowpath
I = average rainfall intensity (in/hr)

Project Name: **Cholla Power Plant- Ash Fill**
Subject: **100-Year Peak Discharge**
Location: **Joseph City, AZ**

Date: **02/03/09**
Computed By: **MCW**
Checked By:

Ash Fill Channel - Post Development Off-1

100-yr, 24-hr Precipitation =	2.77	in
100-yr, 10 min Intensity =	5.73	in/hr
Hydrologic Zone =	6	
Length of Longest Flowpath =	1,357	feet
	0.26	miles
Upper Elevation=	5192.00	feet
Lower Elevation=	5121.00	feet
Slope of Longest Flowpath =	276.26	ft/mi
Kb =	0.10	

Q=CIA

C_{50B}= 0.30

I= 5.73 in/hr
Area = 14.10 acres

Total Area = 14.10 acres

Design Peak Flow = **23.8** cfs

$Tc=11.4L^{0.50}K_b^{0.52}S^{-0.31}I^{-0.38}$

Trials

Tc (min)	I(in/hr)	Calculated Tc (min)	
5	7.34	8.6	
9	6.00	9.3	
10	5.73	9.4	OK*
15	4.74	10.1	
30	3.10	11.9	
60	1.91	14.3	

▨ Denotes information that needs to be entered.
*Note: Minimum allowed Tc = 10 minutes

Tc = time of concentration (hrs)
L = length of longest flowpath (miles)
Kb = watershed resistance coefficient
S = slope of longest flowpath
I = average rainfall intensity (in/hr)

Project Name: **Cholla Power Plant- Ash Fill**
Subject: **100-Year Peak Discharge**
Location: **Joseph City, AZ**

Date: **02/03/09**
Computed By: **MCW**
Checked By:

Ash Fill Channel - Post Development Off-2

100-yr, 24-hr Precipitation = 2.77 in
100-yr, 10 min Intensity = 5.73 in/hr
Hydrologic Zone = 6

Length of Longest Flowpath = 2,076 feet
0.39 miles
Upper Elevation= 5210.00 feet
Lower Elevation= 5118.00 feet
Slope of Longest Flowpath = 233.99 ft/mi
Kb = 0.10

Q=CIA

C_{50B}= 0.30

I= 5.00 in/hr
Area = 34.4 acres

Total Area = 34.4 acres

Design Peak Flow = **50.7** cfs

$Tc=11.4L^{0.50}K_b^{0.52}S^{-0.31}I^{-0.38}$

Trials

Tc (min)	I(in/hr)	Calculated Tc (min)	
5	7.34	11.2	
13	5.00	13.0	OK
15	4.74	13.2	
30	3.10	15.5	
60	1.91	18.7	

▨ Denotes information that needs to be entered.

Tc = time of concentration (hrs)
L = length of longest flowpath (miles)
Kb = watershed resistance coefficient
S = slope of longest flowpath
I = average rainfall intensity (in/hr)

Project Name: **Cholla Power Plant- Ash Fill**
Subject: **100-Year Peak Discharge**
Location: **Joseph City, AZ**

Date: **02/03/09**
Computed By: **MCW**
Checked By:

Ash Fill Channel - Post Development Off-3

100-yr, 24-hr Precipitation = 2.77 in
100-yr, 10 min Intensity = 5.73 in/hr
Hydrologic Zone = 6

Length of Longest Flowpath = 3,505 feet
0.66 miles
Upper Elevation= 5245.00 feet
Lower Elevation= 5119.00 feet
Slope of Longest Flowpath = 189.81 ft/mi
Kb = 0.10

Q=CIA

C_{50B}= 0.30

I= 4.20 in/hr
Area = 49.19 acres

Total Area = 49.19 acres

Design Peak Flow = **60.9** cfs

$Tc=11.4L^{0.50}K_b^{0.52}S^{-0.31}I^{-0.38}$

Trials

Tc (min)	I(in/hr)	Calculated Tc (min)	
5	7.34	15.5	
15	4.74	18.3	
19	4.20	19.2	OK
30	3.10	21.5	
60	1.91	25.9	

▨ Denotes information that needs to be entered.

Tc = time of concentration (hrs)
L = length of longest flowpath (miles)
Kb = watershed resistance coefficient
S = slope of longest flowpath
I = average rainfall intensity (in/hr)

Hydrograph Data
Based on Site Specific Watershed and Rainfall Data
FORMULAS

	A	B	C	D	E	F	G	H	I	J
1	Project Name:		**Cholla Power Plant- Ash Fill**				Date:		**39847**	
2	Subject:		**100-Year Peak Discharge**				Computed By:		**MCW**	
3	Location:		**Joseph City, AZ**				Checked By:			
4										
5	Ash Fill Channel - Pre-development Drainage Area 1					Q=CIA				
6							C_{50B}=	0.295		
7		100-yr, 6-hr Precipitation =		='IDF Data'!H42	in		C_ =	0		
8		100-yr, 10 min Intensity		='IDF Data'!H19	in/hr		$C_{Composite}$=	=(H6*H10+H7*H11)/H12		
9		Hydrologic Zone =		='IDF Data'!F10			I=	=B26	in/hr	
10						50B Area =		59.65	acres	
11						__ Area =		0	acres	
12		Length of Longest Flowpath =		4497.4	feet	Total Area =		=H10+H11	acres	
13				=D12/5280	miles					
14		Upper Elevation=		5245	feet					
15		Lower Elevation=		5079	feet	Design Peak Flow =		**=H8*H9*H12**	cfs	
16		Slope of Longest Flowpath =		=(D14-D15)/D13	ft/mi					
17			Kb =	0.1						
18										
19	$Tc=11.4L^{0.50}K_b^{0.52}S^{-0.31}I^{-0.38}$									
20						Tc =	time of concentration (hrs)			
21	Trials					L =	length of longest flowpath (miles)			
22			Calculated			Kb =	watershed resistance coefficient			
23	Tc (min)	I(in/hr)	Tc (min)			S =	slope of longest flowpath			
24	5	='IDF Data'!H18	`=(11.4*$D$13^0.5*$D$17^0.52*$D$16^-0.31*B24^-0.38)*60`			I =	average rainfall intensity (in/hr)			
25	15	='IDF Data'!H20	`=(11.4*$D$13^0.5*$D$17^0.52*$D$16^-0.31*B25^-0.38)*60`							
26	22	3.8	`=(11.4*$D$13^0.5*$D$17^0.52*$D$16^-0.31*B26^-0.38)*60`	OK						
27	30	3.1	`=(11.4*$D$13^0.5*$D$17^0.52*$D$16^-0.31*B27^-0.38)*60`							
28	60	1.91	`=(11.4*$D$13^0.5*$D$17^0.52*$D$16^-0.31*B28^-0.38)*60`							
29										
30										
31		Denotes information that needs to be entered.								
32										

APPENDIX C

HYDRAULC CALCULATIONS

APPENDIX C

HYDRAULC CALCULATIONS

ON-SITE HYDRAULIC CALCULATIONS

ON-SITE CHANNEL
NORMAL DEPTH CALCULATIONS

Worksheet for DROP Onsite SOUTH channel(25 cfs-5:1)

Project Description

Friction Method	Manning Formula	
Solve For	Normal Depth	

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.20000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	25.00	ft³/s

Results

Normal Depth	0.29	ft
Flow Area	3.14	ft²
Wetted Perimeter	11.58	ft
Top Width	11.46	ft
Critical Depth	0.55	ft
Critical Slope	0.02311	ft/ft
Velocity	7.96	ft/s
Velocity Head	0.98	ft
Specific Energy	1.28	ft
Froude Number	2.68	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.29	ft
Critical Depth	0.55	ft
Channel Slope	0.20000	ft/ft
Critical Slope	0.02311	ft/ft

Worksheet for Onsite SOUTH channel (25 cfs - 1.6% slope)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01600	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	25.00	ft³/s

Results

Normal Depth	0.61	ft
Flow Area	7.09	ft²
Wetted Perimeter	13.31	ft
Top Width	13.07	ft
Critical Depth	0.55	ft
Critical Slope	0.02311	ft/ft
Velocity	3.53	ft/s
Velocity Head	0.19	ft
Specific Energy	0.81	ft
Froude Number	0.84	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.61	ft
Critical Depth	0.55	ft
Channel Slope	0.01600	ft/ft
Critical Slope	0.02311	ft/ft

Worksheet for DROP STRUCTURE Onsite sec-1(95 cfs-5:1)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.20000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	95.00	ft³/s

Results

Normal Depth	0.64	ft
Flow Area	7.43	ft²
Wetted Perimeter	13.45	ft
Top Width	13.20	ft
Critical Depth	1.26	ft
Critical Slope	0.01845	ft/ft
Velocity	12.79	ft/s
Velocity Head	2.54	ft
Specific Energy	3.18	ft
Froude Number	3.01	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.64	ft
Critical Depth	1.26	ft
Channel Slope	0.20000	ft/ft
Critical Slope	0.01845	ft/ft

Worksheet for Onsite channel sec-1(95 cfs - 0.885% slope)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00885	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	95.00	ft^3/s

Results

Normal Depth	1.55	ft
Flow Area	21.43	ft^2
Wetted Perimeter	18.32	ft
Top Width	17.73	ft
Critical Depth	1.26	ft
Critical Slope	0.01845	ft/ft
Velocity	4.43	ft/s
Velocity Head	0.31	ft
Specific Energy	1.85	ft
Froude Number	0.71	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.55	ft
Critical Depth	1.26	ft
Channel Slope	0.00885	ft/ft
Critical Slope	0.01845	ft/ft

Worksheet for Onsite channel sec-2(95 cfs - 1.04% slope)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01040	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	95.00	ft³/s

Results

Normal Depth	1.48	ft
Flow Area	20.25	ft²
Wetted Perimeter	17.96	ft
Top Width	17.39	ft
Critical Depth	1.26	ft
Critical Slope	0.01846	ft/ft
Velocity	4.69	ft/s
Velocity Head	0.34	ft
Specific Energy	1.82	ft
Froude Number	0.77	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.48	ft
Critical Depth	1.26	ft
Channel Slope	0.01040	ft/ft
Critical Slope	0.01846	ft/ft

Worksheet for Onsite channel sec-3(95 cfs - 0.5% slope)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00500	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	95.00	ft³/s

Results

Normal Depth	1.80	ft
Flow Area	26.19	ft²
Wetted Perimeter	19.72	ft
Top Width	19.02	ft
Critical Depth	1.26	ft
Critical Slope	0.01845	ft/ft
Velocity	3.63	ft/s
Velocity Head	0.20	ft
Specific Energy	2.01	ft
Froude Number	0.55	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.80	ft
Critical Depth	1.26	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01845	ft/ft

Worksheet for Onsite channel sec-4(95 cfs - 1.0% slope)

Project Description

Friction Method	Manning Formula	
Solve For	Normal Depth	

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	95.00	ft³/s

Results

Normal Depth	1.49	ft
Flow Area	20.54	ft²
Wetted Perimeter	18.05	ft
Top Width	17.47	ft
Critical Depth	1.26	ft
Critical Slope	0.01845	ft/ft
Velocity	4.63	ft/s
Velocity Head	0.33	ft
Specific Energy	1.83	ft
Froude Number	0.75	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.49	ft
Critical Depth	1.26	ft
Channel Slope	0.01000	ft/ft
Critical Slope	0.01845	ft/ft

Worksheet for Onsite channel sec-5(40 cfs - 1.0% slope)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	40.00	ft³/s

Results

Normal Depth	0.92	ft
Flow Area	11.34	ft²
Wetted Perimeter	14.96	ft
Top Width	14.61	ft
Critical Depth	0.74	ft
Critical Slope	0.02127	ft/ft
Velocity	3.53	ft/s
Velocity Head	0.19	ft
Specific Energy	1.11	ft
Froude Number	0.71	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.92	ft
Critical Depth	0.74	ft
Channel Slope	0.01000	ft/ft
Critical Slope	0.02127	ft/ft

Worksheet for Onsite channel sec-6(40 cfs - 1.0% slope)

Project Description

Friction Method	Manning Formula	
Solve For	Normal Depth	

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	40.00	ft³/s

Results

Normal Depth	0.92	ft
Flow Area	11.34	ft²
Wetted Perimeter	14.96	ft
Top Width	14.61	ft
Critical Depth	0.74	ft
Critical Slope	0.02127	ft/ft
Velocity	3.53	ft/s
Velocity Head	0.19	ft
Specific Energy	1.11	ft
Froude Number	0.71	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.92	ft
Critical Depth	0.74	ft
Channel Slope	0.01000	ft/ft
Critical Slope	0.02127	ft/ft

Worksheet for DROP STRUCTURE Onsite Sec-7 (40 cfs-5:1)

Project Description

Friction Method	Manning Formula	
Solve For	Normal Depth	

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.20000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	40.00	ft³/s

Results

Normal Depth	0.39	ft
Flow Area	4.24	ft²
Wetted Perimeter	12.08	ft
Top Width	11.93	ft
Critical Depth	0.74	ft
Critical Slope	0.02127	ft/ft
Velocity	9.44	ft/s
Velocity Head	1.39	ft
Specific Energy	1.77	ft
Froude Number	2.79	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.39	ft
Critical Depth	0.74	ft
Channel Slope	0.20000	ft/ft
Critical Slope	0.02127	ft/ft

Worksheet for Onsite channel sec-7(40 cfs - 1.0% slope)

Project Description

Friction Method	Manning Formula	
Solve For	Normal Depth	

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	40.00	ft^3/s

Results

Normal Depth	0.92	ft
Flow Area	11.34	ft^2
Wetted Perimeter	14.96	ft
Top Width	14.61	ft
Critical Depth	0.74	ft
Critical Slope	0.02127	ft/ft
Velocity	3.53	ft/s
Velocity Head	0.19	ft
Specific Energy	1.11	ft
Froude Number	0.71	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.92	ft
Critical Depth	0.74	ft
Channel Slope	0.01000	ft/ft
Critical Slope	0.02127	ft/ft

Worksheet for Onsite channel sec-8(40 cfs - 0.5% slope)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00500	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	40.00	ft^3/s

Results

Normal Depth	1.12	ft
Flow Area	14.35	ft^2
Wetted Perimeter	16.04	ft
Top Width	15.60	ft
Critical Depth	0.74	ft
Critical Slope	0.02127	ft/ft
Velocity	2.79	ft/s
Velocity Head	0.12	ft
Specific Energy	1.24	ft
Froude Number	0.51	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.12	ft
Critical Depth	0.74	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.02127	ft/ft

Worksheet for Onsite channel sec-9(40 cfs - 0.5% slope)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00500	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	40.00	ft³/s

Results

Normal Depth	1.12	ft
Flow Area	14.35	ft²
Wetted Perimeter	16.04	ft
Top Width	15.60	ft
Critical Depth	0.74	ft
Critical Slope	0.02127	ft/ft
Velocity	2.79	ft/s
Velocity Head	0.12	ft
Specific Energy	1.24	ft
Froude Number	0.51	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.12	ft
Critical Depth	0.74	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.02127	ft/ft

ON-SITE CHANNEL
RIP-RAP SIZING CALCULATIONS

Cholla Ash Monofill
Riprap Comparison
Onsite Channels Drop Structures

Cholla Ash Monofill Drainage Channel Riprap Rock Size (feet)												
	Method											
Onsite Channel	USACE (D30)	ASCE	USBR	USGS	ISBASH	HEC-11	Maricopa Cty		Min	Max	Chosen Rock Size (D50)	Layer Thickness (ft)
Section 1 (bank)	0.09	0.14	0.26	0.38	0.25	0.05	0.17		0.05	0.38	0.33	1.00
Section 1 (bottom)	0.09	0.13	0.26	0.38	0.25	0.04			0.04	0.38	0.33	1.00
Section 2 (bank)	0.11	0.16	0.29	0.43	0.28	0.06	0.17		0.06	0.43	0.33	1.00
Section 2 (bottom)	0.11	0.14	0.29	0.43	0.28	0.05			0.05	0.43	0.33	1.00
Section 3 (bank)	0.05	0.09	0.17	0.23	0.17	0.03	0.08		0.03	0.23	0.33	1.00
Section 3 (bottom)	0.05	0.09	0.17	0.23	0.17	0.02			0.02	0.23	0.33	1.00
Section 4 (bank)	0.10	0.15	0.29	0.42	0.27	0.06	0.17		0.06	0.42	0.33	1.00
Section 4 (bottom)	0.10	0.14	0.29	0.42	0.27	0.04			0.04	0.42	0.33	1.00
Section 5 (bank)	0.06	0.09	0.16	0.22	0.16	0.03	0.08		0.03	0.22	0.33	1.00
Section 5 (bottom)	0.06	0.08	0.16	0.22	0.16	0.02			0.02	0.22	0.33	1.00
Section 6 (bank)	0.06	0.09	0.16	0.22	0.16	0.03	0.08		0.03	0.22	0.33	1.00
Section 6 (bottom)	0.06	0.08	0.16	0.22	0.16	0.02			0.02	0.22	0.33	1.00
Section 7 (bank)	0.06	0.09	0.16	0.22	0.16	0.03	0.08		0.03	0.22	0.33	1.00
Section 7 (bottom)	0.06	0.08	0.16	0.22	0.16	0.02			0.02	0.22	0.33	1.00
Section 8 (bank)	0.03	0.05	0.10	0.12	0.10	0.01	0.08		0.01	0.12	0.33	1.00
Section 8 (bottom)	0.03	0.05	0.10	0.12	0.10	0.01			0.01	0.12	0.33	1.00
Section 9 (bank)	0.03	0.05	0.10	0.12	0.10	0.01	0.08		0.01	0.12	0.33	1.00
Section 9 (bottom)	0.03	0.05	0.10	0.12	0.10	0.01			0.01	0.12	0.33	1.00
Drop Struc On-sec 1-basin (bnk)	1.61	1.16	2.33	5.02	2.09	1.23	3.50		1.16	5.02	1.00*	2.00
Drop Struc On-sec 1-basin (btm)	1.61	1.07	2.33	5.02	2.09	0.92			0.92	5.02	1.00*	2.00
Drop Struc On-sec 7- 5:1(bnk)	0.85	0.63	1.24	2.39	1.14	0.50	1.83		0.50	2.39	1.00*	2.00
Drop Struc On-sec 7- 5:1(btm)	0.85	0.58	1.24	2.39	1.14	0.37			0.37	2.39	1.00*	2.00
SOUTH Channel												
Section 1 (bank)	0.07	0.09	0.16	0.22	0.16	0.03	0.08		0.03	0.22	0.33	1.00
Section 1 (bottom)	0.07	0.08	0.16	0.22	0.16	0.02			0.02	0.22	0.33	1.00
Drop Struc On-SOUTH-basin (bnk)	0.60	0.45	0.88	1.58	0.81	0.34	1.33		0.34	1.58	1.00*	2.00
Drop Struc On-SOUTH-basin (btm)	0.60	0.42	0.88	1.58	0.81	0.26			0.26	1.58	1.00*	2.00
*NOTE: All drop structures and basins will consist of grouted riprap.												

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash Onsite Drop Structure SOUTH channel
Design Flood Freque 100 -yr
Location/Station: 32+50 to 33+00

Relevant Equations

$$\boxed{d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}}$$

$$\boxed{K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 7.96 ft/s
d_{avg} = 0.29 ft
D_{50} = 16 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 1.25 ft
d_{50} (inch) = 16 inch <----D50 = 16 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 16 inch

By:________________
Checked:________________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash ONSITE SOUTH Channel
Design Flood Freque 100 -yr
Location/Station: 35+00 to 38+50

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 3.53 ft/s
d_{avg} = 0.61 ft
D_{50} = 1 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 0.08 ft
d_{50} (inch) = 1 inch <----D50 = 1 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 1 inch

Page __________.
Date:________________

By:________________
Checked:________________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash Onsite Drop Structure channel section 1
Design Flood Freque 100 -yr
Location/Station: 32+50 to 33+00

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 12.79 ft/s
d_{avg} = 0.64 ft
D_{50} = 42 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 3.49 ft
d_{50} (inch) = 42 inch <----D50 = 42 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 42 inch

Cholla Ash Monofill
Riprap Calculation

By:_______________
Checked:_______________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash ONSITE Channel section 1
Design Flood Freque 100 -yr
Location/Station: 35+00 to 38+50

Relevant Equations

$$\boxed{d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}}$$

$$\boxed{K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a =	4.43	ft/s	
d_{avg} =	1.55	ft	
D_{50} =	2	inch	Assume a D_{50} and then calculate if it is stable.
θ =	21.80	degree	[2.5:1 (H:V)]
ϕ =	41.0	degree	From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 =	0.82		
d_{50} =	0.09	ft	
d_{50} (inch) =	2	inch	<----D50 = 2 inches is stable.

Therefore, proposed design riprap size (d_{50}) = $\boxed{\text{2 inch}}$

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Page __________.
Date:_______________

Cholla Ash Monofill
Riprap Calculation

By:________________
Checked:________________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash ONSITE Channel section 2
Design Flood Freque 100 -yr
Location/Station: 35+00 to 38+50

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a =	4.69	ft/s	
d_{avg} =	1.48	ft	
D_{50} =	2	inch	Assume a D_{50} and then calculate if it is stable.
θ =	21.80	degree	[2.5:1 (H:V)]
ϕ =	41.0	degree	From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 0.11 ft
d_{50} (inch) = 2 inch <----D50 = 2 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 2 inch

Page __________.
Date:________________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash ONSITE Channel section 3
Design Flood Freque 100 -yr
Location/Station: 35+00 to 38+50

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2 \theta}{\sin^2 \phi} \right]^{0.5}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a =	3.63	ft/s	
d_{avg} =	1.8	ft	
D_{50} =	1	inch	Assume a D_{50} and then calculate if it is stable.
θ =	21.80	degree	[2.5:1 (H:V)]
ϕ =	41.0	degree	From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 0.05 ft
d_{50} (inch) = 1 inch <----D50 = 1 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 1 inch

Cholla Ash Monofill
Riprap Calculation

By:________________
Checked:________________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash ONSITE Channel section 4
Design Flood Freque 100 -yr
Location/Station: 35+00 to 38+50

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 4.63 ft/s
d_{avg} = 1.49 ft
D_{50} = 2 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 0.11 ft
d_{50} (inch) = 2 inch <----D50 = 2 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 2 inch

By:________________
Checked:________________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash ONSITE Channel section 5
Design Flood Freque 100 -yr
Location/Station: 35+00 to 38+50

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a =	3.53	ft/s	
d_{avg} =	0.92	ft	
D_{50} =	1	inch	Assume a D_{50} and then calculate if it is stable.
θ =	21.80	degree	[2.5:1 (H:V)]
ϕ =	41.0	degree	From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 =	0.82		
d_{50} =	0.06	ft	
d_{50} (inch) =	1	inch	<----D50 = 1 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 1 inch

Page __________.
Date:________________

Cholla Ash Monofill
Riprap Calculation

By:______________
Checked:______________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash ONSITE Channel section 6
Design Flood Freque 100 -yr
Location/Station: 35+00 to 38+50

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2 \theta}{\sin^2 \phi}\right]^{0.5}$$

Where.

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 3.53 ft/s
d_{avg} = 0.92 ft
D_{50} = 1 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 0.06 ft
d_{50} (inch) = 1 inch <----D50 = 1 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 1 inch

Cholla Ash Monofill
Riprap Calculation

By:________________
Checked:________________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash ONSITE Drop Structure section 7
Design Flood Freque 100 -yr
Location/Station: 35+00 to 38+50

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2 \theta}{\sin^2 \phi}\right]^{0.5}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 9.44 ft/s
d_{avg} = 0.39 ft
D_{50} = 22 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 1.80 ft
d_{50} (inch) = 22 inch <----D50 = 22 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 22 inch

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash ONSITE Channel section 7
Design Flood Freque 100 -yr
Location/Station: 35+00 to 38+50

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 3.53 ft/s
d_{avg} = 0.92 ft
D_{50} = 1 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 0.06 ft
d_{50} (inch) = 1 inch <----D50 = 1 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 1 inch

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash ONSITE Channel section 8
Design Flood Freque 100 -yr
Location/Station: 35+00 to 38+50

Relevant Equations

$$\boxed{d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}}$$

$$\boxed{K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 2.79 ft/s
d_{avg} = 1.12 ft
D_{50} = 1 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 0.03 ft
d_{50} (inch) = 1 inch <----D50 = 1 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 1 inch

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash ONSITE Channel section 9
Design Flood Freque 100 -yr
Location/Station: 35+00 to 38+50

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2 \theta}{\sin^2 \phi}\right]^{0.5}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 2.79 ft/s
d_{avg} = 1.12 ft
D_{50} = 1 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 0.03 ft
d_{50} (inch) = 1 inch <----D50 = 1 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 1 inch

Cholla Ash Monofill
Riprap Calculation
Formulas

By:______________
Checked:______________

	A	B	C	D	E	F	G	H

1 **Calculation of Riprap Size for Channel Lining**

2 Calculations are based on Drainage Design Manual for Maricopa County (Manual)

3

4 Channel Name: Cholla Ash Offsite Channel section 1

5 Design Flood Frequency: 100 -yr

6 Location/Station: 1+50 to 7+50

7

8

9 Relevant Equations

10

11

12–15

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

16–18

$$K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}$$

19 Where,

20 d_{50} = Median diameter of the riprap materials, ft

21 V_a = Average velocity in the main channel, ft/s

22 d_{avg} = Average depth of flow in the main channel, ft

23 K_1 = Bank angle correction factor

24 θ = Bank angle with the horizontal, degree

25 ϕ = Riprap material's angle of repose, degree

26

27

28 Input Parameters

29 (Based on output from FlowMaster and based on the Manual)

30

31 V_a = 7.96 ft/s

32 d_{avg} = 0.29 ft

33 D_{50} = 16 inch Assume a D_{50} and then calculate if it is stable.

34 θ = 21.8 degree [2.5:1 (H:V)]

35 ϕ = 41 degree From Figure 6.14 of the Manual for rounded riprap - attached.

36

37 Hence,

38 K_1 = =(1-((SIN(RADIANS(C34)))^2/(SIN(RADIANS(C35)))^2))^0.5

39 d_{50} = =0.001*C31^3/(C32^0.5*C38^1.5) ft

40 d_{50} (inch) = =CEILING(C39*12,1) inch <----D50 = =C33 inches is stable.

41

42

43 **Therefore, proposed design riprap size (d_{50}) =** **=C33 inch**

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Page ________
Date:______________

```
Date: 02/12/2009 Time: 17:05
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                  WEST Consultants, Inc.                  *
*                                                          *
*                                                          *
* Version 3.0                                 March, 2005 *
*                                                          *
*                                                          *
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* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE              PH: 858-487-9378 *
* SUITE 340                              FAX:858-487-9448 *
* SAN DIEGO, CA 92127         WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Onsite
Description: Onsite SOUTH Channel DROP

______________________ USACE Method ______________________

Input Parameters:
-----------------
Velocity Type                                      Average
Channel Shape                                  Trapezoidal
Channel Type                                      Straight
Bend Angle (deg)                                       N/A
Average Channel Velocity                         7.96 ft/s
Bottom Width                                           N/A
Bend Radius                                            N/A
Top Width                                              N/A
Unit Weight of Stone                       165. lbs/cu ft
Riprap Layer Thickness                                1.00
Local Flow Depth                                   0.29 ft
Cotangent of Side Slope                               2.50
Safety Factor                                          1.1
Riprap Placement                              Channel Bank
Rock Type                                          Angular

Output Results:
---------------

Computed D30                                       0.60 ft
Computed Local Depth Averaged Velocity           7.96 ft/s
Local Velocity/Avg. Velocity                          1.00
Side Slope Correction Factor                          1.06
Correction for Layer Thickness                        1.00
Correction for Secondary Currents                     1.00

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness         1.250 ft
Selected Minimum D30     0.61 ft
Selected Minimum D90     0.88 ft

                                     Stone Weight, lbs
Percent Lighter by Weight         Minimum          Maximum
----------------------------------------------------------
W100                                  67.             169.
 W50                                  34.              50.
```

```
 W15                                        11.                  25.

 _______________________  ASCE Method  _______________________


 Input Parameters:
 -----------------

 Local Velocity                                         7.96 ft/s
 Cotangent of Side slope                                     2.50
 Unit Weight of Stone                               165. lbs/cu ft
 Riprap Placement                                     Channel Bank


 Output Results:
 ---------------

 Computed D50                                              0.45 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight     165.0 lbs/cu ft
 Layer Thickness            0.750 ft
 Selected Minimum D30        0.37 ft
 Selected Minimum D90        0.53 ft


                                          Stone Weight, lbs
 Percent Lighter by Weight            Minimum              Maximum
 ------------------------------------------------------------------
 W100                                     15.                  36.
  W50                                      7.                  11.
  W15                                      2.                   5.

 _______________________  USBR Method  _______________________


 Input Parameters:
 -----------------

 Average Channel Velocity                               7.96 ft/s


 Output Results:
 ---------------

 Computed D50                                              0.88 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight     165.0 lbs/cu ft
 Layer Thickness            1.500 ft
 Selected Minimum D30        0.73 ft
 Selected Minimum D90        1.06 ft


                                          Stone Weight, lbs
 Percent Lighter by Weight            Minimum              Maximum
 ------------------------------------------------------------------
 W100                                    117.                 292.
  W50                                     58.                  86.
  W15                                     18.                  43.
```

```
                         Onsite SOUTH Channel-DROP
_______________________ USGS Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                            7.96 ft/s


Output Results:
---------------

Computed D50                                        1.58 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness          2.750 ft
Selected Minimum D30      1.34 ft
Selected Minimum D90      1.94 ft


                                    Stone Weight, lbs
Percent Lighter by Weight        Minimum           Maximum
_____________________________________________________________
W100                                719.              1797.
 W50                                359.               532.
 W15                                112.               266.

______________________ Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                            7.96 ft/s
Unit Weight of Stone                           165. lbs/cu ft
Turbulence Level                                         High


Output Results:
---------------

Computed D50                                        0.81 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness          1.500 ft
Selected Minimum D30      0.73 ft
Selected Minimum D90      1.06 ft


                                    Stone Weight, lbs
Percent Lighter by Weight        Minimum           Maximum
_____________________________________________________________
W100                                117.               292.
 W50                                 58.                86.
 W15                                 18.                43.

____________________ Cal B & SP Method ____________________


Input Parameters:
```

```
-----------------

Average Channel Velocity                          7.96 ft/s
Velocity Affecting Bank                          10.61 ft/s
Unit Weight of Stone                        165. lbs/cu ft
Cotangent of Side slope                               2.50
Flow Type                                        Impinging


Output Results:
---------------

Computed W                                       40.71 lbs


                 ** CalTrans A Gradation **

(1) Outside Layer:

Gradation Class                                    1/2 Ton
Layer Thickness                                    3.40 ft

Percent Larger than                        Rock Size (Ton)
__________________________________________________________

0 - 5                                                 1.00
50 - 100                                              0.50
95 - 100                                              0.25

(2) Inner Layer:

Gradation Class                                       None
Layer Thickness                                    0.00 ft

(3) Backing:

Backing Class No.                                        1
Layer Thickness                                     1.8 ft

(4) Fabric:

Fabric Type                                              B

Total Thickness (1)+(2)+(3)+(4):                    5.2 ft


______________________ HEC-11 Method ______________________

Input Parameters:
-----------------

Average Channel Velocity                         7.96 ft/s
Average Flow Depth                                 3.00 ft
Unit Weight of Stone                       165. lbs/cu ft
Cotangent of Side Slope                              2.50
Material Angle of Repose                        41.00 deg.
```

```
                          Onsite SOUTH Channel-DROP
Riprap Placement                                  Channel Bank
Safety Factor                                              1.1


Output Results:
---------------

Computed D50                                           0.34 ft


                   ** FHWA Gradation**


Gradation Class           Facing
Layer Thickness           1.90 ft


Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
_____________________________________________________________
D100                               1.30                 200.
 D50                               0.95                  75.
 D10                               0.40                   5.
```

```
Date: 02/12/2009 Time: 17:05
*************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                 *
*                           BY                              *
*                  WEST Consultants, Inc.                   *
*                                                           *
*                                                           *
* Version 3.0                                 March, 2005 *
*                                                           *
*                                                           *
* COPYRIGHT (c) 2005                                        *
* WEST CONSULTANTS, INC.                                    *
* 16870 WEST BERNARDO DRIVE                PH: 858-487-9378 *
* SUITE 340                                FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
*************************************************************


Project: Cholla Ash Onsite
Description: Onsite SOUTH Channel DROP_BTM

______________________   USACE Method ______________________

Input Parameters:
-----------------
Velocity Type                                         Average
Channel Shape                                     Trapezoidal
Channel Type                                         Straight
Bend Angle (deg)                                          N/A
Average Channel Velocity                            7.96 ft/s
Bottom width                                              N/A
Bend Radius                                               N/A
Top Width                                                 N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Layer Thickness                                   1.00
Local Flow Depth                                      0.29 ft
Cotangent of Side Slope                                   N/A
Safety Factor                                             1.1
Riprap Placement                               Channel Bottom
Rock Type                                             Angular

Output Results:
---------------

Computed D30                                          0.60 ft
Computed Local Depth Averaged Velocity              7.96 ft/s
Local Velocity/Avg. Velocity                             1.00
Side Slope Correction Factor                             1.06
Correction for Layer Thickness                           1.00
Correction for Secondary Currents                        1.00

  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness            1.250 ft
Selected Minimum D30        0.61 ft
Selected Minimum D90        0.88 ft
```

```
                                      Stone Weight, lbs
Percent Lighter by Weight          Minimum             Maximum
______________________________________________________________
W100                                   67.                169.
 W50                                   34.                 50.
 W15                                   11.                 25.

________________________ ASCE Method _________________________


Input Parameters:
-----------------

Local Velocity                                     7.96 ft/s
Cotangent of Side slope                                  N/A
Unit Weight of Stone                           165. lbs/cu ft
Riprap Placement                               Channel Bottom


Output Results:
----------------

Computed D50                                         0.42 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                      Stone Weight, lbs
Percent Lighter by Weight          Minimum             Maximum
______________________________________________________________
W100                                   15.                 36.
 W50                                    7.                 11.
 W15                                    2.                  5.

________________________ USBR Method _________________________


Input Parameters:
-----------------

Average Channel Velocity                           7.96 ft/s


Output Results:
---------------

Computed D50                                         0.88 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           1.500 ft
```

```
Selected Minimum D30        0.73 ft
Selected Minimum D90        1.06 ft


                                   Stone Weight, lbs
Percent Lighter by Weight       Minimum           Maximum
______________________________________________________________
W100                              117.              292.
 W50                               58.               86.
 W15                               18.               43.

________________________  USGS Method  _________________________

Input Parameters:
-----------------

Average Channel Velocity                           7.96 ft/s


Output Results:
---------------

Computed D50                                        1.58 ft

  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           2.750 ft
Selected Minimum D30       1.34 ft
Selected Minimum D90       1.94 ft


                                   Stone Weight, lbs
Percent Lighter by Weight       Minimum           Maximum
______________________________________________________________
W100                              719.             1797.
 W50                              359.              532.
 W15                              112.              266.

_______________________  Isbash Method  _______________________

Input Parameters:
-----------------

Average Channel Velocity                           7.96 ft/s
Unit Weight of Stone                          165. lbs/cu ft
Turbulence Level                                        High


Output Results:
---------------

Computed D50                                        0.81 ft

  *** Using Gradations from COE ETL 1110-2-120 ***
```

```
Specific Weight      165.0 lbs/cu ft
Layer Thickness            1.500 ft
Selected Minimum D30        0.73 ft
Selected Minimum D90        1.06 ft


                                         Stone Weight, lbs
Percent Lighter by Weight           Minimum              Maximum
_____________________________________________________________________
W100                                    117.                 292.
 W50                                     58.                  86.
 W15                                     18.                  43.

____________________  Cal B & SP Method  ____________________


Input Parameters:
-----------------

Average Channel Velocity                               7.96 ft/s
Velocity Affecting Bank                               10.61 ft/s
Unit Weight of Stone                              165. lbs/cu ft
Cotangent of Side slope                                     2.50
Flow Type                                              Impinging


Output Results:
---------------

Computed W                                             40.71 lbs


                 ** CalTrans A Gradation **


(1) Outside Layer:


Gradation Class                                          1/2 Ton
Layer Thickness                                          3.40 ft


Percent Larger than                              Rock Size (Ton)
_____________________________________________________________________

0 - 5                                                       1.00
50 - 100                                                    0.50
95 - 100                                                    0.25


(2) Inner Layer:


Gradation Class                                             None
Layer Thickness                                          0.00 ft


(3) Backing:


Backing Class No.                                              1
```

```
Layer Thickness                                             1.8 ft


(4) Fabric:


Fabric Type                                                      B


Total Thickness (1)+(2)+(3)+(4):                            5.2 ft


______________________  HEC-11 Method  ______________________


Input Parameters:
-----------------

Average Channel Velocity                                7.96 ft/s
Average Flow Depth                                        3.00 ft
Unit Weight of Stone                              165. lbs/cu ft
Cotangent of Side Slope                                      N/A
Material Angle of Repose                                    deg.
Riprap Placement                                  Channel Bottom
Safety Factor                                                1.1


Output Results:
---------------

Computed D50                                             0.26 ft


                      ** FHWA Gradation**


Gradation Class             Facing
Layer Thickness             1.90 ft


Percent Smaller by Size   Rock Size, ft      Rock Weight, lbs
______________________________________________________________
D100                                1.30                 200.
 D50                                0.95                  75.
 D10                                0.40                   5.
```

```
                             Onsite SOUTH Channel
Date: 02/12/2009 Time: 17:03
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                   WEST Consultants, Inc.                 *
*                                                          *
*                                                          *
* Version 3.0                                  March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Onsite
Description: Onsite SOUTH Channel


______________________   USACE Method ______________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                           3.53 ft/s
Bottom Width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     0.61 ft
Cotangent of Side Slope                                 2.50
Safety Factor                                            1.1
Riprap Placement                                Channel Bank
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         0.07 ft
Computed Local Depth Averaged Velocity             3.53 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight         Minimum            Maximum
____________________________________________________________
W100                                  15.                36.
 W50                                   7.                11.
```

```
________________________  ASCE Method  ________________________

Input Parameters:
-----------------

Local Velocity                                      3.53 ft/s
Cotangent of Side Slope                                  2.50
Unit Weight of Stone                           165. lbs/cu ft
Riprap Placement                                 Channel Bank

Output Results:
---------------

Computed D50                                          0.09 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft

                                        Stone Weight, lbs
Percent Lighter by Weight         Minimum             Maximum
_____________________________________________________________
W100                                  15.                 36.
 W50                                   7.                 11.
 W15                                   2.                  5.

________________________  USBR Method  ________________________

Input Parameters:
-----------------

Average Channel Velocity                            3.53 ft/s

Output Results:
---------------

Computed D50                                          0.16 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft

                                        Stone Weight, lbs
Percent Lighter by Weight         Minimum             Maximum
_____________________________________________________________
W100                                  15.                 36.
 W50                                   7.                 11.
 W15                                   2.                  5.
```

```
                          Onsite SOUTH Channel
 _______________________ USGS Method ________________________


 Input Parameters:
 -----------------

 Average Channel Velocity                              3.53 ft/s


 Output Results:
 ---------------

 Computed D50                                          0.22 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight     165.0 lbs/cu ft
 Layer Thickness           0.750 ft
 Selected Minimum D30       0.37 ft
 Selected Minimum D90       0.53 ft


                                          Stone Weight, lbs
 Percent Lighter by Weight             Minimum            Maximum
 ----------------------------------------------------------------
 W100                                      15.                36.
  W50                                       7.                11.
  W15                                       2.                 5.

 ______________________ Isbash Method ______________________


 Input Parameters:
 -----------------

 Average Channel Velocity                              3.53 ft/s
 Unit Weight of Stone                             165. lbs/cu ft
 Turbulence Level                                           High


 Output Results:
 ---------------

 Computed D50                                          0.16 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight     165.0 lbs/cu ft
 Layer Thickness           0.750 ft
 Selected Minimum D30       0.37 ft
 Selected Minimum D90       0.53 ft


                                          Stone Weight, lbs
 Percent Lighter by Weight             Minimum            Maximum
 ----------------------------------------------------------------
 W100                                      15.                36.
  W50                                       7.                11.
  W15                                       2.                 5.

 ____________________ Cal B & SP Method _____________________


 Input Parameters:
```

```
                           Onsite SOUTH Channel
-----------------

Average Channel Velocity                          3.53 ft/s
Velocity Affecting Bank                           4.71 ft/s
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side slope                                2.50
Flow Type                                         Impinging


Output Results:
---------------

Computed W                                        0.31 lbs


                 ** CalTrans A Gradation **

(1) Outside Layer:

Gradation Class                                   1/2 Ton
Layer Thickness                                   3.40 ft

Percent Larger than                         Rock Size (Ton)
___________________________________________________________

0 - 5                                                1.00
50 - 100                                             0.50
95 - 100                                             0.25

(2) Inner Layer:

Gradation Class                                      None
Layer Thickness                                   0.00 ft

(3) Backing:

Backing Class No.                                       1
Layer Thickness                                    1.8 ft

(4) Fabric:

Fabric Type                                             B

Total Thickness (1)+(2)+(3)+(4):                   5.2 ft

______________________ HEC-11 Method ______________________

Input Parameters:
-----------------

Average Channel Velocity                          3.53 ft/s
Average Flow Depth                                3.00 ft
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side Slope                                2.50
Material Angle of Repose                        41.00 deg.
```

```
                           Onsite SOUTH Channel
Riprap Placement                                      Channel Bank
Safety Factor                                                  1.1


Output Results:
---------------

Computed D50                                               0.03 ft


                     ** FHWA Gradation**


Gradation Class             Facing
Layer Thickness             1.90 ft

Percent Smaller by Size   Rock Size, ft      Rock Weight, lbs
_____________________________________________________________
D100                               1.30                  200.
 D50                               0.95                   75.
 D10                               0.40                    5.
```

```
                           Onsite SOUTH Channel_btm
Date: 02/12/2009 Time: 17:03
*************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                 *
*                            BY                             *
*                   WEST Consultants, Inc.                  *
*                                                           *
*                                                           *
* Version 3.0                                  March, 2005 *
*                                                           *
*                                                           *
* COPYRIGHT (c) 2005                                        *
* WEST CONSULTANTS, INC.                                    *
* 16870 WEST BERNARDO DRIVE                PH: 858-487-9378 *
* SUITE 340                                FAX:858-487-9448 *
* SAN DIEGO, CA 92127         WEB:WWW.WESTCONSULTANTS.COM *
*************************************************************


Project: Cholla Ash Onsite
Description: Onsite SOUTH Channel_btm

______________________  USACE Method ______________________


Input Parameters:
-----------------
Velocity Type                                         Average
Channel Shape                                     Trapezoidal
Channel Type                                         Straight
Bend Angle (deg)                                          N/A
Average Channel Velocity                          3.53 ft/s
Bottom Width                                              N/A
Bend Radius                                               N/A
Top Width                                                 N/A
Unit Weight of Stone                         165. lbs/cu ft
Riprap Layer Thickness                                   1.00
Local Flow Depth                                      0.61 ft
Cotangent of Side Slope                                   N/A
Safety Factor                                             1.1
Riprap Placement                               Channel Bottom
Rock Type                                             Angular


Output Results:
---------------

Computed D30                                          0.07 ft
Computed Local Depth Averaged Velocity             3.53 ft/s
Local Velocity/Avg. Velocity                             1.00
Side Slope Correction Factor                             1.06
Correction for Layer Thickness                           1.00
Correction for Secondary Currents                        1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         0.750 ft
Selected Minimum D30     0.37 ft
Selected Minimum D90     0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight          Minimum            Maximum
_____________________________________________________________
W100                                    15.               36.
 W50                                     7.               11.
```

```
                         Onsite SOUTH Channel_btm
 W15                                2.                  5.

_______________________ ASCE Method _______________________

Input Parameters:
-----------------

Local Velocity                                  3.53 ft/s
Cotangent of Side slope                               N/A
Unit Weight of Stone                       165. lbs/cu ft
Riprap Placement                           Channel Bottom

Output Results:
---------------

Computed D50                                      0.08 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft

                                     Stone Weight, lbs
Percent Lighter by Weight         Minimum          Maximum
____________________________________________________________
W100                                  15.              36.
 W50                                   7.              11.
 W15                                   2.               5.

_______________________ USBR Method _______________________

Input Parameters:
-----------------

Average Channel Velocity                        3.53 ft/s

Output Results:
---------------

Computed D50                                      0.16 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft

                                     Stone Weight, lbs
Percent Lighter by Weight         Minimum          Maximum
____________________________________________________________
W100                                  15.              36.
 W50                                   7.              11.
 W15                                   2.               5.
```

```
                       Onsite SOUTH Channel_btm
_________________________ USGS Method __________________________


Input Parameters:
-----------------

Average Channel Velocity                               3.53 ft/s


Output Results:
---------------

Computed D50                                             0.22 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight            Minimum           Maximum
_______________________________________________________________
W100                                     15.               36.
 W50                                      7.               11.
 W15                                      2.                5.

________________________  Isbash Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                               3.53 ft/s
Unit Weight of Stone                              165. lbs/cu ft
Turbulence Level                                            High


Output Results:
---------------

Computed D50                                             0.16 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight            Minimum           Maximum
_______________________________________________________________
W100                                     15.               36.
 W50                                      7.               11.
 W15                                      2.                5.

_____________________  Cal B & SP Method _____________________


Input Parameters:
```

```
                           Onsite SOUTH Channel_btm
-----------------

Average Channel Velocity                          3.53 ft/s
Velocity Affecting Bank                           4.71 ft/s
Unit Weight of Stone                         165. lbs/cu ft
Cotangent of Side slope                                2.50
Flow Type                                         Impinging


Output Results:
---------------

Computed W                                         0.31 lbs


                ** CalTrans A Gradation **

(1) Outside Layer:

Gradation Class                                    1/2 Ton
Layer Thickness                                    3.40 ft

Percent Larger than                        Rock Size (Ton)
______________________________________________________________

0 - 5                                                 1.00
50 - 100                                              0.50
95 - 100                                              0.25

(2) Inner Layer:

Gradation Class                                       None
Layer Thickness                                    0.00 ft

(3) Backing:

Backing Class No.                                        1
Layer Thickness                                     1.8 ft

(4) Fabric:

Fabric Type                                              B

Total Thickness (1)+(2)+(3)+(4):                    5.2 ft

______________________ HEC-11 Method ______________________

Input Parameters:
-----------------

Average Channel Velocity                         3.53 ft/s
Average Flow Depth                                3.00 ft
Unit Weight of Stone                        165. lbs/cu ft
Cotangent of Side Slope                                N/A
Material Angle of Repose                              deg.
```

```
                         Onsite SOUTH Channel_btm
Riprap Placement                                     Channel Bottom
Safety Factor                                                   1.1


Output Results:
---------------

Computed D50                                               0.02 ft


                    ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft      Rock Weight, lbs
______________________________________________________________
D100                               1.30                  200.
 D50                               0.95                   75.
 D10                               0.40                    5.
```

```
                           ONSITE Channel DROP Sec-1
Date: 02/12/2009 Time: 15:41
*************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                 *
*                            BY                             *
*                   WEST Consultants, Inc.                  *
*                                                           *
*                                                           *
* Version 3.0                                   March, 2005 *
*                                                           *
*                                                           *
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* WEST CONSULTANTS, INC.                                    *
* 16870 WEST BERNARDO DRIVE                PH: 858-487-9378 *
* SUITE 340                                FAX:858-487-9448 *
* SAN DIEGO, CA 92127           WEB:WWW.WESTCONSULTANTS.COM *
*************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel SEC-1 DROP


______________________   USACE Method _______________________


Input Parameters:
-----------------
Velocity Type                                         Average
Channel Shape                                     Trapezoidal
Channel Type                                         Straight
Bend Angle (deg)                                          N/A
Average Channel Velocity                           12.79 ft/s
Bottom Width                                              N/A
Bend Radius                                               N/A
Top Width                                                 N/A
Unit Weight of Stone                           165. lbs/cu ft
Riprap Layer Thickness                                   1.00
Local Flow Depth                                      0.64 ft
Cotangent of Side Slope                                  2.50
Safety Factor                                             1.1
Riprap Placement                                 Channel Bank
Rock Type                                             Angular


Output Results:
---------------

Computed D30                                          1.61 ft
Computed Local Depth Averaged Velocity             12.79 ft/s
Local Velocity/Avg. Velocity                             1.00
Side Slope Correction Factor                             1.06
Correction for Layer Thickness                           1.00
Correction for Secondary Currents                        1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            3.500 ft
Selected Minimum D30        1.70 ft
Selected Minimum D90        2.47 ft


                                       Stone Weight, lbs
Percent Lighter by Weight         Minimum             Maximum
_____________________________________________________________
W100                                1482.               3704.
 W50                                 741.               1096.
```

```
 W15                                         232.              548.

_______________________ ASCE Method _______________________

Input Parameters:
-----------------

Local Velocity                                           12.79 ft/s
Cotangent of Side slope                                        2.50
Unit Weight of Stone                                  165. lbs/cu ft
Riprap Placement                                       Channel Bank

Output Results:
---------------

Computed D50                                                1.16 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness         2.000 ft
Selected Minimum D30     0.97 ft
Selected Minimum D90     1.41 ft

                                          Stone Weight, lbs
Percent Lighter by Weight             Minimum             Maximum
____________________________________________________________________
W100                                     276.              691.
 W50                                     138.              205.
 W15                                      43.              102.

_______________________ USBR Method _______________________

Input Parameters:
-----------------

Average Channel Velocity                                 12.79 ft/s

Output Results:
---------------

Computed D50                                                2.33 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness         4.000 ft
Selected Minimum D30     1.95 ft
Selected Minimum D90     2.82 ft

                                          Stone Weight, lbs
Percent Lighter by Weight             Minimum             Maximum
____________________________________________________________________
W100                                    2212.             5529.
 W50                                    1106.             1637.
 W15                                     346.              818.
```

```
                        ONSITE Channel DROP Sec-1
_______________________ USGS Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                            12.79 ft/s


Output Results:
---------------

Computed D50                                         5.02 ft


  *** Using Gradations from COE ETL 1110-2-120 ***



Warning: The required stone size is greater than the largest
                  USACE stone gradation.

______________________ Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                            12.79 ft/s
Unit Weight of Stone                            165. lbs/cu ft
Turbulence Level                                          High


Output Results:
---------------

Computed D50                                         2.09 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            4.000 ft
Selected Minimum D30        1.95 ft
Selected Minimum D90        2.82 ft


                                       Stone Weight, lbs
Percent Lighter by Weight          Minimum            Maximum
_____________________________________________________________
W100                                2212.              5529.
 W50                                1106.              1637.
 W15                                 346.               818.

______________________ HEC-11 Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                            12.79 ft/s
Average Flow Depth                                   4.00 ft
Unit Weight of Stone                            165. lbs/cu ft
Cotangent of Side Slope                                   2.50
Material Angle of Repose                           41.00 deg.
Riprap Placement                                  Channel Bank
```

```
Safety Factor                                                1.1


Output Results:
---------------

Computed D50                                             1.23 ft

                       ** FHWA Gradation**


Gradation Class            Light
Layer Thickness            2.60 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
_____________________________________________________________
D100                               1.80                 500.
 D50                               1.30                 200.
 D10                               0.40                   5.
```

```
                         ONSITE Channel DROP Sec-1_btm
Date: 02/12/2009 Time: 15:42
************************************************************
*                 RIPRAP DESIGN SYSTEM (RDS)               *
*                             BY                           *
*                    WEST Consultants, Inc.                *
*                                                          *
*                                                          *
* Version 3.0                                March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel SEC-1 DROP bottom


______________________    USACE Method    ______________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                         12.79 ft/s
Bottom Width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                         165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     0.64 ft
Cotangent of Side Slope                                  N/A
Safety Factor                                            1.1
Riprap Placement                              Channel Bottom
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         1.61 ft
Computed Local Depth Averaged Velocity           12.79 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness          3.500 ft
Selected Minimum D30      1.70 ft
Selected Minimum D90      2.47 ft


                                         Stone Weight, lbs
Percent Lighter by Weight           Minimum            Maximum
____________________________________________________________
W100                                  1482.              3704.
 W50                                   741.              1096.
```

```
 W15                                     232.                548.

_______________________  ASCE Method _______________________


Input Parameters:
-----------------


Local Velocity                                        12.79 ft/s
Cotangent of Side slope                                      N/A
Unit Weight of Stone                              165. lbs/cu ft
Riprap Placement                                  Channel Bottom


Output Results:
---------------


Computed D50                                             1.07 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           2.000 ft
Selected Minimum D30       0.97 ft
Selected Minimum D90       1.41 ft


                                        Stone Weight, lbs
Percent Lighter by Weight           Minimum            Maximum
______________________________________________________________
W100                                     276.               691.
 W50                                     138.               205.
 W15                                      43.               102.

_______________________  USBR Method ________________________


Input Parameters:
-----------------


Average Channel Velocity                              12.79 ft/s


Output Results:
---------------


Computed D50                                             2.33 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           4.000 ft
Selected Minimum D30       1.95 ft
Selected Minimum D90       2.82 ft


                                        Stone Weight, lbs
Percent Lighter by Weight           Minimum            Maximum
______________________________________________________________
W100                                    2212.              5529.
 W50                                    1106.              1637.
 W15                                     346.               818.
```

```
                      ONSITE Channel DROP Sec-1_btm
_______________________ USGS Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                          12.79 ft/s


Output Results:
---------------

Computed D50                                       5.02 ft

  *** Using Gradations from COE ETL 1110-2-120 ***



Warning: The required stone size is greater than the largest
                  USACE stone gradation.

_______________________ Isbash Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                          12.79 ft/s
Unit Weight of Stone                          165. lbs/cu ft
Turbulence Level                                        High


Output Results:
---------------

Computed D50                                       2.09 ft

  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness            4.000 ft
Selected Minimum D30        1.95 ft
Selected Minimum D90        2.82 ft


                                     Stone Weight, lbs
Percent Lighter by Weight         Minimum           Maximum
____________________________________________________________
W100                                2212.             5529.
 W50                                1106.             1637.
 W15                                 346.              818.

_______________________ HEC-11 Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                          12.79 ft/s
Average Flow Depth                                  4.00 ft
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side Slope                                  N/A
Material Angle of Repose                                deg.
Riprap Placement                              Channel Bottom
```

```
Safety Factor                                                 1.1


Output Results:
---------------

Computed D50                                              0.92 ft

                    ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
______________________________________________________________
D100                                1.30                 200.
 D50                                0.95                  75.
 D10                                0.40                   5.
```

```
                              ONSITE Channel Sec-1
Date: 02/12/2009 Time: 15:43
************************************************************
*                 RIPRAP DESIGN SYSTEM (RDS)               *
*                            BY                            *
*                    WEST Consultants, Inc.                *
*                                                          *
*                                                          *
* Version 3.0                                 March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127         WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel SEC-1

______________________   USACE Method   ______________________


Input Parameters:
-----------------
Velocity Type                                         Average
Channel Shape                                     Trapezoidal
Channel Type                                         Straight
Bend Angle (deg)                                          N/A
Average Channel Velocity                            4.43 ft/s
Bottom width                                              N/A
Bend Radius                                               N/A
Top width                                                 N/A
Unit weight of Stone                           165. lbs/cu ft
Riprap Layer Thickness                                   1.00
Local Flow Depth                                      1.55 ft
Cotangent of Side Slope                                  2.50
Safety Factor                                             1.1
Riprap Placement                                 Channel Bank
Rock Type                                             Angular


Output Results:
---------------

Computed D30                                          0.09 ft
Computed Local Depth Averaged Velocity              4.43 ft/s
Local Velocity/Avg. Velocity                             1.00
Side Slope Correction Factor                             1.06
Correction for Layer Thickness                           1.00
Correction for Secondary Currents                        1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         0.750 ft
Selected Minimum D30     0.37 ft
Selected Minimum D90     0.53 ft


                                     Stone Weight, lbs
Percent Lighter by Weight          Minimum           Maximum
____________________________________________________________
W100                                   15.               36.
 W50                                    7.               11.
```

```
 W15                                           2.                  5.

____________________ ASCE Method ____________________


Input Parameters:
-----------------

Local Velocity                                             4.43 ft/s
Cotangent of Side slope                                         2.50
Unit Weight of Stone                                 165. lbs/cu ft
Riprap Placement                                       Channel Bank


Output Results:
---------------

Computed D50                                                0.14 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                         Stone Weight, lbs
Percent Lighter by Weight            Minimum            Maximum
____________________________________________________________
W100                                      15.                 36.
 W50                                       7.                 11.
 W15                                       2.                  5.

____________________ USBR Method ____________________


Input Parameters:
-----------------

Average Channel Velocity                                   4.43 ft/s


Output Results:
---------------

Computed D50                                                0.26 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                         Stone Weight, lbs
Percent Lighter by Weight            Minimum            Maximum
____________________________________________________________
W100                                      15.                 36.
 W50                                       7.                 11.
 W15                                       2.                  5.
```

```
                      ONSITE Channel Sec-1
 _______________________ USGS Method ________________________


 Input Parameters:
 -----------------

 Average Channel Velocity                          4.43 ft/s


 Output Results:
 ---------------

 Computed D50                                        0.38 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight      165.0 lbs/cu ft
 Layer Thickness            0.750 ft
 Selected Minimum D30        0.37 ft
 Selected Minimum D90        0.53 ft


                                          Stone Weight, lbs
 Percent Lighter by Weight            Minimum            Maximum
 _______________________________________________________________
 W100                                     15.                36.
  W50                                      7.                11.
  W15                                      2.                 5.


 ______________________ Isbash Method ______________________


 Input Parameters:
 -----------------

 Average Channel Velocity                          4.43 ft/s
 Unit Weight of Stone                         165. lbs/cu ft
 Turbulence Level                                       High


 Output Results:
 ---------------

 Computed D50                                        0.25 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight      165.0 lbs/cu ft
 Layer Thickness            0.750 ft
 Selected Minimum D30        0.37 ft
 Selected Minimum D90        0.53 ft


                                          Stone Weight, lbs
 Percent Lighter by Weight            Minimum            Maximum
 _______________________________________________________________
 W100                                     15.                36.
  W50                                      7.                11.
  W15                                      2.                 5.


 ______________________ HEC-11 Method ______________________


 Input Parameters:
```

```
                             ONSITE Channel Sec-1
-----------------

Average Channel Velocity                           4.43 ft/s
Average Flow Depth                                   4.00 ft
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side Slope                                 2.50
Material Angle of Repose                          41.00 deg.
Riprap Placement                                Channel Bank
Safety Factor                                            1.1


Output Results:
---------------

Computed D50                                         0.05 ft

                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
------------------------------------------------------------
D100                                   1.30             200.
 D50                                   0.95              75.
 D10                                   0.40               5.
```

```
                                   ONSITE Channel Sec-1_btm
Date: 02/12/2009 Time: 15:44
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                           BY                             *
*                   WEST Consultants, Inc.                 *
*                                                          *
*                                                          *
* Version 3.0                                 March, 2005  *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE                PH: 858-487-9378 *
* SUITE 340                                FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel SEC-1 bottom

______________________   USACE Method  ______________________


Input Parameters:
-----------------
Velocity Type                                         Average
Channel Shape                                     Trapezoidal
Channel Type                                         Straight
Bend Angle (deg)                                          N/A
Average Channel Velocity                            4.43 ft/s
Bottom width                                              N/A
Bend Radius                                               N/A
Top width                                                 N/A
Unit Weight of Stone                         165. lbs/cu ft
Riprap Layer Thickness                                   1.00
Local Flow Depth                                      1.55 ft
Cotangent of Side Slope                                   N/A
Safety Factor                                             1.1
Riprap Placement                               Channel Bottom
Rock Type                                             Angular


Output Results:
---------------

Computed D30                                          0.09 ft
Computed Local Depth Averaged Velocity              4.43 ft/s
Local Velocity/Avg. Velocity                             1.00
Side Slope Correction Factor                             1.06
Correction for Layer Thickness                           1.00
Correction for Secondary Currents                        1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight           Minimum           Maximum
____________________________________________________________
W100                                    15.               36.
 W50                                     7.               11.
```

```
 W15                                        2.                 5.

_______________________  ASCE Method  _______________________

Input Parameters:
-----------------

Local Velocity                                          4.43 ft/s
Cotangent of Side slope                                       N/A
Unit Weight of Stone                               165. lbs/cu ft
Riprap Placement                                   Channel Bottom

Output Results:
---------------

Computed D50                                              0.13 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft

                                         Stone Weight, lbs
Percent Lighter by Weight           Minimum            Maximum
______________________________________________________________
W100                                    15.                36.
 W50                                     7.                11.
 W15                                     2.                 5.

_______________________  USBR Method  _______________________

Input Parameters:
-----------------

Average Channel Velocity                                4.43 ft/s

Output Results:
---------------

Computed D50                                              0.26 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft

                                         Stone Weight, lbs
Percent Lighter by Weight           Minimum            Maximum
______________________________________________________________
W100                                    15.                36.
 W50                                     7.                11.
 W15                                     2.                 5.
```

```
                        ONSITE Channel Sec-1_btm
_______________________ USGS Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                              4.43 ft/s


Output Results:
---------------

Computed D50                                          0.38 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                     Stone Weight, lbs
Percent Lighter by Weight         Minimum            Maximum
______________________________________________________________
W100                                 15.                 36.
 W50                                  7.                 11.
 W15                                  2.                  5.

______________________ Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                              4.43 ft/s
Unit Weight of Stone                             165. lbs/cu ft
Turbulence Level                                          High


Output Results:
---------------

Computed D50                                          0.25 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                     Stone Weight, lbs
Percent Lighter by Weight         Minimum            Maximum
______________________________________________________________
W100                                 15.                 36.
 W50                                  7.                 11.
 W15                                  2.                  5.

______________________ HEC-11 Method ______________________


Input Parameters:
```

```
                           ONSITE Channel Sec-1_btm
-----------------

Average Channel Velocity                            4.43 ft/s
Average Flow Depth                                  4.00 ft
Unit Weight of Stone                           165. lbs/cu ft
Cotangent of Side Slope                                   N/A
Material Angle of Repose                                 deg.
Riprap Placement                               Channel Bottom
Safety Factor                                             1.1


Output Results:
---------------

Computed D50                                          0.04 ft

                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
-------------------------------------------------------------
D100                               1.30                 200.
 D50                               0.95                  75.
 D10                               0.40                   5.
```

```
                        ONSITE Channel Sec-2
Date: 02/12/2009 Time: 15:50
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                  WEST Consultants, Inc.                  *
*                                                          *
*                                                          *
* Version 3.0                                 March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE              PH: 858-487-9378 *
* SUITE 340                              FAX:858-487-9448 *
* SAN DIEGO, CA 92127         WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel SEC-2

______________________  USACE Method  ______________________

Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                           4.69 ft/s
Bottom Width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                        165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     1.48 ft
Cotangent of Side Slope                                 2.50
Safety Factor                                            1.1
Riprap Placement                                Channel Bank
Rock Type                                            Angular

Output Results:
---------------

Computed D30                                         0.11 ft
Computed Local Depth Averaged Velocity             4.69 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00

  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness        0.750 ft
Selected Minimum D30     0.37 ft
Selected Minimum D90     0.53 ft


                                      Stone Weight, lbs
Percent Lighter by Weight          Minimum           Maximum
____________________________________________________________
W100                                   15.               36.
 W50                                    7.               11.
```

```
 W15                                         2.                   5.

_________________________  ASCE Method  _________________________


Input Parameters:
-----------------


Local Velocity                                            4.69 ft/s
Cotangent of Side slope                                       2.50
Unit Weight of Stone                                165. lbs/cu ft
Riprap Placement                                      Channel Bank


Output Results:
---------------


Computed D50                                               0.16 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                         Stone Weight, lbs
Percent Lighter by Weight            Minimum             Maximum
_______________________________________________________________
W100                                     15.                 36.
 W50                                      7.                 11.
 W15                                      2.                  5.

_________________________  USBR Method  _________________________


Input Parameters:
-----------------


Average Channel Velocity                                 4.69 ft/s


Output Results:
---------------


Computed D50                                              0.29 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                         Stone Weight, lbs
Percent Lighter by Weight            Minimum             Maximum
_______________________________________________________________
W100                                     15.                 36.
 W50                                      7.                 11.
 W15                                      2.                  5.
```

```
                          ONSITE Channel Sec-2
_______________________  USGS Method  _______________________


Input Parameters:
-----------------

Average Channel Velocity                               4.69 ft/s


Output Results:
---------------

Computed D50                                           0.43 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                          Stone Weight, lbs
Percent Lighter by Weight             Minimum            Maximum
-----------------------------------------------------------------
W100                                      15.                36.
 W50                                       7.                11.
 W15                                       2.                 5.


______________________  Isbash Method  ______________________


Input Parameters:
-----------------

Average Channel Velocity                               4.69 ft/s
Unit Weight of Stone                              165. lbs/cu ft
Turbulence Level                                            High


Output Results:
---------------

Computed D50                                           0.28 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                          Stone Weight, lbs
Percent Lighter by Weight             Minimum            Maximum
-----------------------------------------------------------------
W100                                      15.                36.
 W50                                       7.                11.
 W15                                       2.                 5.


______________________  HEC-11 Method  ______________________


Input Parameters:
```

```
                              ONSITE Channel Sec-2
-----------------

Average Channel Velocity                              4.69 ft/s
Average Flow Depth                                    4.00 ft
Unit Weight of Stone                                165. lbs/cu ft
Cotangent of Side Slope                               2.50
Material Angle of Repose                             41.00 deg.
Riprap Placement                                   Channel Bank
Safety Factor                                         1.1


Output Results:
---------------

Computed D50                                          0.06 ft

                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft      Rock Weight, lbs
-------------------------------------------------------------
D100                               1.30                  200.
 D50                               0.95                   75.
 D10                               0.40                    5.
```

```
                        ONSITE Channel Sec-2_btm
Date: 02/12/2009 Time: 15:50
************************************************************
*                 RIPRAP DESIGN SYSTEM (RDS)               *
*                             BY                           *
*                  WEST Consultants, Inc.                  *
*                                                          *
*                                                          *
* Version 3.0                                March, 2005   *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel SEC-2_btm


______________________ USACE Method ______________________


Input Parameters:
-----------------
Velocity Type                                      Average
Channel Shape                                  Trapezoidal
Channel Type                                      Straight
Bend Angle (deg)                                       N/A
Average Channel Velocity                         4.69 ft/s
Bottom Width                                           N/A
Bend Radius                                            N/A
Top Width                                              N/A
Unit Weight of Stone                       165. lbs/cu ft
Riprap Layer Thickness                                1.00
Local Flow Depth                                   1.48 ft
Cotangent of Side Slope                                N/A
Safety Factor                                          1.1
Riprap Placement                            Channel Bottom
Rock Type                                          Angular


Output Results:
---------------

Computed D30                                       0.11 ft
Computed Local Depth Averaged Velocity           4.69 ft/s
Local Velocity/Avg. Velocity                          1.00
Side Slope Correction Factor                          1.06
Correction for Layer Thickness                        1.00
Correction for Secondary Currents                     1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         0.750 ft
Selected Minimum D30     0.37 ft
Selected Minimum D90     0.53 ft


                                    Stone Weight, lbs
Percent Lighter by Weight        Minimum           Maximum
___________________________________________________________
W100                                 15.               36.
 W50                                  7.               11.
```

```
 W15                                         2.                 5.

___________________________ ASCE Method ___________________________

Input Parameters:
-----------------

Local Velocity                                          4.69 ft/s
Cotangent of Side slope                                       N/A
Unit Weight of Stone                               165. lbs/cu ft
Riprap Placement                                   Channel Bottom

Output Results:
---------------

Computed D50                                              0.14 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight      165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft

                                         Stone Weight, lbs
Percent Lighter by Weight           Minimum                Maximum
__________________________________________________________________
W100                                   15.                    36.
 W50                                    7.                    11.
 W15                                    2.                     5.

___________________________ USBR Method ___________________________

Input Parameters:
-----------------

Average Channel Velocity                                4.69 ft/s

Output Results:
---------------

Computed D50                                              0.29 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight      165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft

                                         Stone Weight, lbs
Percent Lighter by Weight           Minimum                Maximum
__________________________________________________________________
W100                                   15.                    36.
 W50                                    7.                    11.
 W15                                    2.                     5.
```

```
______________________ USGS Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                             4.69 ft/s


Output Results:
---------------

Computed D50                                         0.43 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight          Minimum            Maximum
_____________________________________________________________
W100                                   15.                36.
 W50                                    7.                11.
 W15                                    2.                 5.

_____________________ Isbash Method _____________________


Input Parameters:
-----------------

Average Channel Velocity                             4.69 ft/s
Unit Weight of Stone                            165. lbs/cu ft
Turbulence Level                                          High


Output Results:
---------------

Computed D50                                         0.28 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight          Minimum            Maximum
_____________________________________________________________
W100                                   15.                36.
 W50                                    7.                11.
 W15                                    2.                 5.

_____________________ HEC-11 Method _____________________


Input Parameters:
```

```
                          ONSITE Channel Sec-2_btm
-----------------

Average Channel Velocity                               4.69 ft/s
Average Flow Depth                                     4.00 ft
Unit Weight of Stone                              165. lbs/cu ft
Cotangent of Side Slope                                     N/A
Material Angle of Repose                                   deg.
Riprap Placement                                 Channel Bottom
Safety Factor                                               1.1


Output Results:
---------------

Computed D50                                           0.05 ft

                    ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
------------------------------------------------------------
D100                               1.30                 200.
 D50                               0.95                  75.
 D10                               0.40                   5.
```

```
                         ONSITE Channel Sec-3
Date: 02/12/2009 Time: 15:51
*************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                 *
*                           BY                              *
*                  WEST Consultants, Inc.                   *
*                                                           *
*                                                           *
* Version 3.0                                  March, 2005 *
*                                                           *
*                                                           *
* COPYRIGHT (c) 2005                                        *
* WEST CONSULTANTS, INC.                                    *
* 16870 WEST BERNARDO DRIVE             PH: 858-487-9378 *
* SUITE 340                             FAX:858-487-9448 *
* SAN DIEGO, CA 92127        WEB:WWW.WESTCONSULTANTS.COM *
*************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel SEC-3

______________________  USACE Method  ______________________


Input Parameters:
-----------------
Velocity Type                                      Average
Channel Shape                                  Trapezoidal
Channel Type                                      Straight
Bend Angle (deg)                                       N/A
Average Channel Velocity                         3.63 ft/s
Bottom Width                                           N/A
Bend Radius                                            N/A
Top Width                                              N/A
Unit Weight of Stone                      165. lbs/cu ft
Riprap Layer Thickness                                1.00
Local Flow Depth                                   1.80 ft
Cotangent of Side Slope                               2.50
Safety Factor                                          1.1
Riprap Placement                              Channel Bank
Rock Type                                          Angular


Output Results:
---------------

Computed D30                                       0.05 ft
Computed Local Depth Averaged Velocity           3.63 ft/s
Local Velocity/Avg. Velocity                          1.00
Side Slope Correction Factor                          1.06
Correction for Layer Thickness                        1.00
Correction for Secondary Currents                     1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         0.750 ft
Selected Minimum D30     0.37 ft
Selected Minimum D90     0.53 ft


                                   Stone Weight, lbs
Percent Lighter by Weight       Minimum           Maximum
____________________________________________________________
W100                              15.               36.
 W50                               7.               11.
```

```
 W15                                          2.                 5.

_________________________  ASCE Method  _________________________


Input Parameters:
-----------------

Local Velocity                                             3.63 ft/s
Cotangent of Side slope                                         2.50
Unit Weight of Stone                                  165. lbs/cu ft
Riprap Placement                                        Channel Bank


Output Results:
---------------

Computed D50                                                 0.09 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                          Stone Weight, lbs
Percent Lighter by Weight            Minimum             Maximum
_________________________________________________________________
W100                                     15.                 36.
 W50                                      7.                 11.
 W15                                      2.                  5.

_________________________  USBR Method  _________________________


Input Parameters:
-----------------

Average Channel Velocity                                   3.63 ft/s


Output Results:
---------------

Computed D50                                                 0.17 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                          Stone Weight, lbs
Percent Lighter by Weight            Minimum             Maximum
_________________________________________________________________
W100                                     15.                 36.
 W50                                      7.                 11.
 W15                                      2.                  5.
```

```
                      ONSITE Channel Sec-3
 _______________________ USGS Method ________________________


 Input Parameters:
 -----------------

 Average Channel Velocity                          3.63 ft/s


 Output Results:
 ---------------

 Computed D50                                      0.23 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight     165.0 lbs/cu ft
 Layer Thickness           0.750 ft
 Selected Minimum D30       0.37 ft
 Selected Minimum D90       0.53 ft


                                     Stone Weight, lbs
 Percent Lighter by Weight         Minimum           Maximum
 ___________________________________________________________
 W100                                  15.               36.
  W50                                   7.               11.
  W15                                   2.                5.

 ______________________ Isbash Method _______________________


 Input Parameters:
 -----------------

 Average Channel Velocity                          3.63 ft/s
 Unit Weight of Stone                         165. lbs/cu ft
 Turbulence Level                                       High


 Output Results:
 ---------------

 Computed D50                                      0.17 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight     165.0 lbs/cu ft
 Layer Thickness           0.750 ft
 Selected Minimum D30       0.37 ft
 Selected Minimum D90       0.53 ft


                                     Stone Weight, lbs
 Percent Lighter by Weight         Minimum           Maximum
 ___________________________________________________________
 W100                                  15.               36.
  W50                                   7.               11.
  W15                                   2.                5.

 ______________________ HEC-11 Method _______________________


 Input Parameters:
```

```
                          ONSITE Channel Sec-3
-----------------

Average Channel Velocity                              3.63 ft/s
Average Flow Depth                                    4.00 ft
Unit Weight of Stone                              165. lbs/cu ft
Cotangent of Side Slope                               2.50
Material Angle of Repose                             41.00 deg.
Riprap Placement                                  Channel Bank
Safety Factor                                          1.1


Output Results:
---------------

Computed D50                                          0.03 ft

                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
____________________________________________________________
D100                               1.30                 200.
 D50                               0.95                  75.
 D10                               0.40                   5.
```

```
*************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                 *
*                            BY                             *
*                   WEST Consultants, Inc.                  *
*                                                           *
*                                                           *
* Version 3.0                                  March, 2005 *
*                                                           *
*                                                           *
* COPYRIGHT (c) 2005                                        *
* WEST CONSULTANTS, INC.                                    *
* 16870 WEST BERNARDO DRIVE                PH: 858-487-9378 *
* SUITE 340                                FAX:858-487-9448 *
* SAN DIEGO, CA 92127           WEB:WWW.WESTCONSULTANTS.COM *
*************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel SEC-3_btm


______________________   USACE Method ______________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                           3.63 ft/s
Bottom Width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     1.80 ft
Cotangent of Side Slope                                  N/A
Safety Factor                                            1.1
Riprap Placement                              Channel Bottom
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         0.05 ft
Computed Local Depth Averaged Velocity             3.63 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness             0.750 ft
Selected Minimum D30         0.37 ft
Selected Minimum D90         0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight         Minimum            Maximum
____________________________________________________________
W100                                  15.                36.
 W50                                   7.                11.
```

```
 W15                                      2.                 5.

___________________________ ASCE Method ___________________________


Input Parameters:
-----------------

Local Velocity                                          3.63 ft/s
Cotangent of Side slope                                       N/A
Unit Weight of Stone                                165. lbs/cu ft
Riprap Placement                                    Channel Bottom


Output Results:
---------------

Computed D50                                              0.09 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                          Stone Weight, lbs
Percent Lighter by Weight             Minimum             Maximum
_________________________________________________________________
W100                                      15.                36.
 W50                                       7.                11.
 W15                                       2.                 5.

___________________________ USBR Method ___________________________


Input Parameters:
-----------------

Average Channel Velocity                                3.63 ft/s


Output Results:
---------------

Computed D50                                              0.17 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                          Stone Weight, lbs
Percent Lighter by Weight             Minimum             Maximum
_________________________________________________________________
W100                                      15.                36.
 W50                                       7.                11.
 W15                                       2.                 5.
```

```
                          ONSITE Channel Sec-3_btm
_______________________ USGS Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                                3.63 ft/s


Output Results:
---------------

Computed D50                                            0.23 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                      Stone Weight, lbs
Percent Lighter by Weight          Minimum            Maximum
_____________________________________________________________
W100                                    15.                36.
 W50                                     7.                11.
 W15                                     2.                 5.

______________________ Isbash Method ______________________

Input Parameters:
-----------------

Average Channel Velocity                                3.63 ft/s
Unit Weight of Stone                               165. lbs/cu ft
Turbulence Level                                             High


Output Results:
---------------

Computed D50                                            0.17 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                      Stone Weight, lbs
Percent Lighter by Weight          Minimum            Maximum
_____________________________________________________________
W100                                    15.                36.
 W50                                     7.                11.
 W15                                     2.                 5.

______________________ HEC-11 Method ______________________


Input Parameters:
```

```
                              ONSITE Channel Sec-3_btm
-----------------

Average Channel Velocity                              3.63 ft/s
Average Flow Depth                                    4.00 ft
Unit Weight of Stone                             165. lbs/cu ft
Cotangent of Side Slope                                    N/A
Material Angle of Repose                                  deg.
Riprap Placement                                Channel Bottom
Safety Factor                                              1.1


Output Results:
---------------

Computed D50                                          0.02 ft

                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
____________________________________________________________
D100                               1.30                 200.
 D50                               0.95                  75.
 D10                               0.40                   5.
```

```
                             ONSITE Channel Sec-4
Date: 02/12/2009 Time: 16:30
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                   WEST Consultants, Inc.                 *
*                                                          *
*                                                          *
* Version 3.0                                  March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel SEC-4

_______________________   USACE Method  ______________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                           4.63 ft/s
Bottom Width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     1.49 ft
Cotangent of Side Slope                                 2.50
Safety Factor                                            1.1
Riprap Placement                                Channel Bank
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         0.10 ft
Computed Local Depth Averaged Velocity             4.63 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                      Stone Weight, lbs
Percent Lighter by Weight         Minimum             Maximum
____________________________________________________________
W100                                  15.                 36.
 W50                                   7.                 11.
```

```
 W15                                   2.                5.

___________________  ASCE Method  ___________________

 Input Parameters:
 -----------------

 Local Velocity                                  4.63 ft/s
 Cotangent of Side slope                           2.50
 Unit Weight of Stone                       165. lbs/cu ft
 Riprap Placement                             Channel Bank

 Output Results:
 ---------------

 Computed D50                                    0.15 ft

   *** Using Gradations from COE ETL 1110-2-120 ***

 Specific Weight     165.0 lbs/cu ft
 Layer Thickness           0.750 ft
 Selected Minimum D30       0.37 ft
 Selected Minimum D90       0.53 ft

                                    Stone Weight, lbs
 Percent Lighter by Weight       Minimum           Maximum
 _________________________________________________________
 W100                              15.               36.
  W50                               7.               11.
  W15                               2.                5.

___________________  USBR Method  ___________________

 Input Parameters:
 -----------------

 Average Channel Velocity                        4.63 ft/s

 Output Results:
 ---------------

 Computed D50                                    0.29 ft

   *** Using Gradations from COE ETL 1110-2-120 ***

 Specific Weight     165.0 lbs/cu ft
 Layer Thickness           0.750 ft
 Selected Minimum D30       0.37 ft
 Selected Minimum D90       0.53 ft

                                    Stone Weight, lbs
 Percent Lighter by Weight       Minimum           Maximum
 _________________________________________________________
 W100                              15.               36.
  W50                               7.               11.
  W15                               2.                5.
```

```
                           ONSITE Channel Sec-4
_______________________ USGS Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                             4.63 ft/s


Output Results:
---------------

Computed D50                                           0.42 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                     Stone Weight, lbs
Percent Lighter by Weight          Minimum            Maximum
______________________________________________________________
W100                                 15.                 36.
 W50                                  7.                 11.
 W15                                  2.                  5.

______________________ Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                             4.63 ft/s
Unit Weight of Stone                            165. lbs/cu ft
Turbulence Level                                          High


Output Results:
---------------

Computed D50                                           0.27 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                     Stone Weight, lbs
Percent Lighter by Weight          Minimum            Maximum
______________________________________________________________
W100                                 15.                 36.
 W50                                  7.                 11.
 W15                                  2.                  5.

______________________ HEC-11 Method ______________________


Input Parameters:
```

```
                              ONSITE Channel Sec-4
-----------------

Average Channel Velocity                          4.63 ft/s
Average Flow Depth                                4.00 ft
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side Slope                              2.50
Material Angle of Repose                         41.00 deg.
Riprap Placement                               Channel Bank
Safety Factor                                         1.1


Output Results:
---------------

Computed D50                                      0.06 ft


                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
____________________________________________________________
D100                                1.30                200.
 D50                                0.95                 75.
 D10                                0.40                  5.
```

```
                    ONSITE Channel Sec-4_btm
Date: 02/12/2009 Time: 16:31
*************************************************************
*                 RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                             *
*                   WEST Consultants, Inc.                  *
*                                                           *
*                                                           *
* Version 3.0                                 March, 2005 *
*                                                           *
*                                                           *
* COPYRIGHT (c) 2005                                        *
* WEST CONSULTANTS, INC.                                    *
* 16870 WEST BERNARDO DRIVE                PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127         WEB:WWW.WESTCONSULTANTS.COM *
*************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel SEC-4_btm


______________________  USACE Method  ______________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                           4.63 ft/s
Bottom Width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                         165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     1.49 ft
Cotangent of Side Slope                                  N/A
Safety Factor                                            1.1
Riprap Placement                              Channel Bottom
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         0.10 ft
Computed Local Depth Averaged Velocity             4.63 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                   Stone Weight, lbs
Percent Lighter by Weight       Minimum            Maximum
____________________________________________________________
W100                                 15.                36.
 W50                                  7.                11.
```

```
 W15                                   2.                  5.

_______________________  ASCE Method  _______________________


Input Parameters:
-----------------

Local Velocity                                      4.63 ft/s
Cotangent of Side slope                                   N/A
Unit Weight of Stone                           165. lbs/cu ft
Riprap Placement                               Channel Bottom


Output Results:
---------------

Computed D50                                          0.14 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness             0.750 ft
Selected Minimum D30         0.37 ft
Selected Minimum D90         0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight         Minimum             Maximum
_____________________________________________________________
W100                                  15.                 36.
 W50                                   7.                 11.
 W15                                   2.                  5.

_______________________  USBR Method  _______________________


Input Parameters:
-----------------

Average Channel Velocity                            4.63 ft/s


Output Results:
---------------

Computed D50                                          0.29 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness             0.750 ft
Selected Minimum D30         0.37 ft
Selected Minimum D90         0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight         Minimum             Maximum
_____________________________________________________________
W100                                  15.                 36.
 W50                                   7.                 11.
 W15                                   2.                  5.
```

```
                       ONSITE Channel Sec-4_btm
________________________ USGS Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                             4.63 ft/s


Output Results:
---------------

Computed D50                                           0.42 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight          Minimum             Maximum
--------------------------------------------------------------
W100                                   15.                 36.
 W50                                    7.                 11.
 W15                                    2.                  5.

_______________________ Isbash Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                             4.63 ft/s
Unit Weight of Stone                            165. lbs/cu ft
Turbulence Level                                          High


Output Results:
---------------

Computed D50                                           0.27 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight          Minimum             Maximum
--------------------------------------------------------------
W100                                   15.                 36.
 W50                                    7.                 11.
 W15                                    2.                  5.

_______________________ HEC-11 Method _______________________


Input Parameters:
```

```
                           ONSITE Channel Sec-4_btm
-----------------

Average Channel Velocity                                  4.63 ft/s
Average Flow Depth                                        4.00 ft
Unit Weight of Stone                                   165. lbs/cu ft
Cotangent of Side Slope                                        N/A
Material Angle of Repose                                      deg.
Riprap Placement                                    Channel Bottom
Safety Factor                                                  1.1


Output Results:
---------------

Computed D50                                              0.04 ft

                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
______________________________________________________________
D100                               1.30                  200.
 D50                               0.95                   75.
 D10                               0.40                    5.
```

```
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                   WEST Consultants, Inc.                 *
*                                                          *
*                                                          *
* Version 3.0                                  March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel SEC-5-6-7


______________________ USACE Method ________________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                           3.53 ft/s
Bottom Width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     0.92 ft
Cotangent of Side Slope                                 2.50
Safety Factor                                            1.1
Riprap Placement                                Channel Bank
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         0.06 ft
Computed Local Depth Averaged Velocity             3.53 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                     Stone Weight, lbs
Percent Lighter by Weight        Minimum              Maximum
____________________________________________________________
W100                                 15.                  36.
 W50                                  7.                  11.
```

```
 W15                                            2.                 5.

______________________ ASCE Method ______________________


Input Parameters:
-----------------

Local Velocity                                             3.53 ft/s
Cotangent of Side slope                                      2.50
Unit Weight of Stone                                 165. lbs/cu ft
Riprap Placement                                       Channel Bank


Output Results:
---------------

Computed D50                                                0.09 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                            Stone Weight, lbs
Percent Lighter by Weight              Minimum                Maximum
______________________________________________________________________
W100                                        15.                   36.
 W50                                         7.                   11.
 W15                                         2.                    5.

______________________ USBR Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                                   3.53 ft/s


Output Results:
---------------

Computed D50                                                0.16 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                            Stone Weight, lbs
Percent Lighter by Weight              Minimum                Maximum
______________________________________________________________________
W100                                        15.                   36.
 W50                                         7.                   11.
 W15                                         2.                    5.
```

```
______________________ USGS Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                          3.53 ft/s


Output Results:
---------------

Computed D50                                      0.22 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                   Stone Weight, lbs
Percent Lighter by Weight      Minimum             Maximum
____________________________________________________________
W100                                15.                 36.
 W50                                 7.                 11.
 W15                                 2.                  5.

______________________ Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                          3.53 ft/s
Unit Weight of Stone                         165. lbs/cu ft
Turbulence Level                                       High


Output Results:
---------------

Computed D50                                      0.16 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                   Stone Weight, lbs
Percent Lighter by Weight      Minimum             Maximum
____________________________________________________________
W100                                15.                 36.
 W50                                 7.                 11.
 W15                                 2.                  5.

______________________ HEC-11 Method ______________________


Input Parameters:
```

```
                             ONSITE Channel Sec-5-6-7
-----------------

Average Channel Velocity                          3.53 ft/s
Average Flow Depth                                4.00 ft
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side Slope                              2.50
Material Angle of Repose                         41.00 deg.
Riprap Placement                               Channel Bank
Safety Factor                                         1.1

Output Results:
---------------

Computed D50                                      0.03 ft

                        ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
____________________________________________________________
D100                               1.30                 200.
 D50                               0.95                  75.
 D10                               0.40                   5.
```

```
                    ONSITE Channel Sec-5-6-7_btm
Date: 02/12/2009 Time: 16:32
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                           BY                             *
*                  WEST Consultants, Inc.                  *
*                                                          *
*                                                          *
* Version 3.0                                 March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127         WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel SEC-5-6-7_btm


______________________ USACE Method ______________________


Input Parameters:
-----------------
Velocity Type                                       Average
Channel Shape                                   Trapezoidal
Channel Type                                       Straight
Bend Angle (deg)                                        N/A
Average Channel Velocity                         3.53 ft/s
Bottom Width                                            N/A
Bend Radius                                             N/A
Top Width                                               N/A
Unit Weight of Stone                        165. lbs/cu ft
Riprap Layer Thickness                                 1.00
Local Flow Depth                                    0.92 ft
Cotangent of Side Slope                                 N/A
Safety Factor                                           1.1
Riprap Placement                             Channel Bottom
Rock Type                                           Angular


Output Results:
---------------

Computed D30                                        0.06 ft
Computed Local Depth Averaged Velocity           3.53 ft/s
Local Velocity/Avg. Velocity                           1.00
Side Slope Correction Factor                           1.06
Correction for Layer Thickness                         1.00
Correction for Secondary Currents                      1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness          0.750 ft
Selected Minimum D30      0.37 ft
Selected Minimum D90      0.53 ft


                                   Stone Weight, lbs
Percent Lighter by Weight       Minimum            Maximum
___________________________________________________________
W100                                15.                36.
 W50                                 7.                11.
```

```
W15                                                2.                 5.

_______________________   ASCE Method   _______________________

Input Parameters:
-----------------

Local Velocity                                                3.53 ft/s
Cotangent of Side slope                                             N/A
Unit Weight of Stone                                     165. lbs/cu ft
Riprap Placement                                         Channel Bottom

Output Results:
---------------

Computed D50                                                    0.08 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft

                                         Stone Weight, lbs
Percent Lighter by Weight             Minimum            Maximum
_____________________________________________________________________
W100                                       15.                36.
 W50                                        7.                11.
 W15                                        2.                 5.

_______________________   USBR Method   _______________________

Input Parameters:
-----------------

Average Channel Velocity                                      3.53 ft/s

Output Results:
---------------

Computed D50                                                    0.16 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft

                                         Stone Weight, lbs
Percent Lighter by Weight             Minimum            Maximum
_____________________________________________________________________
W100                                       15.                36.
 W50                                        7.                11.
 W15                                        2.                 5.
```

```
                              ONSITE Channel Sec-5-6-7_btm
_______________________       USGS Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                          3.53 ft/s


Output Results:
---------------

Computed D50                                      0.22 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight          Minimum               Maximum
_______________________________________________________________
W100                                   15.                   36.
 W50                                    7.                   11.
 W15                                    2.                    5.

______________________        Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                          3.53 ft/s
Unit Weight of Stone                         165. lbs/cu ft
Turbulence Level                                       High


Output Results:
---------------

Computed D50                                      0.16 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight          Minimum               Maximum
_______________________________________________________________
W100                                   15.                   36.
 W50                                    7.                   11.
 W15                                    2.                    5.

______________________        HEC-11 Method ______________________


Input Parameters:
```

```
                          ONSITE Channel Sec-5-6-7_btm
-----------------

Average Channel Velocity                                3.53 ft/s
Average Flow Depth                                      4.00 ft
Unit Weight of Stone                                165. lbs/cu ft
Cotangent of Side Slope                                      N/A
Material Angle of Repose                                    deg.
Riprap Placement                                  Channel Bottom
Safety Factor                                                1.1


Output Results:
---------------

Computed D50                                            0.02 ft

                        ** FHWA Gradation**


Gradation Class             Facing
Layer Thickness             1.90 ft

Percent Smaller by Size    Rock Size, ft     Rock Weight, lbs
_____________________________________________________________
D100                               1.30                  200.
 D50                               0.95                   75.
 D10                               0.40                    5.
```

```
                           ONSITE Channel DROP Sec-7
Date: 02/12/2009 Time: 16:41
************************************************************
*               RIPRAP DESIGN SYSTEM (RDS)                 *
*                            BY                            *
*                   WEST Consultants, Inc.                 *
*                                                          *
*                                                          *
* Version 3.0                                  March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel DROP SEC-7

______________________   USACE Method _____________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                           9.44 ft/s
Bottom width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     0.39 ft
Cotangent of Side Slope                                 2.50
Safety Factor                                            1.1
Riprap Placement                                Channel Bank
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         0.85 ft
Computed Local Depth Averaged Velocity             9.44 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           2.000 ft
Selected Minimum D30        0.97 ft
Selected Minimum D90        1.41 ft


                                       Stone Weight, lbs
Percent Lighter by Weight         Minimum            Maximum
____________________________________________________________
W100                                 276.               691.
 W50                                 138.               205.
```

```
 W15                                            43.             102.

_______________________  ASCE Method  _______________________


Input Parameters:
-----------------

Local Velocity                                          9.44 ft/s
Cotangent of Side slope                                      2.50
Unit Weight of Stone                               165. lbs/cu ft
Riprap Placement                                     Channel Bank


Output Results:
---------------

Computed D50                                              0.63 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           1.250 ft
Selected Minimum D30       0.61 ft
Selected Minimum D90       0.88 ft


                                          Stone Weight, lbs
Percent Lighter by Weight              Minimum            Maximum
-----------------------------------------------------------------
W100                                       67.               169.
 W50                                       34.                50.
 W15                                       11.                25.

_______________________  USBR Method  ________________________


Input Parameters:
-----------------

Average Channel Velocity                                9.44 ft/s


Output Results:
---------------

Computed D50                                              1.24 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           2.250 ft
Selected Minimum D30       1.10 ft
Selected Minimum D90       1.59 ft


                                          Stone Weight, lbs
Percent Lighter by Weight              Minimum            Maximum
-----------------------------------------------------------------
W100                                      394.               984.
 W50                                      197.               291.
 W15                                       62.               146.
```

```
                     ONSITE Channel DROP Sec-7
 ____________________ USGS Method _____________________


 Input Parameters:
 -----------------

 Average Channel Velocity                             9.44 ft/s


 Output Results:
 ---------------

 Computed D50                                          2.39 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight      165.0 lbs/cu ft
 Layer Thickness          4.500 ft
 Selected Minimum D30      2.19 ft
 Selected Minimum D90      3.17 ft


                                        Stone Weight, lbs
 Percent Lighter by Weight          Minimum             Maximum
 ______________________________________________________________
 W100                                3149.               7873.
  W50                                1575.               2330.
  W15                                 492.               1165.

 ____________________ Isbash Method ____________________


 Input Parameters:
 -----------------

 Average Channel Velocity                             9.44 ft/s
 Unit Weight of Stone                            165. lbs/cu ft
 Turbulence Level                                          High


 Output Results:
 ---------------

 Computed D50                                          1.14 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight      165.0 lbs/cu ft
 Layer Thickness          2.000 ft
 Selected Minimum D30      0.97 ft
 Selected Minimum D90      1.41 ft


                                        Stone Weight, lbs
 Percent Lighter by Weight          Minimum             Maximum
 ______________________________________________________________
 W100                                 276.                691.
  W50                                 138.                205.
  W15                                  43.                102.

 ____________________ HEC-11 Method ____________________


 Input Parameters:
```

```
                         ONSITE Channel DROP Sec-7
-----------------

Average Channel Velocity                         9.44 ft/s
Average Flow Depth                               4.00 ft
Unit Weight of Stone                       165. lbs/cu ft
Cotangent of Side Slope                          2.50
Material Angle of Repose                    41.00 deg.
Riprap Placement                         Channel Bank
Safety Factor                                     1.1

Output Results:
---------------

Computed D50                                     0.50 ft

                     ** FHWA Gradation**

Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
------------------------------------------------------------
D100                              1.30                  200.
 D50                              0.95                   75.
 D10                              0.40                    5.
```

```
                         ONSITE Channel DROP Sec-7_btm
Date: 02/12/2009 Time: 16:41
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                   WEST Consultants, Inc.                 *
*                                                          *
*                                                          *
* Version 3.0                                  March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE                PH: 858-487-9378 *
* SUITE 340                                FAX:858-487-9448 *
* SAN DIEGO, CA 92127       WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel DROP SEC-7_btm


______________________   USACE Method ______________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                           9.44 ft/s
Bottom Width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                         165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     0.39 ft
Cotangent of Side Slope                                  N/A
Safety Factor                                            1.1
Riprap Placement                              Channel Bottom
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         0.85 ft
Computed Local Depth Averaged Velocity             9.44 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            2.000 ft
Selected Minimum D30        0.97 ft
Selected Minimum D90        1.41 ft


                                       Stone Weight, lbs
Percent Lighter by Weight         Minimum            Maximum
____________________________________________________________
W100                                 276.               691.
 W50                                 138.               205.
```

```
 W15                                  43.               102.

_______________________  ASCE Method  _______________________


Input Parameters:
-----------------

Local Velocity                                     9.44 ft/s
Cotangent of Side slope                                  N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Placement                              Channel Bottom


Output Results:
---------------

Computed D50                                         0.58 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            1.000 ft
Selected Minimum D30        0.49 ft
Selected Minimum D90        0.70 ft


                                       Stone Weight, lbs
Percent Lighter by Weight         Minimum            Maximum
____________________________________________________________
W100                                  35.                86.
 W50                                  17.                26.
 W15                                   5.                13.

_______________________  USBR Method  ________________________


Input Parameters:
-----------------

Average Channel Velocity                           9.44 ft/s


Output Results:
---------------

Computed D50                                         1.24 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            2.250 ft
Selected Minimum D30        1.10 ft
Selected Minimum D90        1.59 ft


                                       Stone Weight, lbs
Percent Lighter by Weight         Minimum            Maximum
____________________________________________________________
W100                                 394.               984.
 W50                                 197.               291.
 W15                                  62.               146.
```

```
                        ONSITE Channel DROP Sec-7_btm
_______________________  USGS Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                            9.44 ft/s


Output Results:
---------------

Computed D50                                        2.39 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         4.500 ft
Selected Minimum D30     2.19 ft
Selected Minimum D90     3.17 ft


                                        Stone Weight, lbs
Percent Lighter by Weight           Minimum            Maximum
______________________________________________________________
W100                                 3149.              7873.
 W50                                 1575.              2330.
 W15                                  492.              1165.

______________________  Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                            9.44 ft/s
Unit Weight of Stone                           165. lbs/cu ft
Turbulence Level                                         High


Output Results:
---------------

Computed D50                                        1.14 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         2.000 ft
Selected Minimum D30     0.97 ft
Selected Minimum D90     1.41 ft


                                        Stone Weight, lbs
Percent Lighter by Weight           Minimum            Maximum
______________________________________________________________
W100                                  276.               691.
 W50                                  138.               205.
 W15                                   43.               102.

______________________  HEC-11 Method ______________________


Input Parameters:
```

```
                        ONSITE Channel DROP Sec-7_btm
-----------------

Average Channel Velocity                         9.44 ft/s
Average Flow Depth                               4.00 ft
Unit Weight of Stone                           165. lbs/cu ft
Cotangent of Side Slope                               N/A
Material Angle of Repose                             deg.
Riprap Placement                             Channel Bottom
Safety Factor                                         1.1


Output Results:
---------------

Computed D50                                     0.37 ft

                      ** FHWA Gradation**


Gradation Class           Facing
Layer Thickness           1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
____________________________________________________________
D100                               1.30                 200.
 D50                               0.95                  75.
 D10                               0.40                   5.
```

```
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                   WEST Consultants, Inc.                 *
*                                                          *
*                                                          *
* Version 3.0                                  March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127           WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel SEC-8-9

______________________   USACE Method   ______________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                           2.79 ft/s
Bottom Width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     1.12 ft
Cotangent of Side Slope                                 2.50
Safety Factor                                            1.1
Riprap Placement                                Channel Bank
Rock Type                                            Angular

Output Results:
---------------

Computed D30                                         0.03 ft
Computed Local Depth Averaged Velocity             2.79 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight         Minimum            Maximum
____________________________________________________________
W100                                  15.                36.
 W50                                   7.                11.
```

```
 W15                                    2.                   5.

_______________________ ASCE Method _______________________

Input Parameters:
-----------------

Local Velocity                                        2.79 ft/s
Cotangent of Side slope                                    2.50
Unit Weight of Stone                              165. lbs/cu ft
Riprap Placement                                   Channel Bank

Output Results:
---------------

Computed D50                                            0.05 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft

                                          Stone Weight, lbs
Percent Lighter by Weight            Minimum            Maximum
_______________________________________________________________
W100                                      15.                36.
 W50                                       7.                11.
 W15                                       2.                 5.

_______________________ USBR Method ________________________

Input Parameters:
-----------------

Average Channel Velocity                              2.79 ft/s

Output Results:
---------------

Computed D50                                            0.10 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft

                                          Stone Weight, lbs
Percent Lighter by Weight            Minimum            Maximum
_______________________________________________________________
W100                                      15.                36.
 W50                                       7.                11.
 W15                                       2.                 5.
```

```
                                ONSITE Channel Sec-8-9
_______________________ USGS Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                         2.79 ft/s


Output Results:
---------------

Computed D50                                     0.12 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                      Stone Weight, lbs
Percent Lighter by Weight          Minimum            Maximum
_____________________________________________________________
W100                                   15.                36.
 W50                                    7.                11.
 W15                                    2.                 5.


______________________ Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                         2.79 ft/s
Unit Weight of Stone                        165. lbs/cu ft
Turbulence Level                                      High


Output Results:
---------------

Computed D50                                     0.10 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                      Stone Weight, lbs
Percent Lighter by Weight          Minimum            Maximum
_____________________________________________________________
W100                                   15.                36.
 W50                                    7.                11.
 W15                                    2.                 5.


______________________ HEC-11 Method ______________________


Input Parameters:
```

```
                            ONSITE Channel Sec-8-9
-----------------

Average Channel Velocity                           2.79 ft/s
Average Flow Depth                                   4.00 ft
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side Slope                                 2.50
Material Angle of Repose                          41.00 deg.
Riprap Placement                                Channel Bank
Safety Factor                                            1.1


Output Results:
---------------

Computed D50                                         0.01 ft


                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
____________________________________________________________
D100                               1.30                 200.
 D50                               0.95                  75.
 D10                               0.40                   5.
```

```
Date: 02/12/2009 Time: 16:43
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                  WEST Consultants, Inc.                  *
*                                                          *
*                                                          *
* Version 3.0                                March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE                PH: 858-487-9378 *
* SUITE 340                                FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Onsite
Description: Onsite Channel SEC-8-9_btm

______________________ USACE Method ______________________

Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                            2.79 ft/s
Bottom width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     1.12 ft
Cotangent of Side Slope                                  N/A
Safety Factor                                            1.1
Riprap Placement                              Channel Bottom
Rock Type                                            Angular

Output Results:
---------------

Computed D30                                         0.03 ft
Computed Local Depth Averaged Velocity              2.79 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight      165.0 lbs/cu ft
Layer Thickness             0.750 ft
Selected Minimum D30         0.37 ft
Selected Minimum D90         0.53 ft
```

```
                                          Stone Weight, lbs
Percent Lighter by Weight            Minimum            Maximum
-------------------------------------------------------------------
W100                                     15.                36.
 W50                                      7.                11.
 W15                                      2.                 5.

_________________________ ASCE Method _________________________


Input Parameters:
-----------------

Local Velocity                                        2.79 ft/s
Cotangent of Side slope                                     N/A
Unit Weight of Stone                             165. lbs/cu ft
Riprap Placement                                 Channel Bottom


Output Results:
---------------

Computed D50                                            0.05 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness             0.750 ft
Selected Minimum D30         0.37 ft
Selected Minimum D90         0.53 ft

                                          Stone Weight, lbs
Percent Lighter by Weight            Minimum            Maximum
-------------------------------------------------------------------
W100                                     15.                36.
 W50                                      7.                11.
 W15                                      2.                 5.

_________________________ USBR Method _________________________


Input Parameters:
-----------------

Average Channel Velocity                              2.79 ft/s


Output Results:
---------------

Computed D50                                            0.10 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness             0.750 ft
```

```
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft

                                         Stone Weight, lbs
Percent Lighter by Weight           Minimum             Maximum
------------------------------------------------------------------
W100                                     15.                 36.
 W50                                      7.                 11.
 W15                                      2.                  5.

______________________  USGS Method  ________________________

Input Parameters:
-----------------

Average Channel Velocity                              2.79 ft/s

Output Results:
---------------

Computed D50                                           0.12 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight      165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft

                                         Stone Weight, lbs
Percent Lighter by Weight           Minimum             Maximum
------------------------------------------------------------------
W100                                     15.                 36.
 W50                                      7.                 11.
 W15                                      2.                  5.

_____________________  Isbash Method  _____________________

Input Parameters:
-----------------

Average Channel Velocity                              2.79 ft/s
Unit Weight of Stone                             165. lbs/cu ft
Turbulence Level                                           High

Output Results:
---------------

Computed D50                                           0.10 ft

  *** Using Gradations from COE ETL 1110-2-120 ***
```

```
Specific Weight      165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                          Stone Weight, lbs
Percent Lighter by Weight            Minimum              Maximum
_____________________________________________________________________
W100                                      15.                  36.
 W50                                       7.                  11.
 W15                                       2.                   5.

______________________  HEC-11 Method  ______________________

Input Parameters:
-----------------

Average Channel Velocity                               2.79 ft/s
Average Flow Depth                                     4.00 ft
Unit Weight of Stone                             165. lbs/cu ft
Cotangent of Side Slope                                     N/A
Material Angle of Repose                                   deg.
Riprap Placement                                 Channel Bottom
Safety Factor                                               1.1

Output Results:
---------------

Computed D50                                            0.01 ft

                     ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
_____________________________________________________________________
D100                               1.30                  200.
 D50                               0.95                   75.
 D10                               0.40                    5.
```

ON-SITE CHANNEL

DROP STRUCTURE CALCULATIONS

Cholla Ash Monofill
Riprap Basin Sizing and Hydraulic Jump
Onsite Drop Structure SOUTH Channel Into Basin

	A	B	C	D	E	F	G	H	I	J
1	**Riprap Basin Sizing**									
2										
3	Q=	25	cfs	flow rate for onsite SOUTH channel into basin						
4	Vallow=	0	ft/s	velocity for basin						
5	TW=	10	ft	normal depth for basin						
6	Wo=	10	ft	channel bottom width						
7										
8	From FHWA Hydraulic Design of Energy Dissipators for Culverts and Channels, July 2006									
9	1) Get intial velocity (Vo), depth (yo), and Froude Number (Fr) for brink conditions									
10										
11	From Flowmaster output files:									
12	yo= ye=	0.29	ft	normal depth for drop						
13	Vo=	7.96	ft/s	velocity for drop						
14	Fr=	2.68		Froude number for drop						
15										
16	2) Select trial D50 and obtain hs/ye from Equation 10.1.									
17										
18	Equation 10.1	$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{g y_e}}\right) - C_o$								
19										
20										
21										
22	Get tailwater parameter Co:									
23	Co =	1.4	if TW/ye < 0.75							
24	Co =	136.331	if 0.75 < TW/ye < 1.0							
25	Co =	3	if 1.0 < TW/ye							
26										
27	TW/ye =	34.48276								
28										
29	**D50 =**	**0.11**	**ft**	D50 of riprap						
30										
31	Check to see that hs/D50 >= 2 and that D50/ye >= 0.1.									
32	D50/ye =	0.37931	>= 0.1	OK						
33	g =	32.2	ft/s2							
34	hs/ye =	0.928133								
35	hs =	0.269159	ft	scour depth						
36	hs/D50 =	2.446896	>=2.0	OK						
37										
38	3) Size the basin									
39	Ls =	10*hs =	2.69	ft	Dissipator Pool Length					
40	Lsmin =	3Wo =	**30**	**ft**						
41										
42	Lb =	15hs =	4.04	ft	Total Pool Length					
43	Lbmin =	4Wo =	**40**	**ft**						
44	La =	**10**	**ft**	Apron Length						
45	Wb =	10	ft	maintaining channel bottom depth						
46										

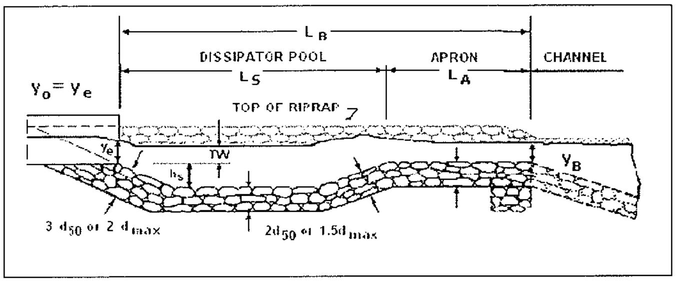


Figure 10.1. Profile of Riprap Basin

Cholla Ash Monofill
Riprap Basin Sizing and Hydraulic Jump
Onsite Drop Structure SOUTH Channel Into Basin

Hydraulic Jump

From Drainage Design Manual for Maricopa County, Hydraulics: Hydraulic Structures, 2003

Y1 = 0.29 ft upstream normal depth for drop
Ydn = 10 ft downstream normal depth basin
Q = 25 cfs flow through the drop
g = 32.2 ft/s2
A1 = 3.14 ft2 area of flow through the drop
A2 = 10.43 ft2 area of flow in next section
z = 2.5 ft sideslope H:1
b = 10 ft bottom width of channel

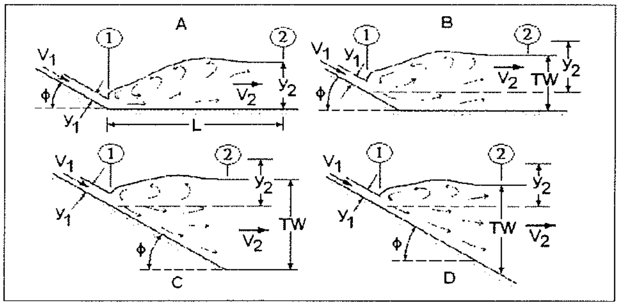


Figure 6.10. Hydraulic Jump Types Sloping Channels (Bradley, 1961)

2) Calculate sequant height of jump.

Equation 7.2

$$\boxed{Y_2 = \frac{1}{2} Y_1 \left[\left(1 + 8F_{r1}^2\right)^{\frac{1}{2}} - 1 \right]}$$

Y2 = **0.96** ft OK height of jump

3) Another check on sequant height of jump.

Use Fig. 7-8

$$Fr1 = \boxed{\frac{V}{\sqrt{g y_m}}}$$

V= 7.96 ft/s
top width = 11.46 ft
ym = 0.27 ft = flow area / top width
Fr1 = 2.68

J = Y2 / Y1 t = b/(zy1)
J = 3.1 t = 13.79
Y2 = **0.899** ft use larger height of jump

1) Calculate depth at beginning location of jump.

Equation 7.3

$$\boxed{\frac{ZY_1^3}{3} + \frac{ZY_1^2}{2} + \frac{Q}{gA_1} = \frac{ZY_2^3}{3} + \frac{bY_2^2}{3} + \frac{Q}{gA_2}}$$

Leq = 0.373 Req = 0.375 (Plug in values for Y2 until both sides equal)
Yb = **0.29** ft OK depth at jump location

4) Calculate length of jump.

Use Fig. 7-9

Lj / y1 = 33
Lj = 9.57 ft = jump length

Therefore: Min. Length of jump = **30 ft**
Min. Length of apron = **10 ft**
Total Length of basin = **40 ft**

Cholla Ash Monofill
Riprap Basin Sizing and Hydraulic Jump
Onsite Channel SEC-1 Into Basin

	A	B	C	D	E	F	G	H	I	J
1	**Riprap Basin Sizing**									
2										
3	Q=	95	cfs	flow rate for onsite channel SEC-1 into basin						
4	Vallow=	0	ft/s	velocity for basin						
5	TW=	10	ft	normal depth for basin						
6	Wo=	10	ft	channel bottom width						
7										
8	From FHWA Hydraulic Design of Energy Dissipators for Culverts and Channels, July 2006									
9	1) Get intial velocity (Vo), depth (yo), and Froude Number (Fr) for brink conditions									
10										
11	From Flowmaster output files:									
12	yo= ye=	0.64	ft	normal depth for drop						
13	Vo=	12.79	ft/s	velocity for drop						
14	Fr=	3.01		Froude number for drop						
15										
16	2) Select trial D50 and obtain hs/ye from Equation 10.1.									
17										
18	Equation 10.1		$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o$							
19										
20										
21										
22	Get tailwater parameter Co:									
23	Co =	1.4	if TW/ye < 0.75							
24	Co =	60.9	if 0.75 < TW/ye < 1.0							
25	Co =	3	if 1.0 < TW/ye							
26										
27	TW/ye =	15.625								
28										
29	**D50 =**	**0.29**	**ft**	D50 of riprap						
30										
31	Check to see that hs/D50 >= 2 and that D50/ye >= 0.1.									
32	D50/ye =	0.453125	>= 0.1	OK						
33	g =	32.2	ft/s2							
34	hs/ye =	1.000783								
35	hs =	0.640501	ft	scour depth						
36	hs/D50 =	2.208625	>=2.0	OK						
37										
38	3) Size the basin									
39	Ls =	10*hs =	6.41	ft	Dissipator Pool Length					
40	Lsmin =	3Wo =	**30**	**ft**						
41										
42	Lb =	15hs =	9.61	ft	Total Pool Length					
43	Lbmin =	4Wo =	**40**	**ft**						
44	La =	**10**	**ft**	Apron Length						
45	Wb =	10	ft	maintaining channel bottom depth						
46										

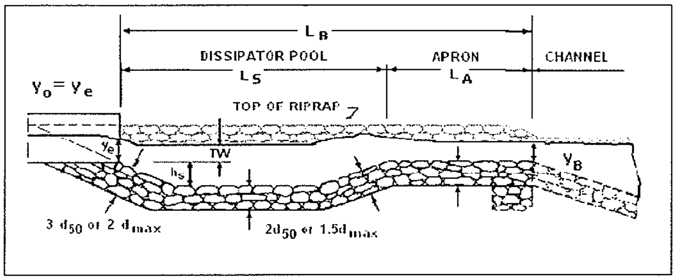


Figure 10.1. Profile of Riprap Basin

Cholla Ash Monofill
Riprap Basin Sizing and Hydraulic Jump
Onsite Channel SEC-1 Into Basin

Hydraulic Jump

From Drainage Design Manual for Maricopa County, Hydraulics: Hydraulic Structures, 2003

Y1 = 0.64 ft upstream normal depth for drop
Ydn = 10 ft downstream normal depth basin
Q = 95 cfs flow through the drop
g = 32.2 ft/s2
A1 = 7.43 ft2 area of flow through the drop
A2 = 10.43 ft2 area of flow in next section
z = 2.5 ft sideslope H:1
b = 10 ft bottom width of channel

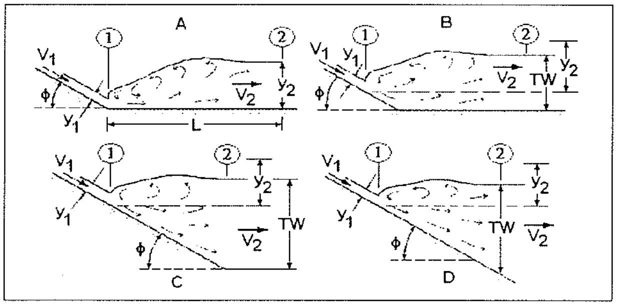


Figure 6.10. Hydraulic Jump Types Sloping Channels (Bradley, 1961)

2) Calculate sequant height of jump.
Equation 7.2

$$\boxed{Y_2 = \frac{1}{2}Y_1\left[\left(1+8F_{r1}^2\right)^{\frac{1}{2}}-1\right]}$$

Y2 = **2.42** ft OK height of jump

3) Another check on sequant height of jump.
Use Fig. 7-8

Fr1 = $\boxed{\frac{V}{\sqrt{g y_m}}}$

V= 12.79 ft/s
top width = 13.20 ft
ym = 0.56 ft = flow area / top width
Fr1 = 3.00

J = Y2 / Y1 t = b/(zy1)
J = 3.5 t = 6.25
Y2 = **2.24** ft use larger height of jump

1) Calculate depth at beginning location of jump.
Equation 7.3

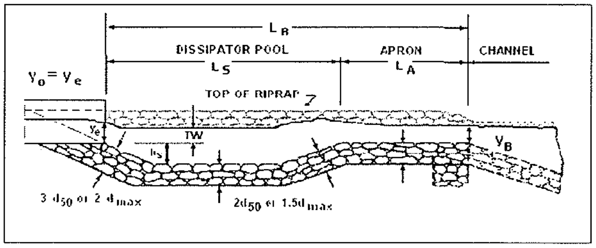
$$\boxed{\frac{ZY_1^3}{3}+\frac{ZY_1^2}{2}+\frac{Q}{gA_1}=\frac{ZY_2^3}{3}+\frac{bY_2^2}{3}+\frac{Q}{gA_2}}$$

Leq = 1.128 Req = 1.143 (Plug in values for Y2 until both sides equal)
Yb = **0.48** ft OK depth at jump location

4) Calculate length of jump.
Use Fig. 7-9
Lj / y1 = 55
Lj = 35.2 ft = jump length

Therefore: Min. Length of jump = **36 ft**
Min. Length of apron = **10 ft**
Total Length of basin = **46 ft**

Cholla Ash Monofill
Riprap Sizing and Hydraulic Jump
Onsite Channel SEC-7 Drop Structure

	A	B	C	D	E	F	G	H	I	J
1	**Riprap Basin Sizing**									
2										
3	Q=	40	cfs	flow rate for onsite channel SEC-7, just before brink of drop						
4	Vallow=	3.53	ft/s	velocity for onsite channel SEC-6, past drop						
5	TW=	0.92	ft	normal depth for onsite channel SEC-6, past drop						
6	Wo=	10	ft	channel bottom width						
7										
8	From FHWA Hydraulic Design of Energy Dissipators for Culverts and Channels, July 2006									
9	1) Get intial velocity (Vo), depth (yo), and Froude Number (Fr) for brink conditions									
10										
11	From Flowmaster output files:									
12	yo= ye=	0.39	ft	normal depth for drop						
13	Vo=	9.44	ft/s	velocity for drop						
14	Fr=	2.79		Froude number for drop						
15										
16	2) Select trial D50 and obtain hs/ye from Equation 10.1.									
17										
18	Equation 10.1		$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{g y_e}}\right) - C_o$							
19										
20										
21										
22	Get tailwater parameter Co:									
23	Co =	1.4	if TW/ye < 0.75							
24	Co =	7.835897	if 0.75 < TW/ye < 1.0							
25	Co =	3	if 1.0 < TW/ye							
26										
27	TW/ye =	2.358974								
28										
29	**D50 =**	**0.16**	**ft**	D50 of riprap						
30					Figure 10.1. Profile of Riprap Basin					
31	Check to see that hs/D50 >= 2 and that D50/ye >= 0.1.									
32	D50/ye =	0.410256	>= 0.1	OK						
33	g =	32.2	ft/s2							
34	hs/ye =	0.916717								
35	hs =	0.35752	ft	scour depth						
36	hs/D50 =	2.234498	>=2.0	OK						
37										
38	3) Size the basin									
39	Ls =	10*hs =	3.58	ft	Dissipator Pool Length					
40	Lsmin =	3Wo =	**30**	**ft**						
41										
42	Lb =	15hs =	5.36	ft	Total Pool Length					
43	Lbmin =	4Wo =	**40**	**ft**						
44	La =	**10**	**ft**	Apron Length						
45	Wb =	10	ft	maintaining channel bottom depth						
46										
47	4) Assess need for downstream riprap due to TW/ye >0.74									
48	Using Figure 10.3									
49	Compute equivalent circular diameter, De, for brink area						$A = \frac{\pi D_e^2}{4} = y_o W_o$			
50	A =	0.3588								
51	De =	0.68								
52										
53	Rock size for riprap after energy dissipators Equation 10.6						$D_{50} = \frac{0.692}{S-1}\left(\frac{V^2}{2g}\right)$			
54	S =	2.64	specific gravity of rock							
55										
56	L/De	L (ft)	Vl/Vo (Fig. 10.3)	Vl (ft/s)	D50 (ft)					
57	14.79513	10	0.42	3.9648	0.10					
58	22.19269	15	0.4	3.776	0.09					
59	25.15172	**17**	0.38	**3.5872**	**0.08**		**Riprap placement required for 17 ft from brink.**			
60	29.59026	20	0.3	2.832	0.05					

Cholla Ash Monofill
Riprap Sizing and Hydraulic Jump
Onsite Channel SEC-7 Drop Structure

A B C D E F G H I J

61 **Hydraulic Jump**

62 From Drainage Design Manual for Maricopa County, Hydraulics: Hydraulic Structures, 2003

63 Y1 = 0.39 ft upstream normal depth for drop

64 **Ydn = 0.92 ft downstream normal depth**

65 Q = 40 cfs flow through the drop

66 g = 32.2 ft/s2

67 A1 = 4.24 ft2 area of flow through the drop

68 A2 = 11.34 ft2 area of flow in next section

69 z = 2.5 ft sideslope H:1

70 b = 10 ft bottom width of channel

71

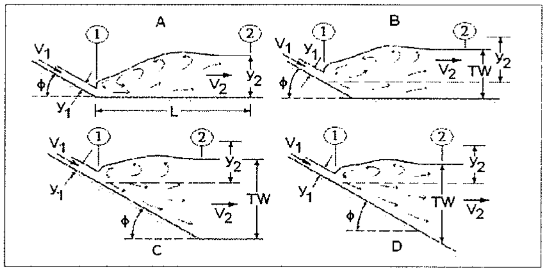


Figure 6.10. Hydraulic Jump Types Sloping Channels (Bradley, 1961)

72 2) Calculate sequant height of jump.

73 Equation 7.2

74–76

$$\boxed{Y_2 = \frac{1}{2}Y_1\left[\left(1+8F_{r1}^2\right)^{\frac{1}{2}}-1\right]}$$

77 Y2 = **1.36** ft OK height of jump

78

79 3) Another check on sequant height of jump.

80 Use Fig. 7-8

81 V= 9.43 ft/s

82 Fr1 = $\boxed{\frac{V}{\sqrt{gy_m}}}$ top width = 11.93 ft

83 ym = 0.36 ft = flow area / top width

84 Fr1 = 2.79

85

86 J = Y2 / Y1 t = b/(zy1)

87 J = 3.4 t = 10.26

88 Y2 = **1.326** ft use larger of Y2 for max height of jump

89

90 1) Calculate depth at beginning location of jump.

91 Equation 7.3

92–93

$$\boxed{\frac{ZY_1^3}{3}+\frac{ZY_1^2}{2}+\frac{Q}{gA_1}=\frac{ZY_b^3}{3}+\frac{bY_b^2}{3}+\frac{Q}{gA_b}}$$

94

95 Leq = 0.533 Req = 0.528 (Plug in values for Yb until both sides equal)

96 Yb = **0.34** ft OK depth at beginning jump location

97

98 4) Calculate length of jump.

99 Use Fig. 7-9

100 Lj / y1 = 41

101 Lj = 15.99 ft = jump length

102

103 Therefore: Min. Length of jump = **30 ft**

104 Min. Length of apron = **10 ft**

105 Total Length of basin = **40 ft**

106 Total Length of required riprap= **17 ft** (from brink of drop)

Cholla Ash Monofill
Sloping Drop Structure
Riprap Sizing and Hydraulic Jump Formulas

	A	B	C	D	E	F	G	H	I
1	**Riprap Basin Sizing**								
2									
3	Q=	80	cfs	flow rate for section 6, just before brink of drop					
4	Vallow=	4.39	ft/s	velocity for section 5, past drop					
5	TW=	1.36	ft	normal depth for section 5, past drop					
6	Wo=	10	ft	channel bottom w					
7									
8	From FHWA Hydraulic Design of Energy Dissipators for Culverts and Channels, July 2006								
9	1) Get intial velocity (Vo), depth (yo), and Froude Number (Fr) for brink conditions								
10									
11	From Flowmaster output files:								
12	yo= ye=	0.58	ft	normal depth for (					
13	Vo=	12.05	ft/s	velocity for drop					
14	Fr=	2.96		Froude number for drop					
15									
16	2) Select trial D50 and obtain hs/ye from Equation 10.1.								
17									
18	Equation 10.1	$\frac{h_s}{y_e}=0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right)-C_o$							
19									
20									
21									
22	Get tailwater parameter Co:								
23	Co =	1.4	if TW/ye < 0.75						
24	Co =	=4*B5/B12-1.6	if 0.75 < TW/ye < 1.0						
25	Co =	3	if 1.0 < TW/ye						
26									
27	TW/ye =	=B5/B12							
28									
29	**D50 =**	**0.25**	**ft**	D50 of riprap					
30									
31	Check to see that hs/D50 >= 2 and that D50/ye >= 0.1.								
32	D50/ye =	=B29/B12	>= 0.1	OK					
33	g =	32.2	ft/s2						
34	hs/ye =	=0.86*((B32)^(-0.55))*(B14)-B25							
35	hs =	=B34*B12	ft	scour depth					
36	hs/D50 =	=B35/B29	>=2.0	OK					
37									
38	3) Size the basin								
39	Ls =	10*hs =	=10*B35	ft	Dissipator Pool Length				
40	Lsmin =	3Wo =	**=3*B6**	**ft**					
41									
42	Lb =	15hs =	=15*B35	ft	Total Pool Length				
43	Lbmin =	4Wo =	**=4*B6**	**ft**					
44	La =	**=C43-C40**	**ft**	Apron Length					
45	Wb =	10	ft	maintaining channel bottom depth					
46									
47	4) Assess need for downstream riprap due to TW/ye >0.74 **(for Drop Structures in channel only)**								
48	Using Figure 10.3		$A=\frac{\pi D_e^2}{4}=y_oW_o$						
49	Compute equivalent circular diameter, De, for brink area								
50	A =	=B5*B12							
51	De =	=(B50*4/PI())^0.5							
52									
53	Rock size for riprap afl								
54	S =	=165/62.4	specific gravity of rock		$D_{50}=\frac{0.692}{S-1}\left(\frac{V^2}{2g}\right)$				
55									

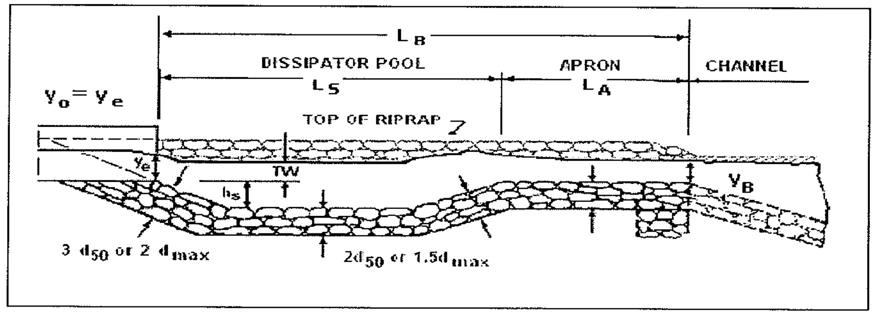


Figure 10.1. Profile of Riprap Basin

Cholla Ash Monofill
Sloping Drop Structure
Riprap Sizing and Hydraulic Jump Formulas

	A	B	C	D	E	F	G	H	I
56	L/De	L (ft)	Vl/Vo (Fig. 10.3)	Vl (ft/s)	D50 (ft)				
57	=B57/$B$51	10	0.42	=C57*$B$13	=(0.692/($B$54-1))*((D57^2)/(2*'Drop Off-basin'!$B$33))				
58	=B58/$B$51	15	0.4	=C58*$B$13	=(0.692/($B$54-1))*((D58^2)/(2*'Drop Off-basin'!$B$33))				
59	=B59/$B$51	**17**	0.38	**=C59*$B$13**	**=(0.692/($B$54-1))*((D59^2)/(2*'Drop Off-basin'!$B$33))**			**Riprap placement required for 17 ft from brink.**	
60	=B60/$B$51	20	0.3	=C60*$B$13	=(0.692/($B$54-1))*((D60^2)/(2*'Drop Off-basin'!$B$33))				
61									
62	**Hydraulic Jump**								
63	From Drainage Design Manual for Maricopa County, Hydraulics: Hydraulic Structures, 2003								
64	Y1 =	0.58	ft	upstream normal depth for drop					
65	**Ydn =**	**1.36**	**ft**	**downstream normal depth section 5**					
66	Q =	80	cfs	flow through the d					
67	g =	32.2	ft/s2						
68	A1 =	6.64	ft2	area of flow through the drop					
69	A2 =	10.43	ft2	area of flow in next section					
70	z =	2.5	ft	sideslope H:1					
71	b =	10	ft	bottom width of channel					
72									
73	2) Calculate sequant height of jump.								
74	Equation 7.2	$Y_2 = \frac{1}{2}Y_1\left[\left(1+8F_{r1}^2\right)^{\frac{1}{2}}-1\right]$							
75									
76									
77									
78	Y2 =	**=0.5*B64*(((1+8*(D85^2))^0.5)-1)**	ft	OK	height				
79									
80	3) Another check on sequant height of jump.								
81	Use Fig. 7-8								
82		$\frac{V}{\sqrt{gy_m}}$	V=	=B66/B68	ft/s				
83	Fr1 =		top width =	12.9	ft				
84			ym =	=B68/D83	ft	= flow area / top width			
85			Fr1 =	=D82/SQRT(B67*D84)					
86									
87	J = Y2 / Y1			t = b/(zy1)					
88	J =	3.5		t =	=B71/(B70*B64)				
89	Y2 =	**=B88*B64**	ft	use larger	height of jump				
90									
91	1) Calculate depth at beginning location of jump.								
92	Equation 7.3	$\frac{ZY_1^3}{3}+\frac{ZY_1^2}{2}+\frac{Q}{gA_1}=\frac{ZY_2^3}{3}+\frac{bY_2^2}{3}+\frac{Q}{gA_2}$							
93									
94									
95									
96	Leq =	=(B70*(B64^3)/3)+(B70*(B64^2)/2)+(B66/(B67*B68))	Req =	=(B70*B97^3/3)+(B71*B97^2/3)+(B66/(B67*B69))				(Plug in values for Y2	
97	Yb =	**0.44**	ft	OK	depth at jump location			until both sides equal)	
98									
99	4) Calculate length of jump.								
100	Use Fig. 7-9								
101	Lj / y1 =	55							
102	Lj =	=B101*B64	ft	= jump length					
103									
104			Therefore: Min. Length of jump =	**32**	**ft**				
105			Min. Length of apron =	**10**	**ft**				
106			Total Length of basin =	**=D105+D104**	**ft**				

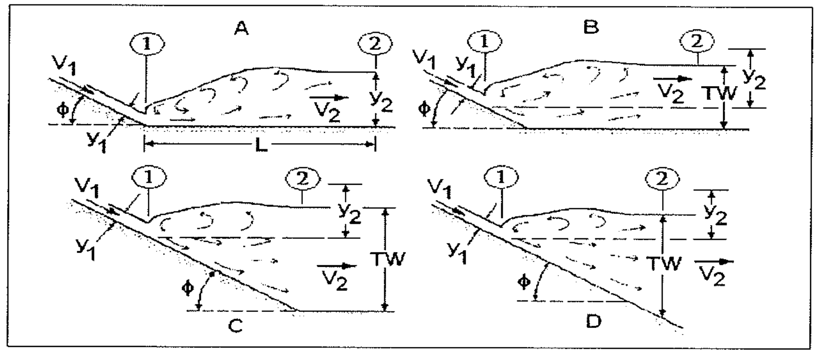


Figure 6.10. Hydraulic Jump Types Sloping Channels (Bradley, 1961)

ON-SITE STORAGE VOLUME CALCULATION

Cholla Ash Monofill
On-Site Basin Calculation

Depth	Storage Area (sq ft)	Storage Area (ac)	Volume *(1) (cu ft)	Volume (ac-ft)	Total Volume (ac ft)
0	18,225	0.42	0	0	0
9	35,721	0.82	238,383	5.473	5.5
12	45,369	1.04	121,347	2.786	8.3

Notes: The volume was calculated using the conic equation (V = h/3 x (a1 + a2 + (a1 x a2)^(1/2))

OFF-SITE HYDRAULIC CALCULATIONS

OFF-SITE CHANNEL

NORMAL DEPTH CALCULATIONS

Worksheet for DROP Channel Section 1 (25 cfs-5:1)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.20000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	25.00	ft³/s

Results

Normal Depth	0.29	ft
Flow Area	3.14	ft²
Wetted Perimeter	11.58	ft
Top Width	11.46	ft
Critical Depth	0.55	ft
Critical Slope	0.02311	ft/ft
Velocity	7.96	ft/s
Velocity Head	0.98	ft
Specific Energy	1.28	ft
Froude Number	2.68	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.29	ft
Critical Depth	0.55	ft
Channel Slope	0.20000	ft/ft
Critical Slope	0.02311	ft/ft

Worksheet for Channel Section 1 (30 cfs - 0.885% Slope)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00885	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	25.00	ft³/s

Results

Normal Depth	0.73	ft
Flow Area	8.62	ft²
Wetted Perimeter	13.93	ft
Top Width	13.65	ft
Critical Depth	0.55	ft
Critical Slope	0.02311	ft/ft
Velocity	2.90	ft/s
Velocity Head	0.13	ft
Specific Energy	0.86	ft
Froude Number	0.64	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.73	ft
Critical Depth	0.55	ft
Channel Slope	0.00885	ft/ft
Critical Slope	0.02311	ft/ft

Worksheet for Channel Section 2 (80 cfs - 0.104% Slope)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01040	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	80.00	ft^3/s

Results

Normal Depth	1.35	ft
Flow Area	17.97	ft^2
Wetted Perimeter	17.24	ft
Top Width	16.73	ft
Critical Depth	1.14	ft
Critical Slope	0.01896	ft/ft
Velocity	4.45	ft/s
Velocity Head	0.31	ft
Specific Energy	1.65	ft
Froude Number	0.76	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.35	ft
Critical Depth	1.14	ft
Channel Slope	0.01040	ft/ft
Critical Slope	0.01896	ft/ft

Worksheet for Channel Section 3 (140 cfs - 0.5% Slope)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00500	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	140.00	ft³/s

Results

Normal Depth	2.22	ft
Flow Area	34.50	ft²
Wetted Perimeter	21.95	ft
Top Width	21.10	ft
Critical Depth	1.59	ft
Critical Slope	0.01739	ft/ft
Velocity	4.06	ft/s
Velocity Head	0.26	ft
Specific Energy	2.48	ft
Froude Number	0.56	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.22	ft
Critical Depth	1.59	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01739	ft/ft

Worksheet for Channel Section 4 (140 cfs - 1.0% Slope)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	150.00	ft^3/s

Results

Normal Depth	1.91	ft
Flow Area	28.32	ft^2
Wetted Perimeter	20.31	ft
Top Width	19.57	ft
Critical Depth	1.65	ft
Critical Slope	0.01721	ft/ft
Velocity	5.30	ft/s
Velocity Head	0.44	ft
Specific Energy	2.35	ft
Froude Number	0.78	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.91	ft
Critical Depth	1.65	ft
Channel Slope	0.01000	ft/ft
Critical Slope	0.01721	ft/ft

Worksheet for Channel Section 5 (80 cfs - 1.0% Slope)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	80.00	ft^3/s

Results

Normal Depth	1.36	ft
Flow Area	18.22	ft^2
Wetted Perimeter	17.32	ft
Top Width	16.80	ft
Critical Depth	1.14	ft
Critical Slope	0.01896	ft/ft
Velocity	4.39	ft/s
Velocity Head	0.30	ft
Specific Energy	1.66	ft
Froude Number	0.74	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.36	ft
Critical Depth	1.14	ft
Channel Slope	0.01000	ft/ft
Critical Slope	0.01896	ft/ft

Worksheet for DROP STRUCTURE Channel Sec-6 (80 cfs-5:1)

Project Description

Friction Method	Manning Formula	
Solve For	Normal Depth	

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.20000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	80.00	ft³/s

Results

Normal Depth	0.58	ft
Flow Area	6.64	ft²
Wetted Perimeter	13.12	ft
Top Width	12.90	ft
Critical Depth	1.14	ft
Critical Slope	0.01896	ft/ft
Velocity	12.05	ft/s
Velocity Head	2.26	ft
Specific Energy	2.84	ft
Froude Number	2.96	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.58	ft
Critical Depth	1.14	ft
Channel Slope	0.20000	ft/ft
Critical Slope	0.01896	ft/ft

Worksheet for Channel Section 6 (80 cfs - 1.0% Slope)

Project Description

Friction Method	Manning Formula	
Solve For	Normal Depth	

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	80.00	ft³/s

Results

Normal Depth	1.36	ft
Flow Area	18.22	ft²
Wetted Perimeter	17.32	ft
Top Width	16.80	ft
Critical Depth	1.14	ft
Critical Slope	0.01896	ft/ft
Velocity	4.39	ft/s
Velocity Head	0.30	ft
Specific Energy	1.66	ft
Froude Number	0.74	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.36	ft
Critical Depth	1.14	ft
Channel Slope	0.01000	ft/ft
Critical Slope	0.01896	ft/ft

Worksheet for Channel Section 7 (25 cfs - 0.5% Slope)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00500	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	25.00	ft³/s

Results

Normal Depth		0.86	ft
Flow Area		10.43	ft²
Wetted Perimeter		14.62	ft
Top Width		14.29	ft
Critical Depth		0.55	ft
Critical Slope		0.02311	ft/ft
Velocity		2.40	ft/s
Velocity Head		0.09	ft
Specific Energy		0.95	ft
Froude Number		0.49	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.86	ft
Critical Depth	0.55	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.02311	ft/ft

OFF-SITE CHANNEL

RIP-RAP SIZING CALCULATIONS

Cholla Ash Monofill
Riprap Size Comparison
Offsite Channel Drop Structures

Cholla Ash Monofill Drainage Channel Riprap Rock Size (feet)												
	Method											
Offsite Channel	USACE (D30)	ASCE	USBR	USGS	ISBASH	HEC-11	Maricopa Cty		Min	Max	Chosen Rock Size (D50)	Layer Thickness (ft)
Section 1 (bank)	0.04	0.06	0.11	0.13	0.11	0.02	0.04		0.02	0.13	0.33	1.00
Section 1 (bottom)	0.04	0.06	0.11	0.13	0.11	0.02			0.02	0.13	0.33	1.00
Section 2 (bank)	0.10	0.14	0.26	0.38	0.25	0.05	0.10		0.05	0.38	0.33	1.00
Section 2 (bottom)	0.10	0.14	0.26	0.38	0.25	0.05			0.05	0.38	0.33	1.00
Section 3 (bank)	0.06	0.10	0.20	0.27	0.19	0.03	0.06		0.03	0.27	0.33	1.00
Section 3 (bottom)	0.06	0.10	0.20	0.27	0.19	0.03			0.03	0.27	0.33	1.00
Section 4 (bank)	0.14	0.20	0.38	0.59	0.36	0.09	0.14		0.09	0.59	0.50	1.00
Section 4 (bottom)	0.14	0.20	0.38	0.59	0.36	0.09			0.09	0.59	0.50	1.00
Section 5 (bank)	0.09	0.14	0.26	0.37	0.25	0.05	0.10		0.05	0.37	0.33	1.00
Section 5 (bottom)	0.09	0.04	0.26	0.37	0.25	0.05			0.04	0.37	0.33	1.00
Section 6 (bank)	0.09	0.14	0.26	0.37	0.25	0.05	0.10		0.05	0.37	0.33	1.00
Section 6 (bottom)	0.09	0.04	0.26	0.37	0.25	0.05			0.04	0.37	0.33	1.00
Section 7 (bank)	0.02	0.04	0.07	0.08	0.07	0.01	0.02		0.01	0.08	0.33	1.00
Section 7 (bottom)	0.02	0.04	0.07	0.08	0.07	0.01			0.01	0.08	0.33	1.00
Drop Struc Sec-6-5:1 (bnk)	1.42	1.03	2.06	4.34	1.86	1.03	3.07		1.03	4.34	1.00*	2.00
Drop Struc Sec-6-5:1 (btm)	1.42	0.95	2.06	4.34	1.86	0.77			0.77	4.34	1.00*	2.00
Drop Struc Sec-1-basin (bnk)	0.60	0.45	0.88	1.58	0.81	0.30	1.33		0.30	1.58	1.00*	2.00
Drop Struc Sec-1-basin (btm)	0.60	0.42	0.88	1.58	0.81	0.22			0.22	1.58	1.00*	2.00
*NOTE: All drop structures and basins will consist of grouted riprap.												

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2/12/2009

Cholla Ash Monofill
Riprap Calculation

By:________________
Checked:________________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash Offsite Channel section 1 Drop Structure
Design Flood Freque 100 -yr
Location/Station: 1+50 to 7+50

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a =	7.96	ft/s	
d_{avg} =	0.29	ft	
D_{50} =	16	inch	Assume a D_{50} and then calculate if it is stable.
θ =	21.80	degree	[2.5:1 (H:V)]
ϕ =	41.0	degree	From Figure 6.14 of the Manual for rounded riprap - attached.

Hence.

K_1 =	0.82		
d_{50} =	1.25	ft	
d_{50} (inch) =	16	inch	<----D50 = 16 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 16 inch

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Date:________________

Cholla Ash Monofill
Riprap Calculation

By:______________
Checked:______________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash Offsite Channel section 1
Design Flood Freque 100 -yr
Location/Station: 1+50 to 7+50

Relevant Equations

$$\boxed{d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}}$$

$$\boxed{K_1 = \left[1 - \frac{\sin^2 \theta}{\sin^2 \phi}\right]^{0.5}}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 2.90 ft/s
d_{avg} = 0.73 ft
D_{50} = 6 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 0.04 ft
d_{50} (inch) = 1 inch <----D50 = 6 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 6 inch

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Date:____________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash Offsite Channel section 2
Design Flood Freque 100 -yr
Location/Station: 8+00 to 11+00

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2 \theta}{\sin^2 \phi}\right]^{0.5}$$

Where,

d_{50} =	Median diameter of the riprap materials, ft
V_a =	Average velocity in the main channel, ft/s
d_{avg} =	Average depth of flow in the main channel, ft
K_1 =	Bank angle correction factor
θ =	Bank angle with the horizontal, degree
ϕ =	Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a =	4.45	ft/s	
d_{avg} =	1.35	ft	
D_{50} =	6	inch	Assume a D_{50} and then calculate if it is stable.
θ =	21.80	degree	[2.5:1 (H:V)]
ϕ =	41.0	degree	From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 =	0.82		
d_{50} =	0.10	ft	
d_{50} (inch) =	2	inch	<----D50 = 6 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 6 inch

By:____________
Checked:____________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash Offsite Channel section 3
Design Flood Freque 100 -yr
Location/Station: 11+50 to 13+75

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2 \theta}{\sin^2 \phi}\right]^{0.5}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 3.85 ft/s
d_{avg} = 1.85 ft
D_{50} = 6 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 0.06 ft
d_{50} (inch) = 1 inch <----D50 = 6 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 6 inch

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash Offsite Channel section 4
Design Flood Freque 100 -yr
Location/Station: 13+75 to 23+50

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 5.30 ft/s
d_{avg} = 1.91 ft
D_{50} = 6 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 0.14 ft
d_{50} (inch) = 2 inch <----D50 = 6 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 6 inch

By:________________
Checked:________________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash Offsite Channel section 5
Design Flood Freque 100 -yr
Location/Station: 23+50 to 32+50

Relevant Equations

$$\boxed{d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}}$$

$$\boxed{K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a =	4.39	ft/s	
d_{avg} =	1.36	ft	
D_{50} =	6	inch	Assume a D_{50} and then calculate if it is stable.
θ =	21.80	degree	[2.5:1 (H:V)]
ϕ =	41.0	degree	From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 =	0.82		
d_{50} =	0.10	ft	
d_{50} (inch) =	2	inch	<----D50 = 6 inches is stable.

Therefore, proposed design riprap size (d_{50}) = **6 inch**

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Date:________________

By:________________
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Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash Offsite Channel section 6
Design Flood Freque 100 -yr
Location/Station: 33+00 to 35+00

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 4.39 ft/s
d_{avg} = 1.36 ft
D_{50} = 6 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 0.10 ft
d_{50} (inch) = 2 inch <----D50 = 6 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 6 inch

Page ________
Date:________________

Cholla Ash Monofill
Riprap Calculation

By:________________
Checked:________________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash Offsite Drop Structure section 6
Design Flood Freque 100 -yr
Location/Station: 32+50 to 33+00

Relevant Equations

$$\boxed{d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}}$$

$$\boxed{K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\phi}\right]^{0.5}}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 12.05 ft/s
d_{avg} = 0.58 ft
D_{50} = 37 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 3.07 ft
d_{50} (inch) = 37 inch <----D50 = 37 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 37 inch

Page ________
Date:________________

Calculation of Riprap Size for Channel Lining

Calculations are based on Drainage Design Manual for Maricopa County (Manual)

Channel Name: Cholla Ash Offsite Channel section 7
Design Flood Freque 100 -yr
Location/Station: 35+00 to 38+50

Relevant Equations

$$d_{50} = \frac{0.001 V_a^3}{d_{avg}^{0.5} K_1^{1.5}}$$

$$K_1 = \left[1 - \frac{\sin^2 \theta}{\sin^2 \phi}\right]^{0.5}$$

Where,

d_{50} = Median diameter of the riprap materials, ft
V_a = Average velocity in the main channel, ft/s
d_{avg} = Average depth of flow in the main channel, ft
K_1 = Bank angle correction factor
θ = Bank angle with the horizontal, degree
ϕ = Riprap material's angle of repose, degree

Input Parameters

(Based on output from FlowMaster and based on the Manual)

V_a = 2.40 ft/s
d_{avg} = 0.86 ft
D_{50} = 6 inch Assume a D_{50} and then calculate if it is stable.
θ = 21.80 degree [2.5:1 (H:V)]
ϕ = 41.0 degree From Figure 6.14 of the Manual for rounded riprap - attached.

Hence,

K_1 = 0.82
d_{50} = 0.02 ft
d_{50} (inch) = 1 inch <----D50 = 6 inches is stable.

Therefore, proposed design riprap size (d_{50}) = 6 inch

```
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                  WEST Consultants, Inc.                  *
*                                                          *
*                                                          *
* Version 3.0                                 March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - Section 1 Drop

______________________ USACE Method ______________________

Input Parameters:
-----------------
Velocity Type                                      Average
Channel Shape                                  Trapezoidal
Channel Type                                      Straight
Bend Angle (deg)                                       N/A
Average Channel Velocity                         7.96 ft/s
Bottom Width                                           N/A
Bend Radius                                            N/A
Top Width                                              N/A
Unit Weight of Stone                       165. lbs/cu ft
Riprap Layer Thickness                                1.00
Local Flow Depth                                   0.29 ft
Cotangent of Side Slope                               2.50
Safety Factor                                          1.1
Riprap Placement                              Channel Bank
Rock Type                                          Angular


Output Results:
---------------

Computed D30                                       0.60 ft
Computed Local Depth Averaged Velocity           7.96 ft/s
Local Velocity/Avg. Velocity                          1.00
Side Slope Correction Factor                          1.06
Correction for Layer Thickness                        1.00
Correction for Secondary Currents                     1.00

  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness          1.250 ft
Selected Minimum D30      0.61 ft
Selected Minimum D90      0.88 ft


                                    Stone Weight, lbs
Percent Lighter by Weight        Minimum          Maximum
__________________________________________________________
W100                                67.              169.
 W50                                34.               50.
```

```
 W15                                       11.               25.

__________________________ ASCE Method __________________________


Input Parameters:
-----------------

Local Velocity                                           7.96 ft/s
Cotangent of Side slope                                       2.50
Unit Weight of Stone                                165. lbs/cu ft
Riprap Placement                                      Channel Bank


Output Results:
---------------

Computed D50                                               0.45 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight           Minimum              Maximum
_________________________________________________________________
W100                                     15.                 36.
 W50                                      7.                 11.
 W15                                      2.                  5.

__________________________ USBR Method __________________________


Input Parameters:
-----------------

Average Channel Velocity                                 7.96 ft/s


Output Results:
---------------

Computed D50                                               0.88 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           1.500 ft
Selected Minimum D30       0.73 ft
Selected Minimum D90       1.06 ft


                                        Stone Weight, lbs
Percent Lighter by Weight           Minimum              Maximum
_________________________________________________________________
W100                                    117.                292.
 W50                                     58.                 86.
 W15                                     18.                 43.
```

```
                        Drop Structure Offsite Sec-1-basin(0.2%slope)
_______________________ USGS Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                                  7.96 ft/s


Output Results:
---------------

Computed D50                                              1.58 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           2.750 ft
Selected Minimum D30       1.34 ft
Selected Minimum D90       1.94 ft


                                           Stone Weight, lbs
Percent Lighter by Weight             Minimum             Maximum
__________________________________________________________________
W100                                     719.               1797.
 W50                                     359.                532.
 W15                                     112.                266.

______________________ Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                                  7.96 ft/s
Unit Weight of Stone                                 165. lbs/cu ft
Turbulence Level                                               High


Output Results:
---------------

Computed D50                                              0.81 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           1.500 ft
Selected Minimum D30       0.73 ft
Selected Minimum D90       1.06 ft


                                           Stone Weight, lbs
Percent Lighter by Weight             Minimum             Maximum
__________________________________________________________________
W100                                     117.                292.
 W50                                      58.                 86.
 W15                                      18.                 43.

____________________ Cal B & SP Method ____________________


Input Parameters:
```

```
                 Drop Structure Offsite Sec-1-basin(0.2%slope)
-----------------

Average Channel Velocity                           7.96 ft/s
Velocity Affecting Bank                           10.61 ft/s
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side slope                                 2.50
Flow Type                                          Impinging


Output Results:
---------------

Computed W                                         40.71 lbs


                 ** CalTrans A Gradation **

(1) Outside Layer:


Gradation Class                                      1/2 Ton
Layer Thickness                                      3.40 ft

Percent Larger than                          Rock Size (Ton)
____________________________________________________________

0 - 5                                                   1.00
50 - 100                                                0.50
95 - 100                                                0.25


(2) Inner Layer:


Gradation Class                                         None
Layer Thickness                                      0.00 ft


(3) Backing:


Backing Class No.                                          1
Layer Thickness                                       1.8 ft


(4) Fabric:


Fabric Type                                                B


Total Thickness (1)+(2)+(3)+(4):                      5.2 ft


______________________ HEC-11 Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                           7.96 ft/s
Average Flow Depth                                   4.00 ft
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side Slope                                 2.50
Material Angle of Repose                          41.00 deg.
```

```
                 Drop Structure Offsite Sec-1-basin(0.2%slope)
Riprap Placement                                Channel Bank
Safety Factor                                            1.1


Output Results:
---------------

Computed D50                                         0.30 ft

                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
____________________________________________________________
D100                                 1.30               200.
 D50                                 0.95                75.
 D10                                 0.40                 5.
```

```
                Drop Structure Offsite Sec-1-basin_btm(0.2%slope)
Date: 02/12/2009 Time: 10:02
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                  WEST Consultants, Inc.                  *
*                                                          *
*                                                          *
* Version 3.0                                  March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE                PH: 858-487-9378 *
* SUITE 340                                FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - Section 1 DROP btm


______________________  USACE Method  ______________________


Input Parameters:
-----------------
Velocity Type                                     Average
Channel Shape                                 Trapezoidal
Channel Type                                     Straight
Bend Angle (deg)                                      N/A
Average Channel Velocity                        7.96 ft/s
Bottom Width                                          N/A
Bend Radius                                           N/A
Top Width                                             N/A
Unit Weight of Stone                      165. lbs/cu ft
Riprap Layer Thickness                               1.00
Local Flow Depth                                  0.29 ft
Cotangent of Side Slope                               N/A
Safety Factor                                         1.1
Riprap Placement                           Channel Bottom
Rock Type                                         Angular


Output Results:
---------------

Computed D30                                      0.60 ft
Computed Local Depth Averaged Velocity          7.96 ft/s
Local Velocity/Avg. Velocity                         1.00
Side Slope Correction Factor                         1.06
Correction for Layer Thickness                       1.00
Correction for Secondary Currents                    1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         1.250 ft
Selected Minimum D30     0.61 ft
Selected Minimum D90     0.88 ft


                                    Stone Weight, lbs
Percent Lighter by Weight        Minimum           Maximum
-----------------------------------------------------------
W100                               67.              169.
 W50                               34.               50.
```

```
                Drop Structure Offsite Sec-1-basin_btm(0.2%slope)
 W15                                       11.                 25.

 _______________________ ASCE Method ________________________

 Input Parameters:
 -----------------

 Local Velocity                                          7.96 ft/s
 Cotangent of Side slope                                       N/A
 Unit Weight of Stone                                165. lbs/cu ft
 Riprap Placement                                    Channel Bottom

 Output Results:
 ---------------

 Computed D50                                              0.42 ft

   *** Using Gradations from COE ETL 1110-2-120 ***

 Specific Weight      165.0 lbs/cu ft
 Layer Thickness             0.750 ft
 Selected Minimum D30         0.37 ft
 Selected Minimum D90         0.53 ft

                                           Stone Weight, lbs
 Percent Lighter by Weight              Minimum           Maximum
 ________________________________________________________________
 W100                                       15.                36.
  W50                                        7.                11.
  W15                                        2.                 5.

 _______________________ USBR Method ________________________

 Input Parameters:
 -----------------

 Average Channel Velocity                                7.96 ft/s

 Output Results:
 ---------------

 Computed D50                                              0.88 ft

   *** Using Gradations from COE ETL 1110-2-120 ***

 Specific Weight      165.0 lbs/cu ft
 Layer Thickness             1.500 ft
 Selected Minimum D30         0.73 ft
 Selected Minimum D90         1.06 ft

                                           Stone Weight, lbs
 Percent Lighter by Weight              Minimum           Maximum
 ________________________________________________________________
 W100                                      117.               292.
  W50                                       58.                86.
  W15                                       18.                43.
```

```
                 Drop Structure Offsite Sec-1-basin_btm(0.2%slope)
_______________________ USGS Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                            7.96 ft/s


Output Results:
---------------

Computed D50                                        1.58 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness          2.750 ft
Selected Minimum D30      1.34 ft
Selected Minimum D90      1.94 ft


                                          Stone Weight, lbs
Percent Lighter by Weight              Minimum            Maximum
_____________________________________________________________
W100                                      719.              1797.
 W50                                      359.               532.
 W15                                      112.               266.


______________________ Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                            7.96 ft/s
Unit Weight of Stone                            165. lbs/cu ft
Turbulence Level                                         High


Output Results:
---------------

Computed D50                                        0.81 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness          1.500 ft
Selected Minimum D30      0.73 ft
Selected Minimum D90      1.06 ft


                                          Stone Weight, lbs
Percent Lighter by Weight              Minimum            Maximum
_____________________________________________________________
W100                                      117.               292.
 W50                                       58.                86.
 W15                                       18.                43.

____________________ Cal B & SP Method ____________________


Input Parameters:
```

```
               Drop Structure Offsite Sec-1-basin_btm(0.2%slope)
-----------------

Average Channel Velocity                              7.96 ft/s
Velocity Affecting Bank                              10.61 ft/s
Unit Weight of Stone                             165. lbs/cu ft
Cotangent of Side slope                                    2.50
Flow Type                                             Impinging


Output Results:
---------------

Computed W                                            40.71 lbs


                 ** CalTrans A Gradation **


(1) Outside Layer:


Gradation Class                                         1/2 Ton
Layer Thickness                                         3.40 ft

Percent Larger than                              Rock Size (Ton)
________________________________________________________________

0 - 5                                                      1.00
50 - 100                                                   0.50
95 - 100                                                   0.25


(2) Inner Layer:


Gradation Class                                            None
Layer Thickness                                         0.00 ft


(3) Backing:


Backing Class No.                                             1
Layer Thickness                                          1.8 ft


(4) Fabric:


Fabric Type                                                   B


Total Thickness (1)+(2)+(3)+(4):                         5.2 ft


_______________________  HEC-11 Method  ________________________


Input Parameters:
-----------------

Average Channel Velocity                              7.96 ft/s
Average Flow Depth                                      4.00 ft
Unit Weight of Stone                             165. lbs/cu ft
Cotangent of Side Slope                                     N/A
Material Angle of Repose                                   deg.
```

```
               Drop Structure Offsite Sec-1-basin_btm(0.2%slope)
Riprap Placement                              Channel Bottom
Safety Factor                                            1.1


Output Results:
---------------

Computed D50                                         0.22 ft


                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
------------------------------------------------------------
D100                                   1.30             200.
 D50                                   0.95              75.
 D10                                   0.40               5.
```

```
                                Offsite Channel Sec-1
Date: 02/06/2009 Time: 16:25
************************************************************
*                 RIPRAP DESIGN SYSTEM (RDS)               *
*                            BY                            *
*                  WEST Consultants, Inc.                  *
*                                                          *
*                                                          *
* Version 3.0                                 March, 2005  *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE                PH: 858-487-9378 *
* SUITE 340                                FAX:858-487-9448 *
* SAN DIEGO, CA 92127        WEB:WWW.WESTCONSULTANTS.COM  *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - Section 1


______________________ USACE Method ______________________


Input Parameters:
-----------------
Velocity Type                                      Average
Channel Shape                                  Trapezoidal
Channel Type                                      Straight
Bend Angle (deg)                                       N/A
Average Channel Velocity                       2.90 ft/s
Bottom Width                                           N/A
Bend Radius                                            N/A
Top Width                                              N/A
Unit Weight of Stone                        165. lbs/cu ft
Riprap Layer Thickness                                1.00
Local Flow Depth                                   0.73 ft
Cotangent of Side Slope                               2.50
Safety Factor                                          1.1
Riprap Placement                              Channel Bank
Rock Type                                          Angular


Output Results:
---------------

Computed D30                                       0.04 ft
Computed Local Depth Averaged Velocity           2.90 ft/s
Local Velocity/Avg. Velocity                          1.00
Side Slope Correction Factor                          1.06
Correction for Layer Thickness                        1.00
Correction for Secondary Currents                     1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                     Stone Weight, lbs
Percent Lighter by Weight        Minimum            Maximum
____________________________________________________________
W100                                 15.                36.
 W50                                  7.                11.
```

```
 W15                                     2.                     5.

___________________________ ASCE Method __________________________


Input Parameters:
-----------------

Local Velocity                                          2.90 ft/s
Cotangent of Side slope                                     2.50
Unit Weight of Stone                                165. lbs/cu ft
Riprap Placement                                      Channel Bank


Output Results:
---------------

Computed D50                                             0.06 ft

  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         0.750 ft
Selected Minimum D30     0.37 ft
Selected Minimum D90     0.53 ft


                                             Stone Weight, lbs
Percent Lighter by Weight               Minimum             Maximum
____________________________________________________________________
W100                                       15.                  36.
 W50                                        7.                  11.
 W15                                        2.                   5.

___________________________ USBR Method ___________________________

Input Parameters:
-----------------

Average Channel Velocity                                2.90 ft/s


Output Results:
---------------

Computed D50                                             0.11 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         0.750 ft
Selected Minimum D30     0.37 ft
Selected Minimum D90     0.53 ft


                                             Stone Weight, lbs
Percent Lighter by Weight               Minimum             Maximum
____________________________________________________________________
W100                                       15.                  36.
 W50                                        7.                  11.
 W15                                        2.                   5.
```

```
                       Offsite Channel Sec-1
________________________ USGS Method _________________________


Input Parameters:
-----------------

Average Channel Velocity                              2.90 ft/s


Output Results:
---------------

Computed D50                                          0.13 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                     Stone Weight, lbs
Percent Lighter by Weight        Minimum            Maximum
_____________________________________________________________
W100                                 15.                36.
 W50                                  7.                11.
 W15                                  2.                 5.

______________________  Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                              2.90 ft/s
Unit Weight of Stone                             165. lbs/cu ft
Turbulence Level                                           High


Output Results:
---------------

Computed D50                                          0.11 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                     Stone Weight, lbs
Percent Lighter by Weight        Minimum            Maximum
_____________________________________________________________
W100                                 15.                36.
 W50                                  7.                11.
 W15                                  2.                 5.

____________________  Cal B & SP Method ____________________


Input Parameters:
```

```
-----------------

Average Channel Velocity                          2.90 ft/s
Velocity Affecting Bank                           3.87 ft/s
Unit Weight of Stone                        165. lbs/cu ft
Cotangent of Side slope                               2.50
Flow Type                                        Impinging


Output Results:
---------------

Computed W                                        0.10 lbs


                 ** CalTrans A Gradation **

(1) Outside Layer:


Gradation Class                                    1/2 Ton
Layer Thickness                                    3.40 ft

Percent Larger than                        Rock Size (Ton)
____________________________________________________________

0 - 5                                                 1.00
50 - 100                                              0.50
95 - 100                                              0.25

(2) Inner Layer:

Gradation Class                                       None
Layer Thickness                                    0.00 ft

(3) Backing:

Backing Class No.                                        1
Layer Thickness                                     1.8 ft

(4) Fabric:

Fabric Type                                              B

Total Thickness (1)+(2)+(3)+(4):                    5.2 ft

______________________ HEC-11 Method ______________________

Input Parameters:
-----------------

Average Channel Velocity                         2.90 ft/s
Average Flow Depth                                 3.00 ft
Unit Weight of Stone                       165. lbs/cu ft
Cotangent of Side Slope                              2.50
Material Angle of Repose                       41.00 deg.
```

```
                             Offsite Channel Sec-1
Riprap Placement                                Channel Bank
Safety Factor                                            1.1


Output Results:
---------------

Computed D50                                         0.02 ft

                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
------------------------------------------------------------
D100                                1.30                200.
 D50                                0.95                 75.
 D10                                0.40                  5.
```

```
Date: 02/08/2009 Time: 12:42
************************************************************
*              RIPRAP DESIGN SYSTEM (RDS)                  *
*                         BY                               *
*               WEST Consultants, Inc.                     *
*                                                          *
*                                                          *
* Version 3.0                                March, 2005   *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE                PH: 858-487-9378 *
* SUITE 340                                FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - 10 ft bottom width
```

Sect. 1 - btm

```
______________________      USACE Method ______________________


Input Parameters:
-----------------
Velocity Type                                      Average
Channel Shape                                  Trapezoidal
Channel Type                                      Straight
Bend Angle (deg)                                       N/A
Average Channel Velocity                         2.90 ft/s
Bottom width                                           N/A
Bend Radius                                            N/A
Top Width                                              N/A
Unit Weight of Stone                       165. lbs/cu ft
Riprap Layer Thickness                                1.00
Local Flow Depth                                   0.73 ft
Cotangent of Side Slope                               2.50
Safety Factor                                          1.1
Riprap Placement                              Channel Bank
Rock Type                                          Angular


Output Results:
---------------

Computed D30                                       0.04 ft
Computed Local Depth Averaged Velocity            2.90 ft/s
Local Velocity/Avg. Velocity                          1.00
Side Slope Correction Factor                          1.06
Correction for Layer Thickness                        1.00
Correction for Secondary Currents                     1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft
```

```
                                         Stone Weight, lbs
Percent Lighter by Weight           Minimum               Maximum
__________________________________________________________________
W100                                    15.                   36.
 W50                                     7.                   11.
 W15                                     2.                    5.

_______________________  ASCE Method  ____________________________

Input Parameters:
-----------------

Local Velocity                                         2.90 ft/s
Cotangent of Side slope                                     2.50
Unit Weight of Stone                              165. lbs/cu ft
Riprap Placement                                    Channel Bank

Output Results:
---------------

Computed D50                                             0.06 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft

                                         Stone Weight, lbs
Percent Lighter by Weight           Minimum               Maximum
__________________________________________________________________
W100                                    15.                   36.
 W50                                     7.                   11.
 W15                                     2.                    5.

_______________________  USBR Method  ____________________________

Input Parameters:
-----------------

Average Channel Velocity                               2.90 ft/s

Output Results:
---------------

Computed D50                                             0.11 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
```

```
Selected Minimum D30         0.37 ft
Selected Minimum D90         0.53 ft


                                         Stone Weight, lbs
Percent Lighter by Weight            Minimum            Maximum
_____________________________________________________________
W100                                     15.                36.
 W50                                      7.                11.
 W15                                      2.                 5.

________________________ USGS Method _________________________

Input Parameters:
-----------------

Average Channel Velocity                             2.90 ft/s


Output Results:
---------------

Computed D50                                         0.13 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness             0.750 ft
Selected Minimum D30         0.37 ft
Selected Minimum D90         0.53 ft


                                         Stone Weight, lbs
Percent Lighter by Weight            Minimum            Maximum
_____________________________________________________________
W100                                     15.                36.
 W50                                      7.                11.
 W15                                      2.                 5.

_______________________ Isbash Method ________________________

Input Parameters:
-----------------

Average Channel Velocity                             2.90 ft/s
Unit Weight of Stone                         165. lbs/cu ft
Turbulence Level                                          High


Output Results:
---------------

Computed D50                                         0.11 ft


  *** Using Gradations from COE ETL 1110-2-120 ***
```

```
Specific Weight      165.0 lbs/cu ft
Layer Thickness          0.750 ft
Selected Minimum D30      0.37 ft
Selected Minimum D90      0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight          Minimum              Maximum
_____________________________________________________________
W100                                   15.                  36.
 W50                                    7.                  11.
 W15                                    2.                   5.

____________________ Cal B & SP Method ____________________


Input Parameters:
-----------------

Average Channel Velocity                              2.90 ft/s
Velocity Affecting Bank                               3.87 ft/s
Unit Weight of Stone                           165. lbs/cu ft
Cotangent of Side slope                               2.50
Flow Type                                         Impinging


Output Results:
---------------

Computed W                                             0.10 lbs


                ** CalTrans A Gradation **


(1) Outside Layer:


Gradation Class                                       1/2 Ton
Layer Thickness                                       3.40 ft


Percent Larger than                           Rock Size (Ton)
_____________________________________________________________

0 - 5                                                   1.00
50 - 100                                                0.50
95 - 100                                                0.25


(2) Inner Layer:


Gradation Class                                         None
Layer Thickness                                      0.00 ft


(3) Backing:


Backing Class No.                                          1
```

```
Layer Thickness                                      1.8 ft


(4) Fabric:


Fabric Type                                            B


Total Thickness (1)+(2)+(3)+(4):                     5.2 ft


______________________ HEC-11 Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                          2.90 ft/s
Average Flow Depth                                3.00 ft
Unit Weight of Stone                        165. lbs/cu ft
Cotangent of Side Slope                              2.50
Material Angle of Repose                         41.00 deg.
Riprap Placement                             Channel Bank
Safety Factor                                         1.1

Output Results:
---------------

Computed D50                                       0.02 ft

                        ** FHWA Gradation**


Gradation Class             Facing
Layer Thickness             1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
____________________________________________________________
D100                              1.30                  200.
 D50                              0.95                   75.
 D10                              0.40                    5.
```

```
Date: 02/06/2009 Time: 16:26
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                   WEST Consultants, Inc.                 *
*                                                          *
*                                                          *
* Version 3.0                                  March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - Section 2

______________________ USACE Method ______________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                           4.45 ft/s
Bottom width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                         165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     1.35 ft
Cotangent of Side Slope                                 2.50
Safety Factor                                            1.1
Riprap Placement                                Channel Bank
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         0.10 ft
Computed Local Depth Averaged Velocity             4.45 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight         Minimum            Maximum
____________________________________________________________
W100                                  15.                36.
 W50                                   7.                11.
```

```
 W15                                               2.                  5.

_______________________  ASCE Method  _______________________

Input Parameters:
-----------------

Local Velocity                                                4.45 ft/s
Cotangent of Side slope                                            2.50
Unit Weight of Stone                                    165. lbs/cu ft
Riprap Placement                                          Channel Bank

Output Results:
---------------

Computed D50                                                    0.14 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft

                                           Stone Weight, lbs
Percent Lighter by Weight             Minimum             Maximum
_____________________________________________________________
W100                                            15.                 36.
 W50                                             7.                 11.
 W15                                             2.                  5.

_______________________  USBR Method  ________________________

Input Parameters:
-----------------

Average Channel Velocity                                      4.45 ft/s

Output Results:
---------------

Computed D50                                                    0.26 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft

                                           Stone Weight, lbs
Percent Lighter by Weight             Minimum             Maximum
_____________________________________________________________
W100                                            15.                 36.
 W50                                             7.                 11.
 W15                                             2.                  5.
```

```
                           Offsite Channel Sec-2
_______________________  USGS Method  _______________________


Input Parameters:
-----------------

Average Channel Velocity                              4.45 ft/s


Output Results:
---------------

Computed D50                                          0.38 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                     Stone Weight, lbs
Percent Lighter by Weight          Minimum            Maximum
_____________________________________________________________
W100                                   15.                36.
 W50                                    7.                11.
 W15                                    2.                 5.

______________________  Isbash Method  ______________________


Input Parameters:
-----------------

Average Channel Velocity                              4.45 ft/s
Unit Weight of Stone                             165. lbs/cu ft
Turbulence Level                                           High


Output Results:
---------------

Computed D50                                          0.25 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                     Stone Weight, lbs
Percent Lighter by Weight          Minimum            Maximum
_____________________________________________________________
W100                                   15.                36.
 W50                                    7.                11.
 W15                                    2.                 5.

____________________  Cal B & SP Method  ____________________


Input Parameters:
```

```
                         Offsite Channel Sec-2
-----------------

Average Channel Velocity                               4.45 ft/s
Velocity Affecting Bank                                5.93 ft/s
Unit Weight of Stone                              165. lbs/cu ft
Cotangent of Side slope                                     2.50
Flow Type                                              Impinging


Output Results:
---------------

Computed W                                              1.24 lbs


               ** CalTrans A Gradation **

(1) Outside Layer:

Gradation Class                                         1/2 Ton
Layer Thickness                                         3.40 ft

Percent Larger than                              Rock Size (Ton)
________________________________________________________________

0 - 5                                                      1.00
50 - 100                                                   0.50
95 - 100                                                   0.25

(2) Inner Layer:

Gradation Class                                            None
Layer Thickness                                         0.00 ft

(3) Backing:

Backing Class No.                                             1
Layer Thickness                                          1.8 ft

(4) Fabric:

Fabric Type                                                   B

Total Thickness (1)+(2)+(3)+(4):                         5.2 ft

_______________________ HEC-11 Method _______________________

Input Parameters:
-----------------

Average Channel Velocity                               4.45 ft/s
Average Flow Depth                                      4.00 ft
Unit Weight of Stone                              165. lbs/cu ft
Cotangent of Side Slope                                     2.50
Material Angle of Repose                              41.00 deg.
```

```
                          Offsite Channel Sec-2
Riprap Placement                                    Channel Bank
Safety Factor                                                1.1


Output Results:
---------------

Computed D50                                             0.05 ft


                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft      Rock Weight, lbs
--------------------------------------------------------------
D100                               1.30                  200.
 D50                               0.95                   75.
 D10                               0.40                    5.
```

```
                               Offsite Channel Sec-2_btm
Date: 02/06/2009 Time: 17:01
************************************************************
*                 RIPRAP DESIGN SYSTEM (RDS)               *
*                            BY                            *
*                   WEST Consultants, Inc.                 *
*                                                          *
*                                                          *
* Version 3.0                                March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE                PH: 858-487-9378 *
* SUITE 340                                FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - Section 2 btm


______________________ USACE Method ______________________


Input Parameters:
-----------------
Velocity Type                                       Average
Channel Shape                                   Trapezoidal
Channel Type                                       Straight
Bend Angle (deg)                                        N/A
Average Channel Velocity                          4.45 ft/s
Bottom width                                            N/A
Bend Radius                                             N/A
Top Width                                               N/A
Unit Weight of Stone                        165. lbs/cu ft
Riprap Layer Thickness                                 1.00
Local Flow Depth                                    1.35 ft
Cotangent of Side Slope                                2.50
Safety Factor                                           1.1
Riprap Placement                               Channel Bank
Rock Type                                           Angular


Output Results:
---------------

Computed D30                                        0.10 ft
Computed Local Depth Averaged Velocity            4.45 ft/s
Local Velocity/Avg. Velocity                           1.00
Side Slope Correction Factor                           1.06
Correction for Layer Thickness                         1.00
Correction for Secondary Currents                      1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                      Stone Weight, lbs
Percent Lighter by Weight          Minimum          Maximum
___________________________________________________________
W100                                  15.              36.
 W50                                   7.              11.
```

```
 W15                                       2.                  5.

 _______________________ ASCE Method _______________________


 Input Parameters:
 -----------------

 Local Velocity                                       4.45 ft/s
 Cotangent of Side slope                                  2.50
 Unit Weight of Stone                            165. lbs/cu ft
 Riprap Placement                                  Channel Bank


 Output Results:
 ---------------

 Computed D50                                           0.14 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight     165.0 lbs/cu ft
 Layer Thickness            0.750 ft
 Selected Minimum D30        0.37 ft
 Selected Minimum D90        0.53 ft


                                          Stone Weight, lbs
 Percent Lighter by Weight             Minimum            Maximum
 ________________________________________________________________
 W100                                      15.                36.
  W50                                       7.                11.
  W15                                       2.                 5.

 _______________________ USBR Method _______________________


 Input Parameters:
 -----------------

 Average Channel Velocity                             4.45 ft/s


 Output Results:
 ---------------

 Computed D50                                           0.26 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight     165.0 lbs/cu ft
 Layer Thickness            0.750 ft
 Selected Minimum D30        0.37 ft
 Selected Minimum D90        0.53 ft


                                          Stone Weight, lbs
 Percent Lighter by Weight             Minimum            Maximum
 ________________________________________________________________
 W100                                      15.                36.
  W50                                       7.                11.
  W15                                       2.                 5.
```

```
                       Offsite Channel Sec-2_btm
_______________________ USGS Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                             4.45 ft/s


Output Results:
---------------

Computed D50                                         0.38 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight            Minimum           Maximum
______________________________________________________________
W100                                     15.               36.
 W50                                      7.               11.
 W15                                      2.                5.

______________________ Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                             4.45 ft/s
Unit Weight of Stone                            165. lbs/cu ft
Turbulence Level                                          High


Output Results:
---------------

Computed D50                                         0.25 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight            Minimum           Maximum
______________________________________________________________
W100                                     15.               36.
 W50                                      7.               11.
 W15                                      2.                5.

____________________ Cal B & SP Method ____________________


Input Parameters:
```

```
                         Offsite Channel Sec-2_btm
-----------------

Average Channel Velocity                          4.45 ft/s
Velocity Affecting Bank                           5.93 ft/s
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side slope                                 2.50
Flow Type                                          Impinging


Output Results:
---------------

Computed W                                          1.24 lbs


                 ** CalTrans A Gradation **

(1) Outside Layer:

Gradation Class                                      1/2 Ton
Layer Thickness                                      3.40 ft

Percent Larger than                          Rock Size (Ton)
____________________________________________________________

0 - 5                                                   1.00
50 - 100                                                0.50
95 - 100                                                0.25

(2) Inner Layer:

Gradation Class                                         None
Layer Thickness                                      0.00 ft

(3) Backing:

Backing Class No.                                          1
Layer Thickness                                       1.8 ft

(4) Fabric:

Fabric Type                                                B

Total Thickness (1)+(2)+(3)+(4):                      5.2 ft

______________________ HEC-11 Method ______________________

Input Parameters:
-----------------

Average Channel Velocity                           4.45 ft/s
Average Flow Depth                                   4.00 ft
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side Slope                                 2.50
Material Angle of Repose                          41.00 deg.
```

```
                           Offsite Channel Sec-2_btm
Riprap Placement                                Channel Bank
Safety Factor                                            1.1


Output Results:
---------------

Computed D50                                         0.05 ft

                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
____________________________________________________________
D100                               1.30                 200.
 D50                               0.95                  75.
 D10                               0.40                   5.
```

```
                             Offsite Channel Sec-3
Date: 02/06/2009 Time: 16:27
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                   WEST Consultants, Inc.                 *
*                                                          *
*                                                          *
* Version 3.0                                  March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127         WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - Section 3

______________________   USACE Method ______________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                           3.85 ft/s
Bottom width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     1.85 ft
Cotangent of Side Slope                                 2.50
Safety Factor                                            1.1
Riprap Placement                                Channel Bank
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         0.06 ft
Computed Local Depth Averaged Velocity             3.85 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight         Minimum            Maximum
------------------------------------------------------------
W100                                  15.                36.
 W50                                   7.                11.
```

```
 W15                                     2.                  5.

 ______________________  ASCE Method  ______________________

 Input Parameters:
 -----------------

 Local Velocity                                       3.85 ft/s
 Cotangent of Side slope                                   2.50
 Unit Weight of Stone                            165. lbs/cu ft
 Riprap Placement                                  Channel Bank

 Output Results:
 ---------------

 Computed D50                                           0.10 ft

   *** Using Gradations from COE ETL 1110-2-120 ***

 Specific Weight      165.0 lbs/cu ft
 Layer Thickness             0.750 ft
 Selected Minimum D30         0.37 ft
 Selected Minimum D90         0.53 ft

                                      Stone Weight, lbs
 Percent Lighter by Weight          Minimum             Maximum
 ______________________________________________________________
 W100                                  15.                  36.
  W50                                   7.                  11.
  W15                                   2.                   5.

 ______________________  USBR Method  ______________________

 Input Parameters:
 -----------------

 Average Channel Velocity                             3.85 ft/s

 Output Results:
 ---------------

 Computed D50                                           0.20 ft

   *** Using Gradations from COE ETL 1110-2-120 ***

 Specific Weight      165.0 lbs/cu ft
 Layer Thickness             0.750 ft
 Selected Minimum D30         0.37 ft
 Selected Minimum D90         0.53 ft

                                      Stone Weight, lbs
 Percent Lighter by Weight          Minimum             Maximum
 ______________________________________________________________
 W100                                  15.                  36.
  W50                                   7.                  11.
  W15                                   2.                   5.
```

```
                             Offsite Channel Sec-3
_______________________ USGS Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                              3.85 ft/s


Output Results:
---------------

Computed D50                                          0.27 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                            Stone Weight, lbs
Percent Lighter by Weight              Minimum              Maximum
____________________________________________________________________
W100                                         15.                36.
 W50                                          7.                11.
 W15                                          2.                 5.


______________________ Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                              3.85 ft/s
Unit Weight of Stone                             165. lbs/cu ft
Turbulence Level                                           High


Output Results:
---------------

Computed D50                                          0.19 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                            Stone Weight, lbs
Percent Lighter by Weight              Minimum              Maximum
____________________________________________________________________
W100                                         15.                36.
 W50                                          7.                11.
 W15                                          2.                 5.


____________________ Cal B & SP Method ____________________


Input Parameters:
```

```
-----------------

Average Channel Velocity                             3.85 ft/s
Velocity Affecting Bank                              5.13 ft/s
Unit Weight of Stone                           165. lbs/cu ft
Cotangent of Side slope                                  2.50
Flow Type                                            Impinging


Output Results:
---------------

Computed W                                           0.52 lbs


                 ** CalTrans A Gradation **

(1) Outside Layer:

Gradation Class                                       1/2 Ton
Layer Thickness                                       3.40 ft

Percent Larger than                          Rock Size (Ton)
_____________________________________________________________

0 - 5                                                    1.00
50 - 100                                                 0.50
95 - 100                                                 0.25

(2) Inner Layer:

Gradation Class                                          None
Layer Thickness                                       0.00 ft

(3) Backing:

Backing Class No.                                           1
Layer Thickness                                        1.8 ft

(4) Fabric:

Fabric Type                                                 B

Total Thickness (1)+(2)+(3)+(4):                       5.2 ft

______________________ HEC-11 Method ______________________

Input Parameters:
-----------------

Average Channel Velocity                             3.85 ft/s
Average Flow Depth                                    4.00 ft
Unit Weight of Stone                           165. lbs/cu ft
Cotangent of Side Slope                                  2.50
Material Angle of Repose                           41.00 deg.
```

```
                             Offsite Channel Sec-3
Riprap Placement                                Channel Bank
Safety Factor                                            1.1


Output Results:
---------------

Computed D50                                         0.03 ft

                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
------------------------------------------------------------
D100                                1.30                200.
 D50                                0.95                 75.
 D10                                0.40                  5.
```

```
                           Offsite Channel Sec-3_btm
Date: 02/06/2009 Time: 17:00
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                   WEST Consultants, Inc.                 *
*                                                          *
*                                                          *
* Version 3.0                                March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE              PH: 858-487-9378 *
* SUITE 340                              FAX:858-487-9448 *
* SAN DIEGO, CA 92127         WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - Section 3 btm


______________________   USACE Method  ______________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                           3.85 ft/s
Bottom Width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     1.85 ft
Cotangent of Side Slope                                 2.50
Safety Factor                                            1.1
Riprap Placement                                Channel Bank
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         0.06 ft
Computed Local Depth Averaged Velocity             3.85 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight         Minimum            Maximum
____________________________________________________________
W100                                  15.                36.
 W50                                   7.                11.
```

```
 W15                                           2.                 5.

                       ASCE Method

Input Parameters:
-----------------

Local Velocity                                               3.85 ft/s
Cotangent of Side slope                                          2.50
Unit Weight of Stone                                    165. lbs/cu ft
Riprap Placement                                          Channel Bank

Output Results:
---------------

Computed D50                                                   0.10 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft

                                          Stone Weight, lbs
Percent Lighter by Weight            Minimum             Maximum
____________________________________________________________
W100                                          15.                36.
 W50                                           7.                11.
 W15                                           2.                 5.

                       USBR Method

Input Parameters:
-----------------

Average Channel Velocity                                     3.85 ft/s

Output Results:
---------------

Computed D50                                                   0.20 ft

  *** Using Gradations from COE ETL 1110-2-120 ***

Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft

                                          Stone Weight, lbs
Percent Lighter by Weight            Minimum             Maximum
____________________________________________________________
W100                                          15.                36.
 W50                                           7.                11.
 W15                                           2.                 5.
```

```
                  Offsite Channel Sec-3_btm
______________________ USGS Method ______________________


Input Parameters:
----------------

Average Channel Velocity                        3.85 ft/s


Output Results:
---------------

Computed D50                                    0.27 ft

  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight          Minimum             Maximum
----------------------------------------------------------------
W100                                   15.                 36.
 W50                                    7.                 11.
 W15                                    2.                  5.

_____________________ Isbash Method _____________________


Input Parameters:
----------------

Average Channel Velocity                        3.85 ft/s
Unit Weight of Stone                       165. lbs/cu ft
Turbulence Level                                     High


Output Results:
---------------

Computed D50                                    0.19 ft

  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight          Minimum             Maximum
----------------------------------------------------------------
W100                                   15.                 36.
 W50                                    7.                 11.
 W15                                    2.                  5.

___________________ Cal B & SP Method ___________________


Input Parameters:
```

```
-----------------

Average Channel Velocity                           3.85 ft/s
Velocity Affecting Bank                            5.13 ft/s
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side slope                                 2.50
Flow Type                                          Impinging


Output Results:
---------------

Computed W                                          0.52 lbs


                 ** CalTrans A Gradation **

(1) Outside Layer:

Gradation Class                                      1/2 Ton
Layer Thickness                                      3.40 ft

Percent Larger than                          Rock Size (Ton)
____________________________________________________________

0 - 5                                                   1.00
50 - 100                                                0.50
95 - 100                                                0.25

(2) Inner Layer:

Gradation Class                                         None
Layer Thickness                                      0.00 ft

(3) Backing:

Backing Class No.                                          1
Layer Thickness                                       1.8 ft

(4) Fabric:

Fabric Type                                                B

Total Thickness (1)+(2)+(3)+(4):                      5.2 ft

______________________ HEC-11 Method ______________________

Input Parameters:
-----------------

Average Channel Velocity                           3.85 ft/s
Average Flow Depth                                   4.00 ft
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side Slope                                 2.50
Material Angle of Repose                          41.00 deg.
```

```
                           Offsite Channel Sec-3_btm
Riprap Placement                                      Channel Bank
Safety Factor                                                  1.1


Output Results:
---------------

Computed D50                                               0.03 ft

                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
-------------------------------------------------------------
D100                               1.30                 200.
 D50                               0.95                  75.
 D10                               0.40                   5.
```

```
Date: 02/06/2009 Time: 16:31
************************************************************
*               RIPRAP DESIGN SYSTEM (RDS)                 *
*                          BY                              *
*                 WEST Consultants, Inc.                   *
*                                                          *
*                                                          *
* Version 3.0                                March, 2005  *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE             PH: 858-487-9378   *
* SUITE 340                             FAX:858-487-9448   *
* SAN DIEGO, CA 92127           WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - Section 4


______________________ USACE Method ______________________


Input Parameters:
-----------------
Velocity Type                                       Average
Channel Shape                                   Trapezoidal
Channel Type                                       Straight
Bend Angle (deg)                                        N/A
Average Channel Velocity                          5.30 ft/s
Bottom Width                                            N/A
Bend Radius                                             N/A
Top Width                                               N/A
Unit Weight of Stone                         165. lbs/cu ft
Riprap Layer Thickness                                 1.00
Local Flow Depth                                    1.91 ft
Cotangent of Side Slope                                2.50
Safety Factor                                           1.1
Riprap Placement                               Channel Bank
Rock Type                                           Angular


Output Results:
---------------

Computed D30                                        0.14 ft
Computed Local Depth Averaged Velocity            5.30 ft/s
Local Velocity/Avg. Velocity                           1.00
Side Slope Correction Factor                           1.06
Correction for Layer Thickness                         1.00
Correction for Secondary Currents                      1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         0.750 ft
Selected Minimum D30     0.37 ft
Selected Minimum D90     0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight          Minimum             Maximum
____________________________________________________________
W100                                   15.                 36.
 W50                                    7.                 11.
```

```
 W15                                      2.                  5.

 _______________________  ASCE Method  _______________________


 Input Parameters:
 -----------------


 Local Velocity                                       5.30 ft/s
 Cotangent of Side slope                                   2.50
 Unit Weight of Stone                            165. lbs/cu ft
 Riprap Placement                                  Channel Bank


 Output Results:
 ---------------


 Computed D50                                           0.20 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight      165.0 lbs/cu ft
 Layer Thickness           0.750 ft
 Selected Minimum D30       0.37 ft
 Selected Minimum D90       0.53 ft


                                         Stone Weight, lbs
 Percent Lighter by Weight           Minimum            Maximum
 ______________________________________________________________
 W100                                    15.                36.
  W50                                     7.                11.
  W15                                     2.                 5.

 _______________________  USBR Method  ________________________


 Input Parameters:
 -----------------


 Average Channel Velocity                             5.30 ft/s


 Output Results:
 ---------------


 Computed D50                                           0.38 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight      165.0 lbs/cu ft
 Layer Thickness           0.750 ft
 Selected Minimum D30       0.37 ft
 Selected Minimum D90       0.53 ft


                                         Stone Weight, lbs
 Percent Lighter by Weight           Minimum            Maximum
 ______________________________________________________________
 W100                                    15.                36.
  W50                                     7.                11.
  W15                                     2.                 5.
```

```
                                 Offsite Channel Sec-4
_______________________ USGS Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                                5.30 ft/s


Output Results:
---------------

Computed D50                                              0.59 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            1.000 ft
Selected Minimum D30        0.49 ft
Selected Minimum D90        0.70 ft


                                        Stone Weight, lbs
Percent Lighter by Weight           Minimum              Maximum
_________________________________________________________________
W100                                  35.                  86.
 W50                                  17.                  26.
 W15                                   5.                  13.


______________________ Isbash Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                                5.30 ft/s
Unit Weight of Stone                                165. lbs/cu ft
Turbulence Level                                             High


Output Results:
---------------

Computed D50                                              0.36 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight           Minimum              Maximum
_________________________________________________________________
W100                                  15.                  36.
 W50                                   7.                  11.
 W15                                   2.                   5.


_____________________ Cal B & SP Method ____________________


Input Parameters:
```

```
                             Offsite Channel Sec-4
-----------------

Average Channel Velocity                           5.30 ft/s
Velocity Affecting Bank                            7.07 ft/s
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side slope                                 2.50
Flow Type                                          Impinging


Output Results:
---------------

Computed W                                          3.55 lbs


                 ** CalTrans A Gradation **


(1) Outside Layer:


Gradation Class                                      1/2 Ton
Layer Thickness                                      3.40 ft


Percent Larger than                          Rock Size (Ton)
____________________________________________________________

0 - 5                                                   1.00
50 - 100                                                0.50
95 - 100                                                0.25


(2) Inner Layer:


Gradation Class                                         None
Layer Thickness                                      0.00 ft


(3) Backing:


Backing Class No.                                          1
Layer Thickness                                       1.8 ft


(4) Fabric:


Fabric Type                                                B


Total Thickness (1)+(2)+(3)+(4):                      5.2 ft


______________________ HEC-11 Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                           5.30 ft/s
Average Flow Depth                                   4.00 ft
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side Slope                                 2.50
Material Angle of Repose                          41.00 deg.
```

```
                             Offsite Channel Sec-4
Riprap Placement                                Channel Bank
Safety Factor                                            1.1


Output Results:
---------------

Computed D50                                         0.09 ft


                      ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
____________________________________________________________
D100                               1.30                 200.
 D50                               0.95                  75.
 D10                               0.40                   5.
```

```
                          Offsite Channel Sec-4_btm
Date: 02/06/2009 Time: 16:59
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                   WEST Consultants, Inc.                 *
*                                                          *
*                                                          *
* Version 3.0                                  March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - Section 4 btm


______________________   USACE Method   ____________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                           5.30 ft/s
Bottom Width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                        165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     1.91 ft
Cotangent of Side Slope                                 2.50
Safety Factor                                            1.1
Riprap Placement                                Channel Bank
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         0.14 ft
Computed Local Depth Averaged Velocity             5.30 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight            Minimum           Maximum
____________________________________________________________
W100                                     15.             36.
 W50                                      7.             11.
```

```
 W15                                    2.                 5.

_______________________ ASCE Method _______________________


Input Parameters:
-----------------

Local Velocity                                       5.30 ft/s
Cotangent of Side slope                                   2.50
Unit Weight of Stone                              165. lbs/cu ft
Riprap Placement                                  Channel Bank


Output Results:
---------------

Computed D50                                           0.20 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness             0.750 ft
Selected Minimum D30         0.37 ft
Selected Minimum D90         0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight           Minimum            Maximum
--------------------------------------------------------------
W100                                    15.                36.
 W50                                     7.                11.
 W15                                     2.                 5.

_______________________ USBR Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                             5.30 ft/s


Output Results:
---------------

Computed D50                                           0.38 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness             0.750 ft
Selected Minimum D30         0.37 ft
Selected Minimum D90         0.53 ft


                                       Stone Weight, lbs
Percent Lighter by Weight           Minimum            Maximum
--------------------------------------------------------------
W100                                    15.                36.
 W50                                     7.                11.
 W15                                     2.                 5.
```

```
                    Offsite Channel Sec-4_btm
_______________________ USGS Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                            5.30 ft/s


Output Results:
---------------

Computed D50                                          0.59 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            1.000 ft
Selected Minimum D30        0.49 ft
Selected Minimum D90        0.70 ft


                                     Stone Weight, lbs
Percent Lighter by Weight          Minimum           Maximum
____________________________________________________________
W100                                   35.               86.
 W50                                   17.               26.
 W15                                    5.               13.

______________________ Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                            5.30 ft/s
Unit Weight of Stone                           165. lbs/cu ft
Turbulence Level                                         High


Output Results:
---------------

Computed D50                                          0.36 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                     Stone Weight, lbs
Percent Lighter by Weight          Minimum           Maximum
____________________________________________________________
W100                                   15.               36.
 W50                                    7.               11.
 W15                                    2.                5.

____________________ Cal B & SP Method ____________________


Input Parameters:
```

```
                         Offsite Channel Sec-4_btm
-----------------

Average Channel Velocity                               5.30 ft/s
Velocity Affecting Bank                                7.07 ft/s
Unit Weight of Stone                             165. lbs/cu ft
Cotangent of Side slope                                    2.50
Flow Type                                             Impinging


Output Results:
---------------

Computed W                                             3.55 lbs


                 ** CalTrans A Gradation **

(1) Outside Layer:


Gradation Class                                         1/2 Ton
Layer Thickness                                         3.40 ft

Percent Larger than                           Rock Size (Ton)
______________________________________________________________

0 - 5                                                     1.00
50 - 100                                                  0.50
95 - 100                                                  0.25


(2) Inner Layer:


Gradation Class                                           None
Layer Thickness                                         0.00 ft


(3) Backing:


Backing Class No.                                            1
Layer Thickness                                          1.8 ft


(4) Fabric:


Fabric Type                                                  B


Total Thickness (1)+(2)+(3)+(4):                         5.2 ft


_______________________  HEC-11 Method  _______________________


Input Parameters:
-----------------

Average Channel Velocity                               5.30 ft/s
Average Flow Depth                                     4.00 ft
Unit Weight of Stone                             165. lbs/cu ft
Cotangent of Side Slope                                    2.50
Material Angle of Repose                              41.00 deg.
```

```
                        Offsite Channel Sec-4_btm
Riprap Placement                                  Channel Bank
Safety Factor                                              1.1


Output Results:
---------------

Computed D50                                           0.09 ft

                     ** FHWA Gradation**


Gradation Class           Facing
Layer Thickness           1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
____________________________________________________________
D100                               1.30                 200.
 D50                               0.95                  75.
 D10                               0.40                   5.
```

```
Date: 02/06/2009 Time: 16:32
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                           BY                             *
*                 WEST Consultants, Inc.                   *
*                                                          *
*                                                          *
* Version 3.0                                March, 2005   *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE              PH: 858-487-9378  *
* SUITE 340                              FAX:858-487-9448  *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - Section 5&6


______________________ USACE Method ________________________


Input Parameters:
-----------------
Velocity Type                                       Average
Channel Shape                                   Trapezoidal
Channel Type                                       Straight
Bend Angle (deg)                                        N/A
Average Channel Velocity                          4.39 ft/s
Bottom width                                            N/A
Bend Radius                                             N/A
Top Width                                               N/A
Unit Weight of Stone                        165. lbs/cu ft
Riprap Layer Thickness                                 1.00
Local Flow Depth                                    1.36 ft
Cotangent of Side Slope                                2.50
Safety Factor                                           1.1
Riprap Placement                              Channel Bank
Rock Type                                          Angular


Output Results:
---------------

Computed D30                                        0.09 ft
Computed Local Depth Averaged Velocity             4.39 ft/s
Local Velocity/Avg. Velocity                           1.00
Side Slope Correction Factor                           1.06
Correction for Layer Thickness                         1.00
Correction for Secondary Currents                      1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         0.750 ft
Selected Minimum D30     0.37 ft
Selected Minimum D90     0.53 ft


                                    Stone Weight, lbs
Percent Lighter by Weight        Minimum          Maximum
___________________________________________________________
W100                               15.              36.
 W50                                7.              11.
```

```
 W15                                   2.                 5.

 _________________________ ASCE Method _________________________


 Input Parameters:
 -----------------

 Local Velocity                                     4.39 ft/s
 Cotangent of Side slope                                2.50
 Unit Weight of Stone                          165. lbs/cu ft
 Riprap Placement                                Channel Bank


 Output Results:
 ---------------

 Computed D50                                         0.14 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight      165.0 lbs/cu ft
 Layer Thickness            0.750 ft
 Selected Minimum D30        0.37 ft
 Selected Minimum D90        0.53 ft


                                         Stone Weight, lbs
 Percent Lighter by Weight            Minimum          Maximum
 _____________________________________________________________
 W100                                    15.              36.
  W50                                     7.              11.
  W15                                     2.               5.

 _________________________ USBR Method _________________________


 Input Parameters:
 -----------------

 Average Channel Velocity                           4.39 ft/s


 Output Results:
 ---------------

 Computed D50                                         0.26 ft


   *** Using Gradations from COE ETL 1110-2-120 ***


 Specific Weight      165.0 lbs/cu ft
 Layer Thickness            0.750 ft
 Selected Minimum D30        0.37 ft
 Selected Minimum D90        0.53 ft


                                         Stone Weight, lbs
 Percent Lighter by Weight            Minimum          Maximum
 _____________________________________________________________
 W100                                    15.              36.
  W50                                     7.              11.
  W15                                     2.               5.
```

Offsite Channel Sec-5&6

```
_______________________ USGS Method _________________________


Input Parameters:
-----------------

Average Channel Velocity                               4.39 ft/s


Output Results:
---------------

Computed D50                                             0.37 ft

  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                         Stone Weight, lbs
Percent Lighter by Weight           Minimum            Maximum
--------------------------------------------------------------
W100                                     15.                36.
 W50                                      7.                11.
 W15                                      2.                 5.


_______________________ Isbash Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                               4.39 ft/s
Unit Weight of Stone                              165. lbs/cu ft
Turbulence Level                                            High


Output Results:
---------------

Computed D50                                             0.25 ft

  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                         Stone Weight, lbs
Percent Lighter by Weight           Minimum            Maximum
--------------------------------------------------------------
W100                                     15.                36.
 W50                                      7.                11.
 W15                                      2.                 5.


____________________ Cal B & SP Method ______________________


Input Parameters:
```

```
-----------------

Average Channel Velocity                          4.39 ft/s
Velocity Affecting Bank                           5.85 ft/s
Unit Weight of Stone                         165. lbs/cu ft
Cotangent of Side slope                                2.50
Flow Type                                         Impinging


Output Results:
---------------

Computed W                                         1.15 lbs


               ** CalTrans A Gradation **

(1) Outside Layer:

Gradation Class                                     1/2 Ton
Layer Thickness                                     3.40 ft

Percent Larger than                         Rock Size (Ton)
___________________________________________________________

0 - 5                                                  1.00
50 - 100                                               0.50
95 - 100                                               0.25

(2) Inner Layer:

Gradation Class                                        None
Layer Thickness                                     0.00 ft

(3) Backing:

Backing Class No.                                         1
Layer Thickness                                      1.8 ft

(4) Fabric:

Fabric Type                                               B

Total Thickness (1)+(2)+(3)+(4):                     5.2 ft


_____________________ HEC-11 Method _____________________

Input Parameters:
-----------------

Average Channel Velocity                          4.39 ft/s
Average Flow Depth                                  4.00 ft
Unit Weight of Stone                         165. lbs/cu ft
Cotangent of Side Slope                                2.50
Material Angle of Repose                         41.00 deg.
```

```
                            Offsite Channel Sec-5&6
Riprap Placement                                    Channel Bank
Safety Factor                                                1.1


Output Results:
---------------

Computed D50                                             0.05 ft

                      ** FHWA Gradation**


Gradation Class           Facing
Layer Thickness           1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
____________________________________________________________
D100                               1.30                 200.
 D50                               0.95                  75.
 D10                               0.40                   5.
```

```
                        Offsite Channel Sec-5&6_btm
Date: 02/06/2009 Time: 16:59
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                           BY                             *
*                 WEST Consultants, Inc.                   *
*                                                          *
*                                                          *
* Version 3.0                                 March, 2005  *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE              PH: 858-487-9378  *
* SUITE 340                              FAX:858-487-9448  *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - section 5&6 btm


______________________  USACE Method  ______________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                         4.39 ft/s
Bottom Width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     1.36 ft
Cotangent of Side Slope                                 2.50
Safety Factor                                            1.1
Riprap Placement                                Channel Bank
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         0.09 ft
Computed Local Depth Averaged Velocity             4.39 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         0.750 ft
Selected Minimum D30     0.37 ft
Selected Minimum D90     0.53 ft


                                   Stone Weight, lbs
Percent Lighter by Weight       Minimum             Maximum
____________________________________________________________
W100                                 15.                 36.
 W50                                  7.                 11.
```

```
 W15                                     2.                  5.

________________________ ASCE Method ________________________


Input Parameters:
-----------------

Local Velocity                                        2.40 ft/s
Cotangent of Side slope                                    2.50
Unit Weight of Stone                              165. lbs/cu ft
Riprap Placement                                   Channel Bank


Output Results:
---------------

Computed D50                                            0.04 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness          0.750 ft
Selected Minimum D30      0.37 ft
Selected Minimum D90      0.53 ft


                                         Stone Weight, lbs
Percent Lighter by Weight            Minimum             Maximum
________________________________________________________________
W100                                     15.                 36.
 W50                                      7.                 11.
 W15                                      2.                  5.

________________________ USBR Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                              4.39 ft/s


Output Results:
---------------

Computed D50                                            0.26 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness          0.750 ft
Selected Minimum D30      0.37 ft
Selected Minimum D90      0.53 ft


                                         Stone Weight, lbs
Percent Lighter by Weight            Minimum             Maximum
________________________________________________________________
W100                                     15.                 36.
 W50                                      7.                 11.
 W15                                      2.                  5.
```

```
___________________________ USGS Method ____________________________


Input Parameters:
-----------------

Average Channel Velocity                            4.39 ft/s


Output Results:
---------------

Computed D50                                        0.37 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness          0.750 ft
Selected Minimum D30      0.37 ft
Selected Minimum D90      0.53 ft


                                  Stone Weight, lbs
Percent Lighter by Weight       Minimum          Maximum
________________________________________________________
W100                                15.              36.
 W50                                 7.              11.
 W15                                 2.               5.

__________________________ Isbash Method _________________________


Input Parameters:
-----------------

Average Channel Velocity                            4.39 ft/s
Unit Weight of Stone                          165. lbs/cu ft
Turbulence Level                                      High


Output Results:
---------------

Computed D50                                        0.25 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness          0.750 ft
Selected Minimum D30      0.37 ft
Selected Minimum D90      0.53 ft


                                  Stone Weight, lbs
Percent Lighter by Weight       Minimum          Maximum
________________________________________________________
W100                                15.              36.
 W50                                 7.              11.
 W15                                 2.               5.

________________________ Cal B & SP Method ________________________


Input Parameters:
```

```
-----------------

Average Channel Velocity                              4.39 ft/s
Velocity Affecting Bank                               5.85 ft/s
Unit Weight of Stone                            165. lbs/cu ft
Cotangent of Side slope                                   2.50
Flow Type                                            Impinging


Output Results:
---------------

Computed W                                            1.15 lbs


                 ** CalTrans A Gradation **

(1) Outside Layer:

Gradation Class                                        1/2 Ton
Layer Thickness                                        3.40 ft

Percent Larger than                            Rock Size (Ton)
______________________________________________________________

0 - 5                                                     1.00
50 - 100                                                  0.50
95 - 100                                                  0.25

(2) Inner Layer:

Gradation Class                                           None
Layer Thickness                                        0.00 ft

(3) Backing:

Backing Class No.                                            1
Layer Thickness                                         1.8 ft

(4) Fabric:

Fabric Type                                                  B

Total Thickness (1)+(2)+(3)+(4):                        5.2 ft

_______________________ HEC-11 Method _______________________

Input Parameters:
-----------------

Average Channel Velocity                              4.39 ft/s
Average Flow Depth                                     4.00 ft
Unit Weight of Stone                            165. lbs/cu ft
Cotangent of Side Slope                                   2.50
Material Angle of Repose                            41.00 deg.
```

```
                         Offsite Channel Sec-5&6_btm
Riprap Placement                                  Channel Bank
Safety Factor                                              1.1


Output Results:
---------------

Computed D50                                           0.05 ft


                     ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
_______________________________________________________________
D100                               1.30                  200.
 D50                               0.95                   75.
 D10                               0.40                    5.
```

```
                Drop Structure Offsite Channel Sec-6(0.2%slope)
Date: 02/09/2009 Time: 17:30
************************************************************
*                RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                            *
*                  WEST Consultants, Inc.                  *
*                                                          *
*                                                          *
* Version 3.0                                March, 2005  *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
* WEST CONSULTANTS, INC.                                   *
* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - SEction 6 DROP


______________________ USACE Method ______________________


Input Parameters:
-----------------
Velocity Type                                      Average
Channel Shape                                  Trapezoidal
Channel Type                                      Straight
Bend Angle (deg)                                       N/A
Average Channel Velocity                        12.05 ft/s
Bottom width                                           N/A
Bend Radius                                            N/A
Top Width                                              N/A
Unit Weight of Stone                        165. lbs/cu ft
Riprap Layer Thickness                                1.00
Local Flow Depth                                   0.58 ft
Cotangent of Side Slope                               2.50
Safety Factor                                          1.1
Riprap Placement                              Channel Bank
Rock Type                                          Angular


Output Results:
---------------

Computed D30                                       1.42 ft
Computed Local Depth Averaged Velocity            12.05 ft/s
Local Velocity/Avg. Velocity                          1.00
Side Slope Correction Factor                          1.06
Correction for Layer Thickness                        1.00
Correction for Secondary Currents                     1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness            3.000 ft
Selected Minimum D30        1.46 ft
Selected Minimum D90        2.11 ft


                                        Stone Weight, lbs
Percent Lighter by Weight           Minimum           Maximum
____________________________________________________________
W100                                  933.             2333.
 W50                                  467.              690.
```

```
 W15                                        146.                345.

__________________________  ASCE Method __________________________


Input Parameters:
-----------------

Local Velocity                                           12.05 ft/s
Cotangent of Side slope                                        2.50
Unit Weight of Stone                                 165. lbs/cu ft
Riprap Placement                                       Channel Bank


Output Results:
---------------

Computed D50                                                1.03 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            1.750 ft
Selected Minimum D30        0.85 ft
Selected Minimum D90        1.23 ft


                                          Stone Weight, lbs
Percent Lighter by Weight           Minimum             Maximum
_______________________________________________________________
W100                                   185.                463.
 W50                                    93.                137.
 W15                                    29.                 69.

__________________________  USBR Method __________________________


Input Parameters:
-----------------

Average Channel Velocity                                 12.05 ft/s


Output Results:
---------------

Computed D50                                                2.06 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            3.500 ft
Selected Minimum D30        1.70 ft
Selected Minimum D90        2.47 ft


                                          Stone Weight, lbs
Percent Lighter by Weight           Minimum             Maximum
_______________________________________________________________
W100                                  1482.               3704.
 W50                                   741.               1096.
 W15                                   232.                548.
```

```
                 Drop Structure Offsite Channel Sec-6(0.2%slope)
______________________ USGS Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                          12.05 ft/s


Output Results:
---------------

Computed D50                                       4.34 ft


  *** Using Gradations from COE ETL 1110-2-120 ***



Warning: The required stone size is greater than the largest
                  USACE stone gradation.

______________________ Isbash Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                          12.05 ft/s
Unit Weight of Stone                          165. lbs/cu ft
Turbulence Level                                        High


Output Results:
---------------

Computed D50                                       1.86 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           3.500 ft
Selected Minimum D30       1.70 ft
Selected Minimum D90       2.47 ft


                                      Stone Weight, lbs
Percent Lighter by Weight         Minimum           Maximum
_____________________________________________________________
W100                                1482.             3704.
 W50                                 741.             1096.
 W15                                 232.              548.

____________________ Cal B & SP Method ____________________


Input Parameters:
-----------------

Average Channel Velocity                          12.05 ft/s
Velocity Affecting Bank                           16.07 ft/s
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side Slope                                 2.50
Flow Type                                          Impinging
```

```
Output Results:
---------------

Computed W                                          489.90 lbs


                  ** CalTrans A Gradation **

(1) Outside Layer:

Gradation Class                                       1/2 Ton
Layer Thickness                                       3.40 ft

Percent Larger than                            Rock Size (Ton)
______________________________________________________________

0 - 5                                                    1.00
50 - 100                                                 0.50
95 - 100                                                 0.25

(2) Inner Layer:

Gradation Class                                          None
Layer Thickness                                       0.00 ft

(3) Backing:

Backing Class No.                                           1
Layer Thickness                                        1.8 ft

(4) Fabric:

Fabric Type                                                 B

Total Thickness (1)+(2)+(3)+(4):                       5.2 ft


_______________________ HEC-11 Method _______________________

Input Parameters:
-----------------

Average Channel Velocity                          12.05 ft/s
Average Flow Depth                                   4.00 ft
Unit Weight of Stone                        165. lbs/cu ft
Cotangent of Side Slope                                 2.50
Material Angle of Repose                         41.00 deg.
Riprap Placement                               Channel Bank
Safety Factor                                            1.1

Output Results:
---------------

Computed D50                                         1.03 ft
```

```
            Drop Structure Offsite Channel Sec-6(0.2%slope)

                         ** FHWA Gradation**


Gradation Class            Light
Layer Thickness            2.60 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
______________________________________________________________
D100                                1.80                500.
 D50                                1.30                200.
 D10                                0.40                  5.
```

```
Date: 02/09/2009 Time: 17:31
************************************************************
*                 RIPRAP DESIGN SYSTEM (RDS)               *
*                            BY                            *
*                    WEST Consultants, Inc.                *
*                                                          *
*                                                          *
* Version 3.0                                  March, 2005 *
*                                                          *
*                                                          *
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* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127         WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - SECTION 6 DROP btm


______________________ USACE Method ______________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                          12.05 ft/s
Bottom Width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     0.58 ft
Cotangent of Side Slope                                  N/A
Safety Factor                                            1.1
Riprap Placement                              Channel Bottom
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         1.42 ft
Computed Local Depth Averaged Velocity            12.05 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         3.000 ft
Selected Minimum D30     1.46 ft
Selected Minimum D90     2.11 ft


                                  Stone Weight, lbs
Percent Lighter by Weight      Minimum          Maximum
____________________________________________________________
W100                             933.             2333.
 W50                             467.              690.
```

```
 W15                                    146.              345.

_______________________ ASCE Method _______________________


Input Parameters:
-----------------

Local Velocity                                   12.05 ft/s
Cotangent of Side slope                                 N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Placement                              Channel Bottom


Output Results:
---------------

Computed D50                                        0.95 ft

   *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            1.750 ft
Selected Minimum D30        0.85 ft
Selected Minimum D90        1.23 ft


                                      Stone Weight, lbs
Percent Lighter by Weight        Minimum            Maximum
___________________________________________________________
W100                                185.               463.
 W50                                 93.               137.
 W15                                 29.                69.

_______________________ USBR Method _______________________


Input Parameters:
-----------------

Average Channel Velocity                         12.05 ft/s


Output Results:
---------------

Computed D50                                        2.06 ft

   *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            3.500 ft
Selected Minimum D30        1.70 ft
Selected Minimum D90        2.47 ft


                                      Stone Weight, lbs
Percent Lighter by Weight        Minimum            Maximum
___________________________________________________________
W100                               1482.              3704.
 W50                                741.              1096.
 W15                                232.               548.
```

```
                 Drop Structure Offsite Channel Sec-6_btm(0.2%slope)
_______________________ USGS Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                          12.05 ft/s


Output Results:
---------------

Computed D50                                       4.34 ft


  *** Using Gradations from COE ETL 1110-2-120 ***



Warning: The required stone size is greater than the largest
                  USACE stone gradation.

______________________ Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                          12.05 ft/s
Unit Weight of Stone                          165. lbs/cu ft
Turbulence Level                                        High


Output Results:
---------------

Computed D50                                       1.86 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight      165.0 lbs/cu ft
Layer Thickness             3.500 ft
Selected Minimum D30         1.70 ft
Selected Minimum D90         2.47 ft


                                     Stone Weight, lbs
Percent Lighter by Weight          Minimum             Maximum
_____________________________________________________________
W100                                 1482.               3704.
 W50                                  741.               1096.
 W15                                  232.                548.

____________________ Cal B & SP Method ____________________


Input Parameters:
-----------------

Average Channel Velocity                          12.05 ft/s
Velocity Affecting Bank                           16.07 ft/s
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side slope                                 2.50
Flow Type                                          Impinging
```

```
Output Results:
---------------

Computed W                                        489.90 lbs


               ** CalTrans A Gradation **

(1) Outside Layer:

Gradation Class                                     1/2 Ton
Layer Thickness                                     3.40 ft

Percent Larger than                         Rock Size (Ton)
___________________________________________________________

0 - 5                                                  1.00
50 - 100                                               0.50
95 - 100                                               0.25

(2) Inner Layer:

Gradation Class                                        None
Layer Thickness                                     0.00 ft

(3) Backing:

Backing Class No.                                         1
Layer Thickness                                      1.8 ft

(4) Fabric:

Fabric Type                                               B

Total Thickness (1)+(2)+(3)+(4):                     5.2 ft


____________________ HEC-11 Method ____________________

Input Parameters:
-----------------

Average Channel Velocity                         12.05 ft/s
Average Flow Depth                                  4.00 ft
Unit Weight of Stone                        165. lbs/cu ft
Cotangent of Side Slope                                 N/A
Material Angle of Repose                               deg.
Riprap Placement                             Channel Bottom
Safety Factor                                           1.1

Output Results:
---------------

Computed D50                                        0.77 ft
```

```
                 Drop Structure Offsite Channel Sec-6_btm(0.2%slope)

                              ** FHWA Gradation**


Gradation Class            Facing
Layer Thickness            1.90 ft


Percent Smaller by Size    Rock Size, ft      Rock Weight, lbs
______________________________________________________________
D100                                1.30                  200.
 D50                                0.95                   75.
 D10                                0.40                    5.
```

```
************************************************************
*               RIPRAP DESIGN SYSTEM (RDS)                 *
*                          BY                              *
*                  WEST Consultants, Inc.                  *
*                                                          *
*                                                          *
* Version 3.0                                March, 2005 *
*                                                          *
*                                                          *
* COPYRIGHT (c) 2005                                       *
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* 16870 WEST BERNARDO DRIVE               PH: 858-487-9378 *
* SUITE 340                               FAX:858-487-9448 *
* SAN DIEGO, CA 92127         WEB:WWW.WESTCONSULTANTS.COM *
************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - Section 7


______________________  USACE Method  ______________________


Input Parameters:
-----------------
Velocity Type                                         Average
Channel Shape                                     Trapezoidal
Channel Type                                         Straight
Bend Angle (deg)                                          N/A
Average Channel Velocity                            2.40 ft/s
Bottom Width                                              N/A
Bend Radius                                               N/A
Top Width                                                 N/A
Unit Weight of Stone                          165. lbs/cu ft
Riprap Layer Thickness                                   1.00
Local Flow Depth                                      0.86 ft
Cotangent of Side Slope                                  2.50
Safety Factor                                             1.1
Riprap Placement                                 Channel Bank
Rock Type                                             Angular


Output Results:
---------------

Computed D30                                          0.02 ft
Computed Local Depth Averaged Velocity              2.40 ft/s
Local Velocity/Avg. Velocity                             1.00
Side Slope Correction Factor                             1.06
Correction for Layer Thickness                           1.00
Correction for Secondary Currents                        1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         0.750 ft
Selected Minimum D30     0.37 ft
Selected Minimum D90     0.53 ft


                                    Stone Weight, lbs
Percent Lighter by Weight        Minimum           Maximum
____________________________________________________________
W100                                15.               36.
 W50                                 7.               11.
```

```
 W15                                          2.                   5.

_______________________ ASCE Method _______________________


Input Parameters:
-----------------


Local Velocity                                              2.40 ft/s
Cotangent of Side slope                                          2.50
Unit Weight of Stone                                  165. lbs/cu ft
Riprap Placement                                        Channel Bank


Output Results:
---------------


Computed D50                                                  0.04 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                            Stone Weight, lbs
Percent Lighter by Weight              Minimum             Maximum
____________________________________________________________________
W100                                          15.                 36.
 W50                                           7.                 11.
 W15                                           2.                  5.


_______________________ USBR Method ________________________


Input Parameters:
-----------------


Average Channel Velocity                                    2.40 ft/s


Output Results:
---------------


Computed D50                                                  0.07 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness            0.750 ft
Selected Minimum D30        0.37 ft
Selected Minimum D90        0.53 ft


                                            Stone Weight, lbs
Percent Lighter by Weight              Minimum             Maximum
____________________________________________________________________
W100                                          15.                 36.
 W50                                           7.                 11.
 W15                                           2.                  5.
```

```
                      Offsite Channel Sec-7
_______________________ USGS Method ________________________


Input Parameters:
-----------------

Average Channel Velocity                           2.40 ft/s


Output Results:
---------------

Computed D50                                       0.08 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                     Stone Weight, lbs
Percent Lighter by Weight        Minimum            Maximum
_____________________________________________________________
W100                                15.                36.
 W50                                 7.                11.
 W15                                 2.                 5.


______________________ Isbash Method ______________________


Input Parameters:
-----------------

Average Channel Velocity                           2.40 ft/s
Unit Weight of Stone                           165. lbs/cu ft
Turbulence Level                                        High


Output Results:
---------------

Computed D50                                       0.07 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                     Stone Weight, lbs
Percent Lighter by Weight        Minimum            Maximum
_____________________________________________________________
W100                                15.                36.
 W50                                 7.                11.
 W15                                 2.                 5.


____________________ Cal B & SP Method ____________________


Input Parameters:
```

```
                        Offsite Channel Sec-7
----------------

Average Channel Velocity                          2.40 ft/s
Velocity Affecting Bank                           3.20 ft/s
Unit Weight of Stone                         165. lbs/cu ft
Cotangent of Side slope                                2.50
Flow Type                                         Impinging


Output Results:
---------------

Computed W                                         0.03 lbs


                 ** CalTrans A Gradation **

(1) Outside Layer:

Gradation Class                                     1/2 Ton
Layer Thickness                                     3.40 ft

Percent Larger than                         Rock Size (Ton)
___________________________________________________________

0 - 5                                                  1.00
50 - 100                                               0.50
95 - 100                                               0.25

(2) Inner Layer:

Gradation Class                                        None
Layer Thickness                                     0.00 ft

(3) Backing:

Backing Class No.                                         1
Layer Thickness                                      1.8 ft

(4) Fabric:

Fabric Type                                               B

Total Thickness (1)+(2)+(3)+(4):                     5.2 ft


_____________________ HEC-11 Method _____________________

Input Parameters:
----------------

Average Channel Velocity                          2.40 ft/s
Average Flow Depth                                  3.00 ft
Unit Weight of Stone                         165. lbs/cu ft
Cotangent of Side Slope                                2.50
Material Angle of Repose                        41.00 deg.
```

```
                               Offsite Channel Sec-7
Riprap Placement                                       Channel Bank
Safety Factor                                                   1.1


Output Results:
---------------

Computed D50                                                0.01 ft


                         ** FHWA Gradation**


Gradation Class              Facing
Layer Thickness              1.90 ft

Percent Smaller by Size   Rock Size, ft     Rock Weight, lbs
____________________________________________________________
D100                                1.30                200.
 D50                                0.95                 75.
 D10                                0.40                  5.
```

```
                                   Offsite Channel Sec-7_btm
Date: 02/06/2009 Time: 16:58
*************************************************************
*                 RIPRAP DESIGN SYSTEM (RDS)                *
*                            BY                             *
*                   WEST Consultants, Inc.                  *
*                                                           *
*                                                           *
* Version 3.0                                March, 2005    *
*                                                           *
*                                                           *
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* WEST CONSULTANTS, INC.                                    *
* 16870 WEST BERNARDO DRIVE              PH: 858-487-9378   *
* SUITE 340                              FAX:858-487-9448   *
* SAN DIEGO, CA 92127          WEB:WWW.WESTCONSULTANTS.COM  *
*************************************************************


Project: Cholla Ash Offsite
Description: Offsite Channel - Section 7 btm

______________________  USACE Method  ______________________


Input Parameters:
-----------------
Velocity Type                                        Average
Channel Shape                                    Trapezoidal
Channel Type                                        Straight
Bend Angle (deg)                                         N/A
Average Channel Velocity                         2.40 ft/s
Bottom width                                             N/A
Bend Radius                                              N/A
Top Width                                                N/A
Unit Weight of Stone                         165. lbs/cu ft
Riprap Layer Thickness                                  1.00
Local Flow Depth                                     0.86 ft
Cotangent of Side Slope                                  N/A
Safety Factor                                            1.1
Riprap Placement                              Channel Bottom
Rock Type                                            Angular


Output Results:
---------------

Computed D30                                         0.02 ft
Computed Local Depth Averaged Velocity             2.40 ft/s
Local Velocity/Avg. Velocity                            1.00
Side Slope Correction Factor                            1.06
Correction for Layer Thickness                          1.00
Correction for Secondary Currents                       1.00


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness         0.750 ft
Selected Minimum D30     0.37 ft
Selected Minimum D90     0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight            Minimum            Maximum
_______________________________________________________________
W100                                     15.                36.
 W50                                      7.                11.
```

```
 W15                                        2.                 5.

_______________________  ASCE Method  _______________________

Input Parameters:
-----------------

Local Velocity                                         2.40 ft/s
Cotangent of Side slope                                      N/A
Unit Weight of Stone                              165. lbs/cu ft
Riprap Placement                                  Channel Bottom


Output Results:
---------------

Computed D50                                             0.04 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight           Minimum            Maximum
______________________________________________________________
W100                                    15.                36.
 W50                                     7.                11.
 W15                                     2.                 5.

_______________________  USBR Method  ________________________

Input Parameters:
-----------------

Average Channel Velocity                               2.40 ft/s

,
Output Results:
---------------

Computed D50                                             0.07 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                        Stone Weight, lbs
Percent Lighter by Weight           Minimum            Maximum
______________________________________________________________
W100                                    15.                36.
 W50                                     7.                11.
 W15                                     2.                 5.
```

```
                      Offsite Channel Sec-7_btm
_____________________ USGS Method ______________________


Input Parameters:
----------------

Average Channel Velocity                            2.40 ft/s


Output Results:
--------------

Computed D50                                        0.08 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                    Stone Weight, lbs
Percent Lighter by Weight        Minimum           Maximum
__________________________________________________________
W100                                15.               36.
 W50                                 7.               11.
 W15                                 2.                5.


____________________ Isbash Method _____________________


Input Parameters:
----------------

Average Channel Velocity                            2.40 ft/s
Unit Weight of Stone                           165. lbs/cu ft
Turbulence Level                                         High


Output Results:
--------------

Computed D50                                        0.07 ft


  *** Using Gradations from COE ETL 1110-2-120 ***


Specific Weight     165.0 lbs/cu ft
Layer Thickness           0.750 ft
Selected Minimum D30       0.37 ft
Selected Minimum D90       0.53 ft


                                    Stone Weight, lbs
Percent Lighter by Weight        Minimum           Maximum
__________________________________________________________
W100                                15.               36.
 W50                                 7.               11.
 W15                                 2.                5.


__________________ Cal B & SP Method ___________________


Input Parameters:
```

```
                          Offsite Channel Sec-7_btm
-----------------

Average Channel Velocity                           2.40 ft/s
Velocity Affecting Bank                            3.20 ft/s
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side slope                                 2.50
Flow Type                                          Impinging


Output Results:
---------------

Computed W                                          0.03 lbs


                 ** CalTrans A Gradation **

(1) Outside Layer:

Gradation Class                                      1/2 Ton
Layer Thickness                                      3.40 ft

Percent Larger than                          Rock Size (Ton)
____________________________________________________________

0 - 5                                                   1.00
50 - 100                                                0.50
95 - 100                                                0.25

(2) Inner Layer:

Gradation Class                                         None
Layer Thickness                                      0.00 ft

(3) Backing:

Backing Class No.                                          1
Layer Thickness                                       1.8 ft

(4) Fabric:

Fabric Type                                                B

Total Thickness (1)+(2)+(3)+(4):                      5.2 ft


______________________ HEC-11 Method _______________________

Input Parameters:
-----------------

Average Channel Velocity                           2.40 ft/s
Average Flow Depth                                   3.00 ft
Unit Weight of Stone                          165. lbs/cu ft
Cotangent of Side Slope                                  N/A
Material Angle of Repose                                deg.
```

```
                           Offsite Channel Sec-7_btm
Riprap Placement                                   Channel Bottom
Safety Factor                                                 1.1


Output Results:
---------------

Computed D50                                              0.01 ft


                     ** FHWA Gradation**


Gradation Class             Facing
Layer Thickness             1.90 ft

Percent Smaller by Size    Rock Size, ft     Rock Weight, lbs
_______________________________________________________________
D100                                1.30                 200.
 D50                                0.95                  75.
 D10                                0.40                   5.
```

OFF-SITE CHANNEL

DROP STRUCTURE CALCULATIONS

Cholla Ash Monofill

Riprap Basin Sizing and Hydraulic Jump

Offsite Drop Structure Channel Section 1 Into Basin

	A	B	C	D	E	F	G	H	I	J
1	**Riprap Basin Sizing**									
2										
3	Q=	25	cfs	flow rate for section 1 just before brink of drop						
4	Vallow=	0.001	ft/s	velocity for basin, past drop						
5	TW=	10	ft	normal depth for basin, past drop						
6	Wo=	10	ft	channel bottom width						
7										
8	From FHWA Hydraulic Design of Energy Dissipators for Culverts and Channels, July 2006									
9	1) Get intial velocity (Vo), depth (yo), and Froude Number (Fr) for brink conditions									
10										
11	From Flowmaster output files:									
12	yo= ye=	0.29	ft	normal depth for drop						
13	Vo=	7.96	ft/s	velocity for drop						
14	Fr=	2.68		Froude number for drop						
15										
16	2) Select trial D50 and obtain hs/ye from Equation 10.1.									
17										
18	Equation 10.1	$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o$								
19										
20										
21										
22	Get tailwater parameter Co:									
23	Co =	1.4	if TW/ye < 0.75							
24	Co =	136.331	if 0.75 < TW/ye < 1.0							
25	Co =	3	if 1.0 < TW/ye							
26										
27	TW/ye =	34.48276								
28										
29	**D50 =**	**0.11**	**ft**	D50 of riprap						
30										
31	Check to see that hs/D50 >= 2 and that D50/ye >= 0.1.									
32	D50/ye =	0.37931	>= 0.1	OK						
33	g =	32.2	ft/s2							
34	hs/ye =	0.928133								
35	hs =	0.269159	ft	scour depth						
36	hs/D50 =	2.446896	>=2.0	OK						
37										
38	3) Size the basin									
39	Ls =	10*hs =	2.69	ft	Dissipator Pool Length					
40	Lsmin =	3Wo =	**30**	**ft**						
41										
42	Lb =	15hs =	4.04	ft	Total Pool Length					
43	Lbmin =	4Wo =	**40**	**ft**						
44	La =	**10**	**ft**	Apron Length						
45	Wb =	10	ft	maintaining channel bottom depth						
46										

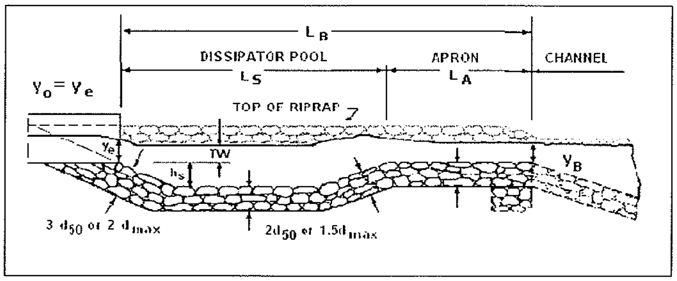

Figure 10.1. Profile of Riprap Basin

Cholla Ash Monofill
Riprap Basin Sizing and Hydraulic Jump
Offsite Drop Structure Channel Section 1 Into Basin

	A	B	C	D	E	F	G	H	I	J

47 **Hydraulic Jump**
48 From Drainage Design Manual for Maricopa County, Hydraulics: Hydraulic Structures, 2003
49 Y1 = 0.29 ft upstream normal depth for drop
50 **Ydn = 10 ft downstream normal depth basin**
51 Q = 25 cfs flow through the drop
52 g = 32.2 ft/s2
53 A1 = 3.14 ft2 area of flow through the drop
54 A2 = 10.43 ft2 area of flow in next section
55 z = 2.5 ft sideslope H:1
56 b = 10 ft bottom width of channel
57
58 2) Calculate sequant height of jump.
59 Equation 7.2
60
61
62

$$\boxed{Y_2 = \frac{1}{2}Y_1\left[\left(1+8F_{r1}^2\right)^{\frac{1}{2}}-1\right]}$$

63 Y2 = **0.96** ft OK height of jump

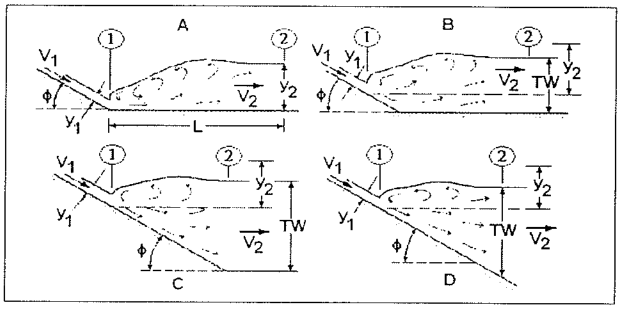

Figure 6.10. Hydraulic Jump Types Sloping Channels (Bradley, 1961)

64
65 3) Another check on sequant height of jump.
66 Use Fig. 7-8
67 V= 7.96 ft/s
68 Fr1 = $\boxed{\frac{V}{\sqrt{gy_m}}}$ top width = 11.46 ft
69 ym = 0.27 ft = flow area / top width
70 Fr1 = 2.68
71
72 J = Y2 / Y1 t = b/(zy1)
73 J = 3.1 t = 13.79
74 Y2 = **0.899** ft use larger height of jump
75
76 1) Calculate depth at beginning location of jump.
77 Equation 7.3
78
79
80

$$\boxed{\frac{ZY_1^3}{3}+\frac{ZY_1^2}{2}+\frac{Q}{gA_1}=\frac{ZY_2^3}{3}+\frac{bY_2^2}{3}+\frac{Q}{gA_2}}$$

81 Leq = 0.373 Req = 0.375 (Plug in values for Y2 until both sides equal)
82 Yb = **0.29** ft OK depth at jump location
83
84 4) Calculate length of jump.
85 Use Fig. 7-9
86 Lj / y1 = 33
87 Lj = 9.57 ft = jump length
88
89 Therefore: Min. Length of jump = **30 ft**
90 Min. Length of apron = **10 ft**
91 Total Length of basin = **40 ft**

Cholla Ash Monofill
Riprap Basin Sizing and Hydraulic Jump
Offsite Drop Structure Channel Section 6

Riprap Basin Sizing

Q= 80 cfs flow rate for section 6, just before brink of drop
Vallow= 4.39 ft/s velocity for section 5, past drop
TW= 1.36 ft normal depth for section 5, past drop
Wo= 10 ft channel bottom width

From FHWA Hydraulic Design of Energy Dissipators for Culverts and Channels, July 2006
1) Get intial velocity (Vo), depth (yo), and Froude Number (Fr) for brink conditions

From Flowmaster output files:
yo= ye= 0.58 ft normal depth for drop
Vo= 12.05 ft/s velocity for drop
Fr= 2.96 Froude number for drop

2) Select trial D50 and obtain hs/ye from Equation 10.1.

Equation 10.1

$$\boxed{\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o}$$

Get tailwater parameter Co:
Co = 1.4 if TW/ye < 0.75
Co = 7.77931 if 0.75 < TW/ye < 1.0
Co = 3 if 1.0 < TW/ye

TW/ye = 2.344828

D50 = 0.25 ft D50 of riprap

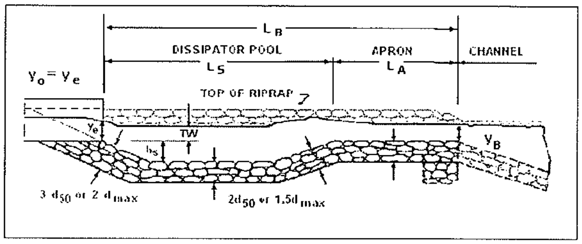

Figure 10.1. Profile of Riprap Basin

Check to see that hs/D50 >= 2 and that D50/ye >= 0.1.
D50/ye = 0.431034 >= 0.1 OK
g = 32.2 ft/s2
hs/ye = 1.043976
hs = 0.605506 ft scour depth
hs/D50 = 2.422024 >=2.0 OK

3) Size the basin
Ls = 10*hs = 6.06 ft Dissipator Pool Length
Lsmin = 3Wo = **30 ft**

Lb = 15hs = 9.08 ft Total Pool Length
Lbmin = 4Wo = **40 ft**
La = **10 ft** Apron Length
Wb = 10 ft maintaining channel bottom depth

4) Assess need for downstream riprap due to TW/ye >0.74
Using Figure 10.3
Compute equivalent circular diameter, De, for brink area

$$\boxed{A = \frac{\pi D_e^2}{4} = y_o W_o}$$

A = 5.8
De = 2.72

Rock size for riprap after energy dissipators - Equation 10.6
S = 2.64 specific gravity of rock

$$\boxed{D_{50} = \frac{0.692}{S-1}\left(\frac{V^2}{2g}\right)}$$

L/De	L (ft)	Vl/Vo (Fig. 10.3)	Vl (ft/s)	D50 (ft)
3.679857	10	0.95	11.4475	0.86
7.359714	20	0.75	9.0375	0.53
11.03957	30	0.5	6.025	0.24
14.71943	40	0.4	4.82	0.15
17.29533	**47**	0.36	**4.338**	**0.12**

Riprap placement required for 47 ft from brink.

Cholla Ash Monofill
Riprap Basin Sizing and Hydraulic Jump
Offsite Drop Structure Channel Section 6

Hydraulic Jump

From Drainage Design Manual for Maricopa County, Hydraulics: Hydraulic Structures, 2003

Y1 = 0.58 ft upstream normal depth for drop
Ydn = 1.36 ft downstream normal depth
Q = 80 cfs flow through the drop
g = 32.2 ft/s2
A1 = 6.64 ft2 area of flow through the drop
A2 = 18.22 ft2 area of flow in next section
z = 2.5 ft sideslope H:1
b = 10 ft bottom width of channel

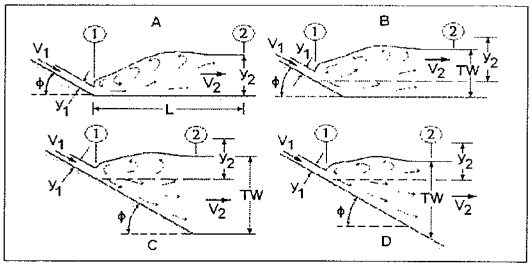

Figure 6.10. Hydraulic Jump Types Sloping Channels (Bradley, 1961)

2) Calculate sequant height of jump.

Equation 7.2

$$\boxed{Y_2 = \frac{1}{2} Y_1 \left[\left(1 + 8F_{r1}^2\right)^{\frac{1}{2}} - 1 \right]}$$

Y2 = **2.15** ft OK height of jump

3) Another check on sequant height of jump.

Use Fig. 7-8

Fr1 = $\boxed{\frac{V}{\sqrt{g y_m}}}$

V= 12.05 ft/s
top width = 12.90 ft
ym = 0.51 ft = flow area / top width
Fr1 = 2.96

J = Y2 / Y1 t = b/(zy1)
J = 3.5 t = 6.90
Y2 = **2.03** ft use larger height of jump

1) Calculate depth at beginning location of jump.

Equation 7.3

$$\boxed{\frac{ZY_1^3}{3} + \frac{ZY_1^2}{2} + \frac{Q}{gA_1} = \frac{ZY_2^3}{3} + \frac{bY_2^2}{3} + \frac{Q}{gA_2}}$$

Leq = 0.957 Req = 0.959 (Plug in values for Y2 until both sides equal)
Yb = **0.47** ft OK depth at jump location

4) Calculate length of jump.

Use Fig. 7-9

Lj / y1 = 55
Lj = 31.9 ft = jump length

Therefore: Min. Length of jump = **32 ft**
Min. Length of apron = **10 ft**
Total Length of basin = **42 ft**
Total Length of required riprap= **47 ft** (from brink of drop)

Cholla Ash Monofill
Sloping Drop Structure
Riprap Sizing and Hydraulic Jump Formulas

	A	B	C	D	E	F	G	H	I
1	**Riprap Basin Sizing**								
2									
3	Q=	80	cfs	flow rate for section 6, just before brink of drop					
4	Vallow=	4.39	ft/s	velocity for section 5, past drop					
5	TW=	1.36	ft	normal depth for section 5, past drop					
6	Wo=	10	ft	channel bottom w					
7									
8	From FHWA Hydraulic Design of Energy Dissipators for Culverts and Channels, July 2006								
9	1) Get intial velocity (Vo), depth (yo), and Froude Number (Fr) for brink conditions								
10									
11	From Flowmaster output files:								
12	yo= ye=	0.58	ft	normal depth for					
13	Vo=	12.05	ft/s	velocity for drop					
14	Fr=	2.96		Froude number for drop					
15									
16	2) Select trial D50 and obtain hs/ye from Equation 10.1.								
17									
18	Equation 10.1	$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o$							
19									
20									
21									
22	Get tailwater parameter Co:								
23	Co =	1.4	if TW/ye < 0.75						
24	Co =	=4*B5/B12-1.6	if 0.75 < TW/ye < 1.0						
25	Co =	3	if 1.0 < TW/ye						
26									
27	TW/ye =	=B5/B12							
28									
29	**D50 =**	**0.25**	**ft**	D50 of riprap					
30									
31	Check to see that hs/D50 >= 2 and that D50/ye >= 0.1.								
32	D50/ye =	=B29/B12	>= 0.1	OK					
33	g =	32.2	ft/s2						
34	hs/ye =	=0.86*((B32)^(-0.55))*(B14)-B25							
35	hs =	=B34*B12	ft	scour depth					
36	hs/D50 =	=B35/B29	>=2.0	OK					
37									
38	3) Size the basin								
39	Ls =	10*hs =	=10*B35	ft		Dissipator Pool Length			
40	Lsmin =	3Wo =	**=3*B6**	**ft**					
41									
42	Lb =	15hs =	=15*B35	ft		Total Pool Length			
43	Lbmin =	4Wo =	**=4*B6**	**ft**					
44	La =	**=C43-C40**	**ft**	Apron Length					
45	Wb =	10	ft	maintaining channel bottom depth					
46									
47	4) Assess need for downstream riprap due to TW/ye >0.74 **(for Drop Structures in channel only)**								
48	Using Figure 10.3								
49	Compute equivalent circular diameter, De, for brink area		$A = \frac{\pi D_e^2}{4} = y_o W_o$						
50	A =	=B5*B12							
51	De =	=(B50*4/PI())^0.5							
52									
53	Rock size for riprap aft								
54	S =	=165/62.4	specific gravity of rock		$D_{50} = \frac{0.692}{S-1}\left(\frac{V^2}{2g}\right)$				
55									

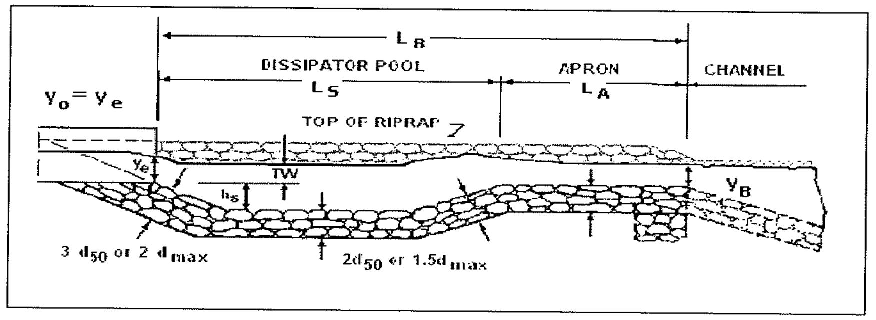

Figure 10.1. Profile of Riprap Basin

Cholla Ash Monofill
Sloping Drop Structure
Riprap Sizing and Hydraulic Jump Formulas

	A	B	C	D	E	F	G	H	I
56	L/De	L (ft)	Vl/Vo (Fig. 10.3)	Vl (ft/s)	D50 (ft)				
57	=B57/\$B\$51	10	0.42	=C57*\$B\$13	=(0.692/(\$B\$54-1))*((D57^2)/(2*'Drop Off-basin'!\$B\$33))				
58	=B58/\$B\$51	15	0.4	=C58*\$B\$13	=(0.692/(\$B\$54-1))*((D58^2)/(2*'Drop Off-basin'!\$B\$33))				
59	=B59/\$B\$51	**17**	0.38	**=C59*\$B\$13**	**=(0.692/(\$B\$54-1))*((D59^2)/(2*'Drop Off-basin'!\$B\$33))**			**Riprap placement required for 17 ft from brink.**	
60	=B60/\$B\$51	20	0.3	=C60*\$B\$13	=(0.692/(\$B\$54-1))*((D60^2)/(2*'Drop Off-basin'!\$B\$33))				
61									

62 **Hydraulic Jump**
63 From Drainage Design Manual for Maricopa County, Hydraulics: Hydraulic Structures, 2003

64	Y1 =	0.58	ft	upstream normal depth for drop	
65	**Ydn =**	**1.36**	**ft**	**downstream normal depth section 5**	
66	Q =	80	cfs	flow through the d	
67	g =	32.2	ft/s2		
68	A1 =	6.64	ft2	area of flow through the drop	
69	A2 =	10.43	ft2	area of flow in next section	
70	z =	2.5	ft	sideslope H:1	
71	b =	10	ft	bottom width of channel	

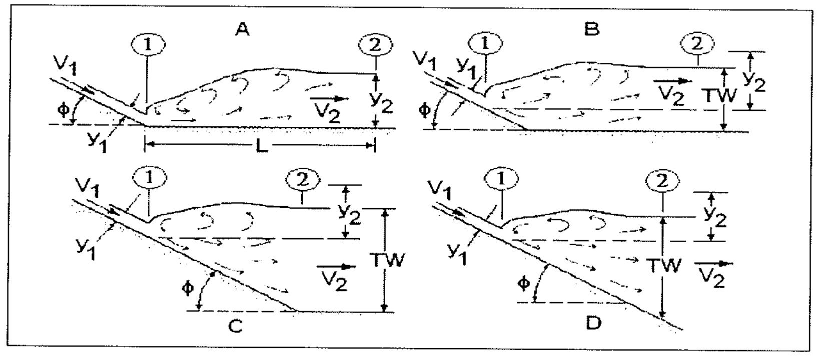

Figure 6.10. Hydraulic Jump Types Sloping Channels (Bradley, 1961)

72

73 2) Calculate sequant height of jump.

74 Equation 7.2

$$\boxed{Y_2 = \frac{1}{2} Y_1 \left[\left(1 + 8F_{r1}^2\right)^{\frac{1}{2}} - 1 \right]}$$

75
76
77
78 Y2 = **=0.5*B64*(((1+8*(D85^2))^0.5)-1)** ft OK height
79

80 3) Another check on sequant height of jump.

81 Use Fig. 7-8

82 V= =B66/B68 ft/s

83 Fr1 = $\boxed{\frac{V}{\sqrt{g y_m}}}$ top width = 12.9 ft

84 ym = =B68/D83 ft = flow area / top width

85 Fr1 = =D82/SQRT(B67*D84)

86

87 J = Y2 / Y1 t = b/(zy1)

88 J = 3.5 t = =B71/(B70*B64)

89 Y2 = **=B88*B64** ft use larger height of jump

90

91 1) Calculate depth at beginning location of jump.

92 Equation 7.3

$$\boxed{\frac{ZY_1^3}{3} + \frac{ZY_1^2}{2} + \frac{Q}{gA_1} = \frac{ZY_2^3}{3} + \frac{bY_2^2}{3} + \frac{Q}{gA_2}}$$

93
94
95
96 Leq = =(B70*(B64^3)/3)+(B70*(B64^2)/2)+(B66/(B67*B68)) Req = =(B70*B97^3/3)+(B71*B97^2/3)+(B66/(B67*B69)) (Plug in values for Y2 until both sides equal)

97 Yb = **0.44** ft OK depth at jump location

98

99 4) Calculate length of jump.

100 Use Fig. 7-9

101 Lj / y1 = 55

102 Lj = =B101*B64 ft = jump length

103

104 Therefore: Min. Length of jump = **32** **ft**

105 Min. Length of apron = **10** **ft**

106 Total Length of basin = **=D105+D104** **ft**

OFF-SITE CHANNEL

CULVERT AND WEIR CALCULATIONS

URS **EXHIBIT 4.7-2**

CALCULATION COVER SHEET

Client: Arizona Public Service Project Name: Cholla Ash Monofill

Project/Calculation Number: 23445548

Title: Weir Equation Calculation

Total Number of Pages (including cover sheet): 6

Total Number of Computer Runs:

Prepared by: Michelle C. West, EIT Date: 2/12/09

Checked by: Date:

Description and Purpose:
The purpose of this calculation is to estimate the height of the weirs for the two culverts in the offsite drainage channel.

The inputs were calculated in Culvertmaster and are attached.

Design Basis/References/Assumptions
The weirs are designed as broad crested and have a weir coefficient (C) of 2.7.
The weirs are 20 feet in length.

Remarks/Conclusions/Results:
See attached printouts.
Calculation Approved by:
Project Manager/Date

Revision No.:	Description of Revision:	Approved by:

Project Manager/Date

URS

Job Cholla Ash Monofill
Project No. 23445548
Page 2 of 6
Sheet ____ of ____
Description Weir Calculation - Offsite
Computed by MCW
Date 2-12-09
Checked by ____
Date ____
Reference

Weir 1 (North Weir) elevation - 5081 ft

Depth = 1.07 ft = H
Length = 20 ft = L
Weir Coefficient (Broad Crested Weir) = 2.7 = C

$$Q = C \times L \times (H)^{3/2} = 2.7(20)(1.07)^{3/2}$$

$$Q = 59.8 \text{ cfs}$$

$$\boxed{Q \cong 60 \text{ cfs}}$$

Weir 2 (South Weir) elevation - 5076.03 ft

Depth = 0.96 ft = H
Length = 20 ft = L
Weir Coeff. = 2.7 = C

$$Q = 2.7(20)(0.96)^{3/2} = 50.8 \text{ cfs}$$

$$\boxed{Q \cong 51 \text{ cfs}}$$

- Inputs from Culvertmaster

Culvert Designer/Analyzer Report
South Culvert (Sta. 7+50 to 8+00)

Analysis Component			
Storm Event	Design	Discharge	25.00 cfs

Peak Discharge Method: User-Specified			
Design Discharge	25.00 cfs	Check Discharge	25.00 cfs

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A ft

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-30 inch Circular	25.00 cfs	5,076.99 ft	7.01 ft/s
Weir	Not Considered	N/A	N/A	N/A

4

Culvert Designer/Analyzer Report
South Culvert (Sta. 7+50 to 8+00)

Component:Culvert-1

Culvert Summary

Computed Headwater Eleva	5,076.99 ft	Discharge	25.00 cfs
Inlet Control HW Elev.	5,076.47 ft	Tailwater Elevation	N/A ft
Outlet Control HW Elev.	5,076.99 ft	Control Type	Outlet Control
Headwater Depth/Height	1.27		

Grades

Upstream Invert	5,073.80 ft	Downstream Invert	5,073.70 ft
Length	50.00 ft	Constructed Slope	0.002000 ft/ft

Hydraulic Profile

Profile	CompositeM2PressureProfile	Depth, Downstream	1.70 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	1.70 ft
Velocity Downstream	7.01 ft/s	Critical Slope	0.019391 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	2.50 ft
Section Size	30 inch	Rise	2.50 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	5,076.99 ft	Upstream Velocity Head	0.40 ft
Ke	0.50	Entrance Loss	0.20 ft

Inlet Control Properties

Inlet Control HW Elev.	5,076.47 ft	Flow Control	Unsubmerged
Inlet Type	Headwall	Area Full	4.9 ft²
K	0.00780	HDS 5 Chart	2
M	2.00000	HDS 5 Scale	1
C	0.03790	Equation Form	1
Y	0.69000		

5

Culvert Designer/Analyzer Report
North Culvert (Sta. 11+00 to 11+50)

Analysis Component			
Storm Event	Design	Discharge	80.00 cfs

Peak Discharge Method: User-Specified			
Design Discharge	80.00 cfs	Check Discharge	80.00 cfs

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A ft

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	2-30 inch Circular	80.00 cfs	5,082.07 ft	8.98 ft/s
Weir	Not Considered	N/A	N/A	N/A

6

Culvert Designer/Analyzer Report
North Culvert (Sta. 11+00 to 11+50)

Component:Culvert-1

Culvert Summary

Computed Headwater Eleva	5,082.07	ft	Discharge	80.00	cfs
Inlet Control HW Elev.	5,081.82	ft	Tailwater Elevation	N/A	ft
Outlet Control HW Elev.	5,082.07	ft	Control Type	Outlet Control	
Headwater Depth/Height	1.63				

Grades

Upstream Invert	5,078.00	ft	Downstream Invert	5,076.93	ft
Length	50.00	ft	Constructed Slope	0.021400	ft/ft

Hydraulic Profile

Profile	CompositeM2PressureProfile		Depth, Downstream	2.13	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	2.13	ft
Velocity Downstream	8.98	ft/s	Critical Slope	0.030441	ft/ft

Section

Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	2.50	ft
Section Size	30 inch		Rise	2.50	ft
Number Sections	2				

Outlet Control Properties

Outlet Control HW Elev.	5,082.07	ft	Upstream Velocity Head	1.03	ft
Ke	0.20		Entrance Loss	0.21	ft

Inlet Control Properties

Inlet Control HW Elev.	5,081.82	ft	Flow Control	N/A	
Inlet Type	Beveled ring, 45° (1:1) bevels		Area Full	9.8	ft²
K	0.00180		HDS 5 Chart	3	
M	2.50000		HDS 5 Scale	A	
C	0.03000		Equation Form	1	
Y	0.74000				

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