DRAINAGE STUDY

FOR

Peoples Residence
Lot 37 Turquoise Hills
8229 North 54th Street
Paradise Valley, Arizona 85253
APN 168-65-030

Prepared for:

Christopher J & Carrie J Peoples Trust
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Prepared by:

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February 14, 2017

TDE Job #16-003

TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION

This report presents the results of a drainage study for a modified drainage swale adjacent to the east portion of the existing house. This drainage swale was widen to accommodate the erosion protection (rip-rap with fabric). The original drainage swale was undersize with no erosion protection.

The site is an approximately an acre parcel of land located at 8229 North 54th Street, Paradise Valley, Arizona (APN 168-65-030). The development will occur in section 32, Township 3 North, Range 4 East, Gila and Salt River Basin and Meridian, Maricopa County, Arizona. (Appendix A)

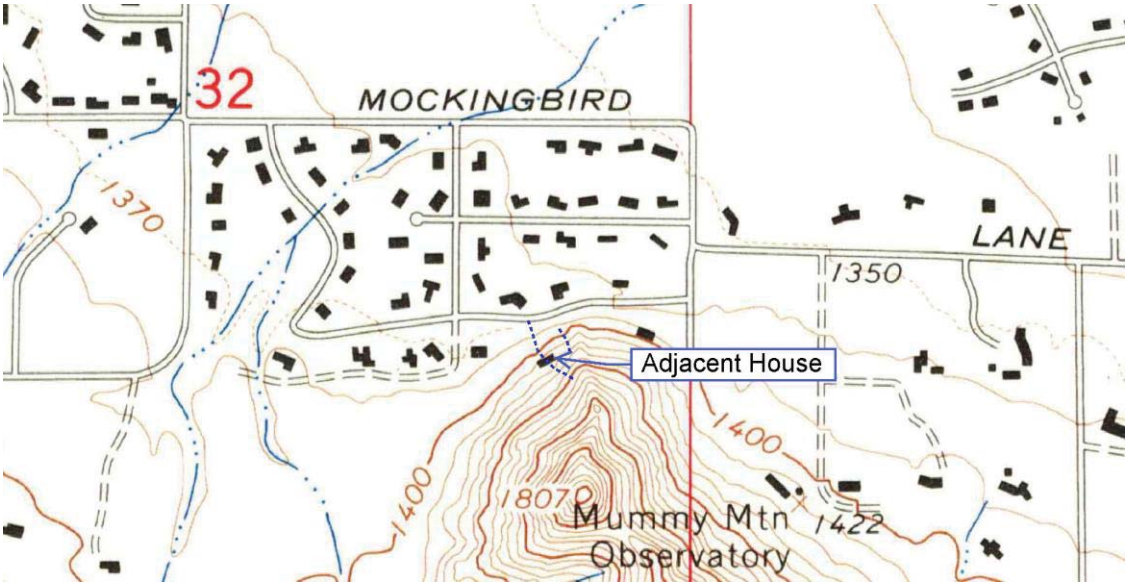
The site consist of an existing single-family residence along with driveway, courtyard, pool, landscape, and walls. The remainder of the site will consists of undisturbed desert.

2.0 WATERSHED DESCRIPTION

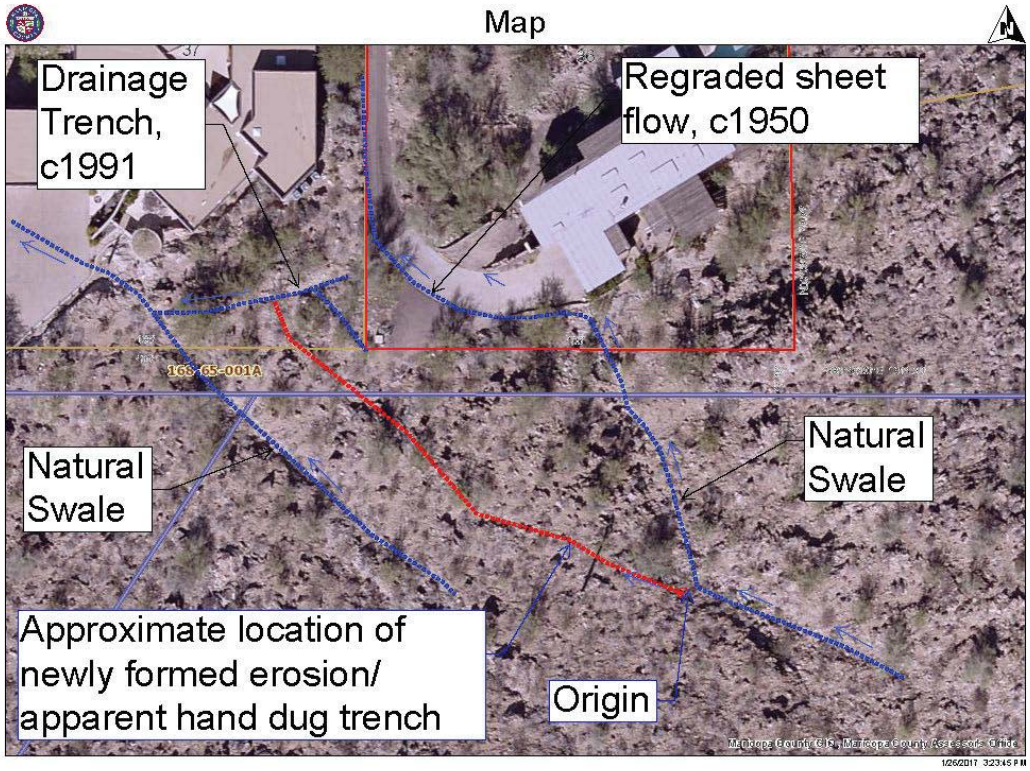
In general, the site and adjacent properties were observed to be moderate to steeply sloping towards the north with roughly 25 percent slope across the site. The watershed consists of a narrow shaped area, originating from the adjacent mountain. There is a drainage swale along the eastern boundary of the property.

According to our field reconnaissance and historical aerial photography and historical USGS topographic Maps, this wash diverted from its original outfall. The pre-developed entrance point onto this property was located approximately midway along the eastern site boundary. This drainage swale along with a partially functioning berm along the eastern property boundary/adjacent property driveway was installed to accommodate the adjacent property development in the 1950s. During storm events, debris is conveyed from the mountain onto Lot 36 Turquoise Hill (adjacent lot to the east) along the driveway and onto the drainage swale.

In addition, a trench along the southern portion of the property was first observed in the 1991 aerial photography. According to the owner, Mr. People, he had this cleaned out and deepened in 2016. This trench captures water which was displaced by the installation of the transformer pad located on the southwest corner of Lot 36 Turquoise Hill. This conveys stormwater back into a wash along the central portion of the southern property line and then across this property's driveway.



(This is an excerpt from the 1965 USGS topographic map "Paradise Valley, Arizona")



(The 2016 aerial photography was obtained from Maricopa County G.I.S. department.)

The site and adjacent properties are covered with Sonoran Desert type vegetation consisting of saguaro and barrel cacti, mesquite, ocotillo and Palo Verde trees, and native grass. General property use within the study area consists primarily of open land spaces and scattered residential property, which consists of zoning RU-43 and Mountain Open Space. (Appendix B). The subject property is at an average elevation of 1,400-feet above mean sea level (on-site topographical survey). Based on the USGS Paradise Valley Quadrangle 7.5-Minutes Maps, general area surface drainage is to the northwest.

The Flood Insurance Rate Map (FIRM) “Maricopa County, Arizona and Incorporated Areas,” Map Number 04013C1765L dated October 2013 Flood Zone X, which is defined by Federal Emergency Management Act (FEMA), as areas determined to be undetermined floodplain (Appendix B).

3.0 DATA ANALYSIS METHODOLOGY

The drainage report has been prepared in accordance with the current versions of the Maricopa County Drainage Policies and Standards Standard 6.13, Drainage Design Manuals for Maricopa County, Volumes 1 – Hydrology and Volume 2 – Hydraulics and Section 1205 of the Maricopa County Zoning Ordinance.

3.1 Hydrologic procedures and assumptions

The Rational Method was used for the drainage study areas (Appendix D). For this study, the coefficient of runoff was determined from the zoning, hydrologic soil group, vegetative cover, and land usages obtain from the Flood Control District of Maricopa County publication entitled "Design Standards and Procedures Manual (DSPM)," July 2010.

DDMSW uses data taken from NOAA Atlas 14, Volume 1, Version 4.0, dated October 4, 2006. NOAA Design Storm Map Index 64 cells 1281 through 1282, 1321 through 1322 was used for this area

3.2 Hydraulic procedures, methods, and assumptions

The determination of the approximate water surface elevations on the washes for 100-year design frequency storm was achieved by using the Manning’s equation for open channel flow. An average "n" value of 0.035 for the Manning's equation was used for the channel (rip-rap bottom) of the wash to calculate depths and critical depths (Appendix D).

Hydraflow Express Extension for Autodesk was used to calculate the water surface elevation.

4.0 Hydrologic Analysis

The Drainage Design Management System for Windows (DDMSW) was used to calculate the runoff for the sub-basin within the drainage area. The following table is a summary of the runoffs at drainage concentration point entering the property.

Watershed/Peak Discharge Rates						
Concentration Point/ Watershed	Area Acre	Length ft	USGE ft	DSGE ft	10 Year cfs	100 Year cfs
Wash A/CP-1*	1.7	583	1700	1410	4.4	8.7
Wash BA/CP-1*	1.03	586	1700	1400	2.8	5.4

*Flows entering the property from the southeast along the adjacent property driveway.

5.0 HYDRAULIC ANALYSIS

The wash and the weir overflow was modeled using the existing condition, see appendix D. The majority of the grading will take place outside the erosion setback and the 100-year High-water elevation.

Drainage Channels							
Location	Shape	Flow Rate	Roughness	Actual Slope	Critical Depth	Velocity	Normal Depth
A - Pre	Irregular	8.7 cfs	0.035	0.189	1.07 ft	8.21 ft/s	0.75’
A - Post	Irregular	8.7 cfs	0.035	0.189	0.47 ft	6.55 ft/s	0.28’

6.0 EROSION CONTROL

The Erosion Setback was determined based upon FCDMC Hydraulic Design Manual. The calculated erosion setback along the washes are 2.9 feet and 9 feet from top of bank. Based upon Arizona State Standard SSA-98, the required setback is 20 feet from top of bank (Appendix E).

The calculated scour depth for the washes are 0.45 feet for wash. Based upon Arizona State Standard SSA-96, the required minimum depth is 3 feet below the flow line

The existing wash will be maintain in its natural slope. The bank stabilization should be constructed of a 12.9-inches thick layer of well-graded material (d_{50}=6") and 9-inches thick layer of well-graded material (d_{50}=6") for the. Rip-rap should be lined with non-woven geo-synthetic fabric beneath the drainage swale.

7.0 SUMMARY AND RECOMMENDATIONS

As a result of this study below are the summary of findings:

- The site is characterized by two wash corridor, which drains in a northern direction.
- The site is located within a FEMA Flood Zone X
- It was concluded that peak storm flows 100-year design frequency will be contained within the modified drainage swale from the relocation of the stormwater entrance point (approximate moved in the 1950s).
- The pre-developed entrance point onto this property was located approximately midway along the eastern site boundary. This entrance/outfall point should be restored when Lot 36 Turquoise Hill (adjacent lot to the east) is redeveloped. This should resolve the current drainage swale adjacent to the house.
- The existing drainage trench along the southern portion of the property function to protect the house from flooding. This drainage trench should remain in place and periodically maintain/cleaned from debris flow.
- The current site development will not adversely impact or increase flooding hazards within, upstream or downstream.

8.0 REFERENCES OR BIBLIOGRAPHY

AutoCAD Hydraflow Express Extension, Version 9, by Autodesk Inc.

Federal Emergency Management Act, Flood Insurance Rate Maps, "Maricopa County, Arizona and Incorporated Areas," Map No. 045013C1765L, October 2013.

Flood Control District of Maricopa County, "Drainage Design Manual, Volume I" June 1, 1992 (revised January 1, 1995)

Flood Control District of Maricopa County, "Drainage Design Manual, Volume II" January 28, 1996

Maricopa County GIS System, Aerial Photography and Topography, 2013

National Oceanic & Atmospheric Administration, National Weather Service, Office of Hydrology, “NOAA ATLAS 14, Volume I.”

Topographic Survey, Starlink Surveying, Inc. on April 2016.

APPENDIX A

VICINITY, AERIAL, & SITE PLAN

Terra Dynamic Engineering
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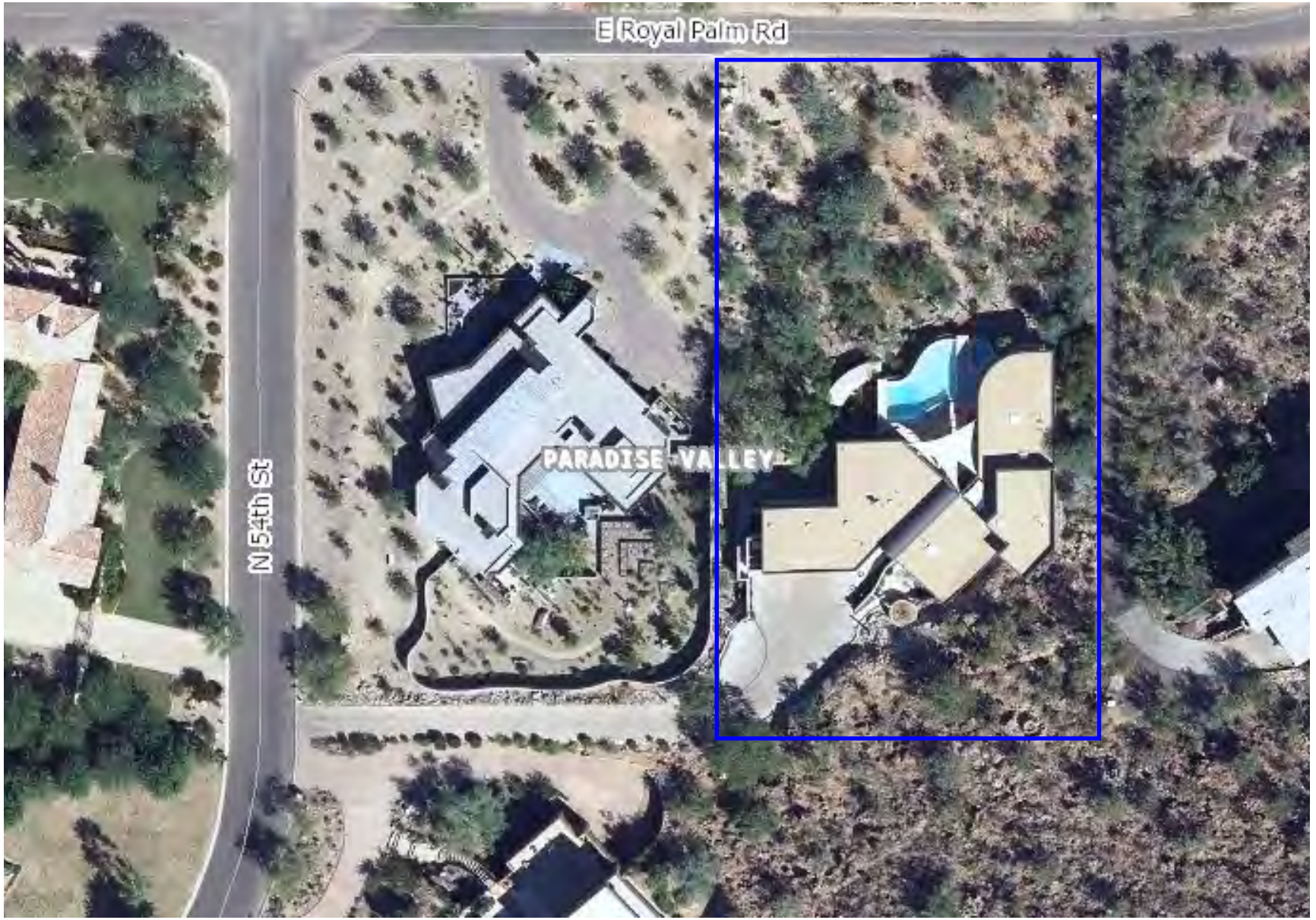
Phoenix, Arizona 85028

Vicinity Map

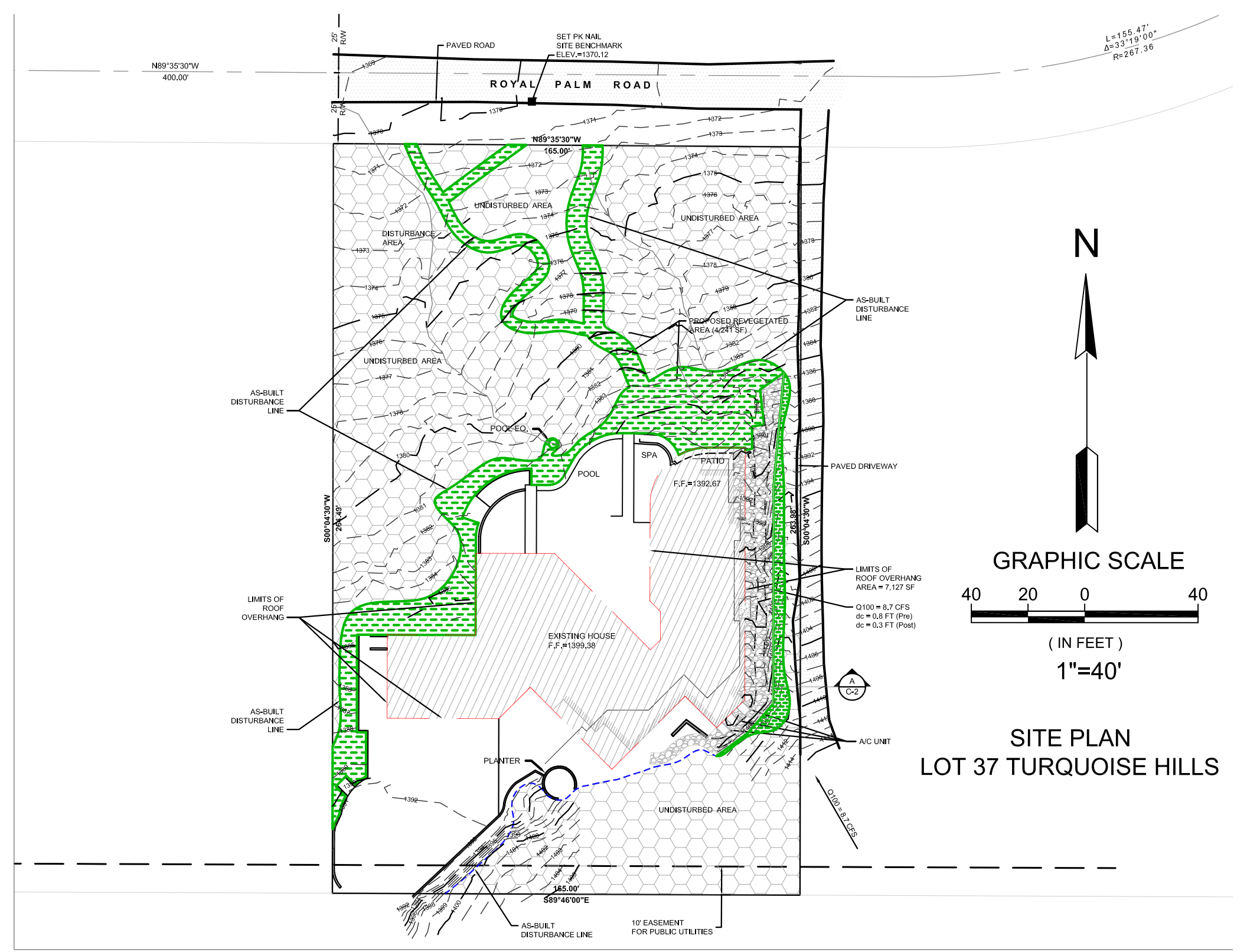
2013 Aerial Photography



2011 Aerial Photography

2000 Aerial Photography

1996 Aerial Photography



SITE PLAN
LOT 37 TURQUOISE HILLS

APPENDIX B

WATERSHED & FEMA MAP

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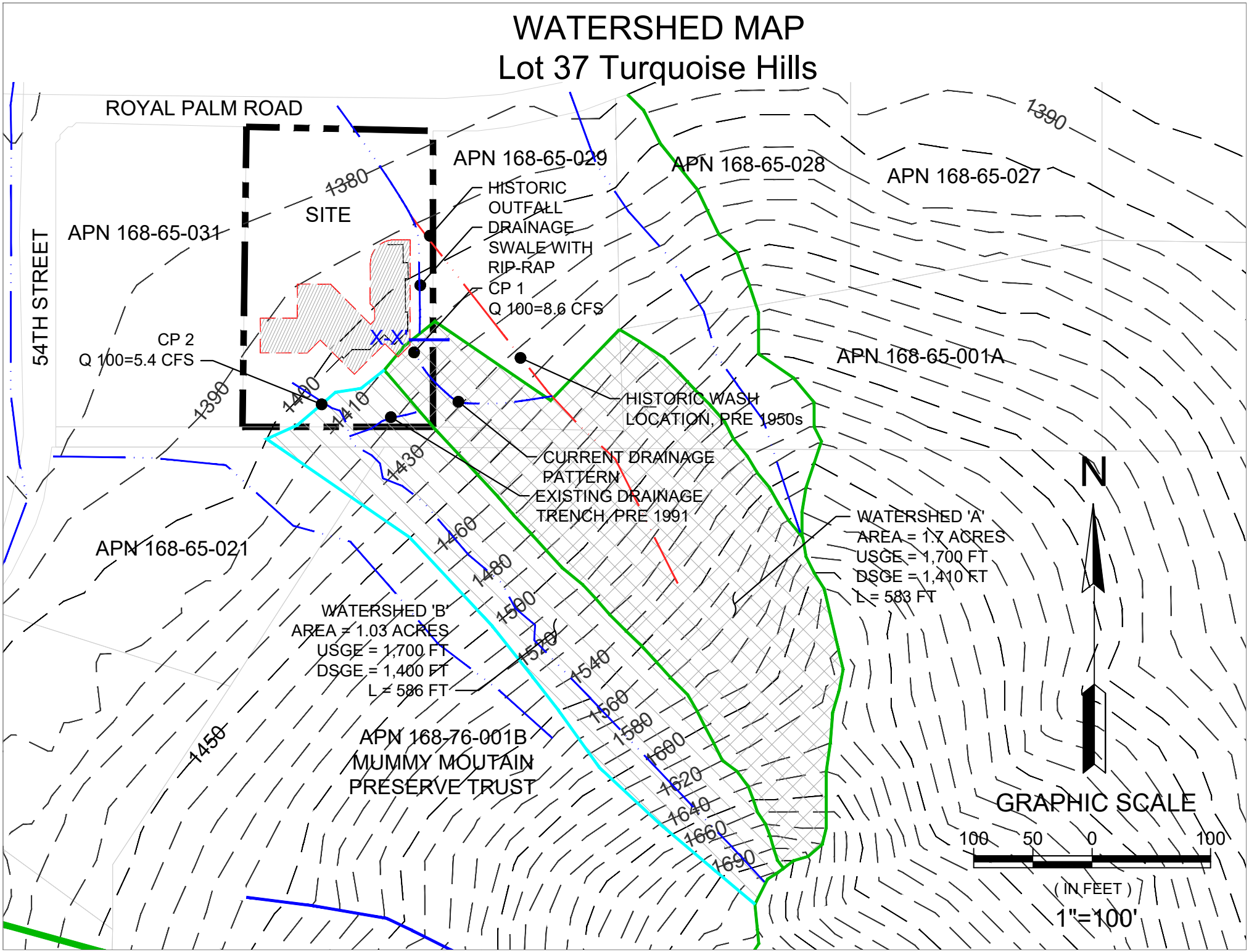
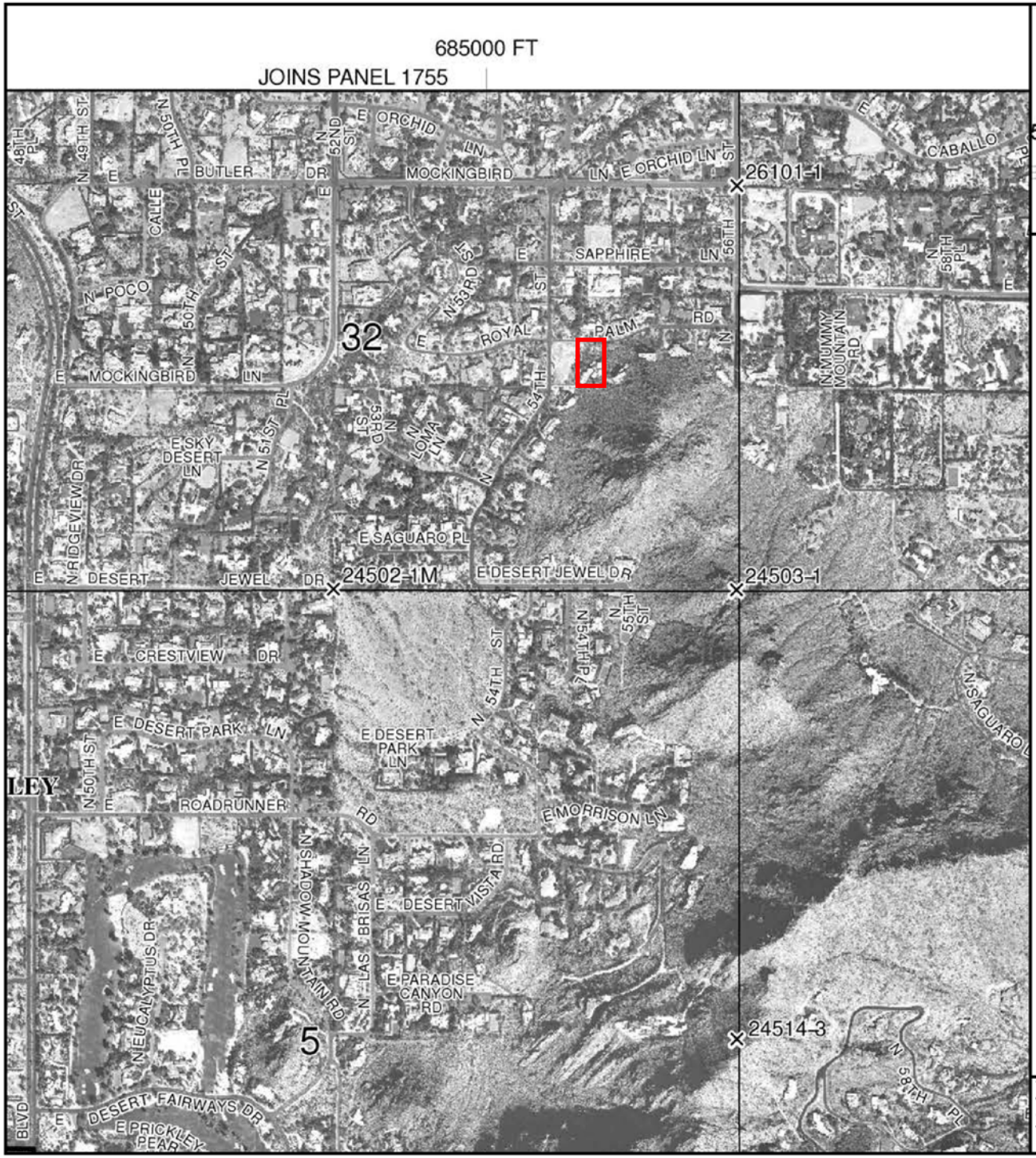

WATERSHED MAP
Lot 37 Turquoise Hills
ROYAL PALM ROAD
54TH STREET
APN 168-65-031
APN 168-65-029
APN 168-65-028
APN 168-65-027
APN 168-65-001A
APN 168-65-021
APN 168-76-001B
MUMMY MOUTAIN
PRESERVE TRUST
SITE
HISTORIC OUTFALL DRAINAGE SWALE WITH RIP-RAP
CP 1
Q 100=8.6 CFS
CP 2
Q 100=5.4 CFS
X-X
HISTORIC WASH LOCATION, PRE 1950s
CURRENT DRAINAGE PATTERN
EXISTING DRAINAGE TRENCH, PRE 1991
WATERSHED 'A'
AREA = 1.7 ACRES
USGE = 1,700 FT
DSGE = 1,410 FT
L = 583 FT
WATERSHED 'B'
AREA = 1.03 ACRES
USGE = 1,700 FT
DSGE = 1,400 FT
L = 586 FT
1380
1390
1400
1410
1430
1450
1460
1480
1500
1520
1540
1560
1580
1600
1620
1640
1660
1690
N
GRAPHIC SCALE
100 50 0 100
(IN FEET)
1"=100'

WATERSHED MAP
Lot 37 Turquoise Hills



MAP SCALE 1" = 1000'

500 0 1000 2000 FEET METE

PANEL 1765L

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

MARICOPA COUNTY, ARIZONA

AND INCORPORATED AREAS

PANEL 1765 OF 4425

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
MARICOPA COUNTY	040037	1765	L
PARADISE VALLEY, TOWN OF	040049	1765	L
PHOENIX, CITY OF	040051	1765	L
SCOTTSDALE, CITY OF	045012	1765	L

Notice: This map was reissued on July 31, 2015 to make a correction. This version replaces any previous versions. See the Notice-to-User Letter that accompanied this correction for details.

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
04013C1765L

MAP REVISED
OCTOBER 16, 2013

Federal Emergency Management Agency

APPENDIX C

FLOW RATE CALCULATIONS

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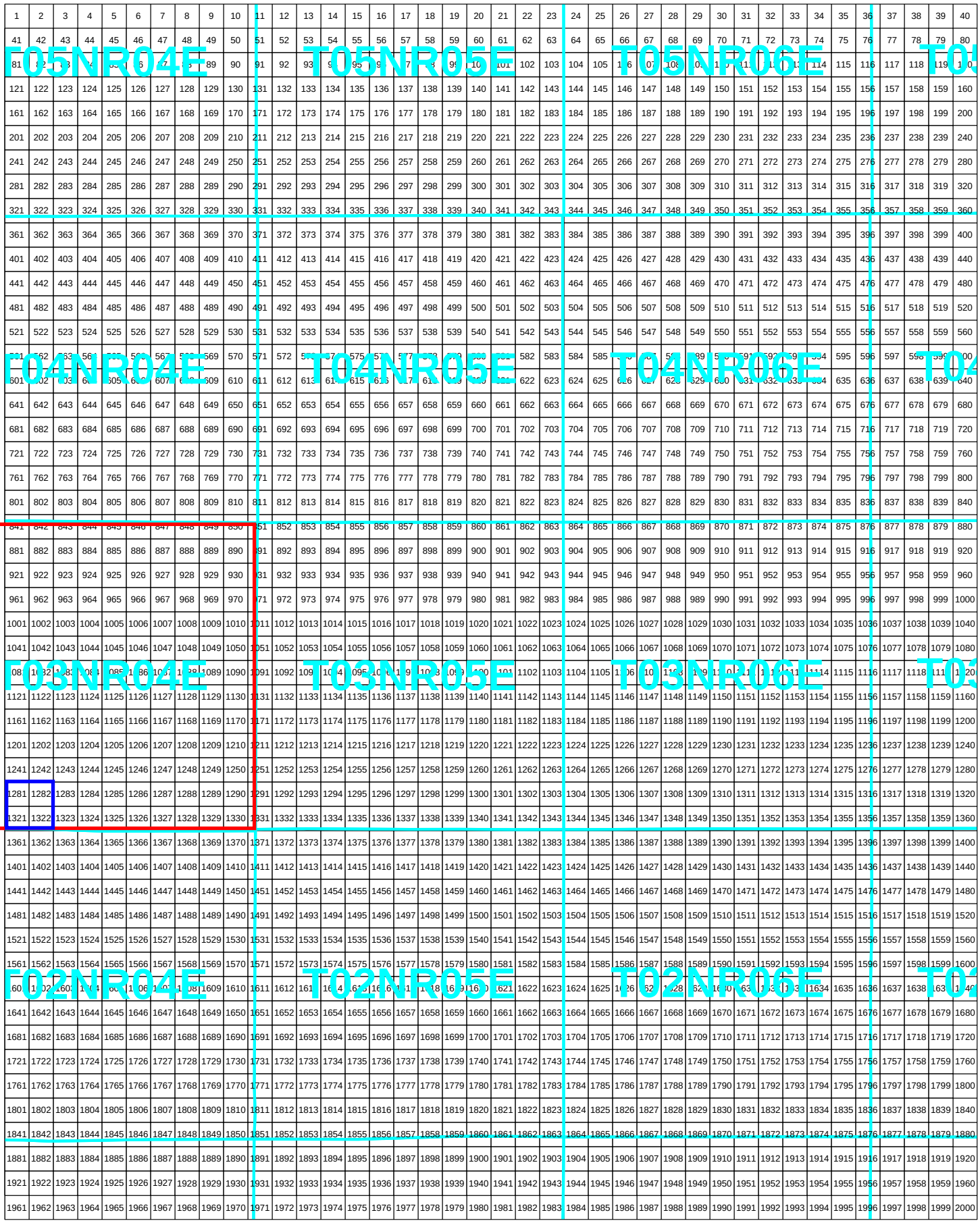
Phoenix, Arizona 85028

Flood Control District of Maricopa County
Drainage Design Management System
SUB BASINS
Project Reference: LOT 37 TURQUOISE HIL

ID	Sub Basin Data							Sub Basin Hydrology Summary					
	Area (acres)	Length (ft)	USGE	DSGE	Slope (ft/mi)	Kb		2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
Major Basin ID: 01													
A	1.7	583	1,700.00	1,410.00	2,626.4	0.193	Q (cfs)	2.6	3.7	4.4	6.0	7.4	8.7
							C	0.55	0.55	0.55	0.61	0.66	0.69
							CA (ac)	0.91	0.91	0.91	1.01	1.09	1.14
							Tc (min)	6	5	5	5	5	5
							i (in/hr)	2.88	4.02	4.84	5.93	6.77	7.62
B	1.0	586	1,700.00	1,400.00	2,703.1	0.200	Q (cfs)	1.6	2.3	2.8	3.7	4.6	5.4
							C	0.55	0.55	0.55	0.61	0.66	0.69
							CA (ac)	0.57	0.57	0.57	0.63	0.68	0.71
							Tc (min)	6	5	5	5	5	5
							i (in/hr)	2.87	4.02	4.84	5.93	6.77	7.62

* Non default value

ID	Method	Duration	2 Yr	5 Yr	10 Yr	25 Yr	50 Yr	100 Yr
DEFAULT	NOAA14	5 MIN	0.247	0.335	0.403	0.494	0.564	0.635
	NOAA14	10 MIN	0.377	0.511	0.614	0.752	0.858	0.967
	NOAA14	15 MIN	0.467	0.633	0.761	0.932	1.064	1.198
	NOAA14	30 MIN	0.629	0.852	1.025	1.255	1.433	1.614
	NOAA14	1 HOUR	0.778	1.055	1.268	1.553	1.773	1.997
	NOAA14	2 HOUR	0.897	1.198	1.428	1.741	1.979	2.226
	NOAA14	3 HOUR	0.979	1.283	1.523	1.860	2.128	2.406
	NOAA14	6 HOUR	1.163	1.488	1.748	2.100	2.376	2.663
	NOAA14	12 HOUR	1.301	1.646	1.916	2.282	2.562	2.851
	NOAA14	24 HOUR	1.551	2.011	2.372	2.879	3.277	3.691



KVL Consultants, Inc.
Noaa14CellIndex64.wor

Cell Size = 2500'x2500'

NOAA 14 Cell Index

Map No. 64

APPENDIX D

DRAINAGE SWALE

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P.O. Box 22131
Phoenix, Arizona 85028

Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Thursday, Sep 1 2016

Lot 37 Turquoise Hill - Section A Pre

User-defined

Invert Elev (ft)	= 1403.50
Slope (%)	= 18.90
N-Value	= 0.035

Calculations

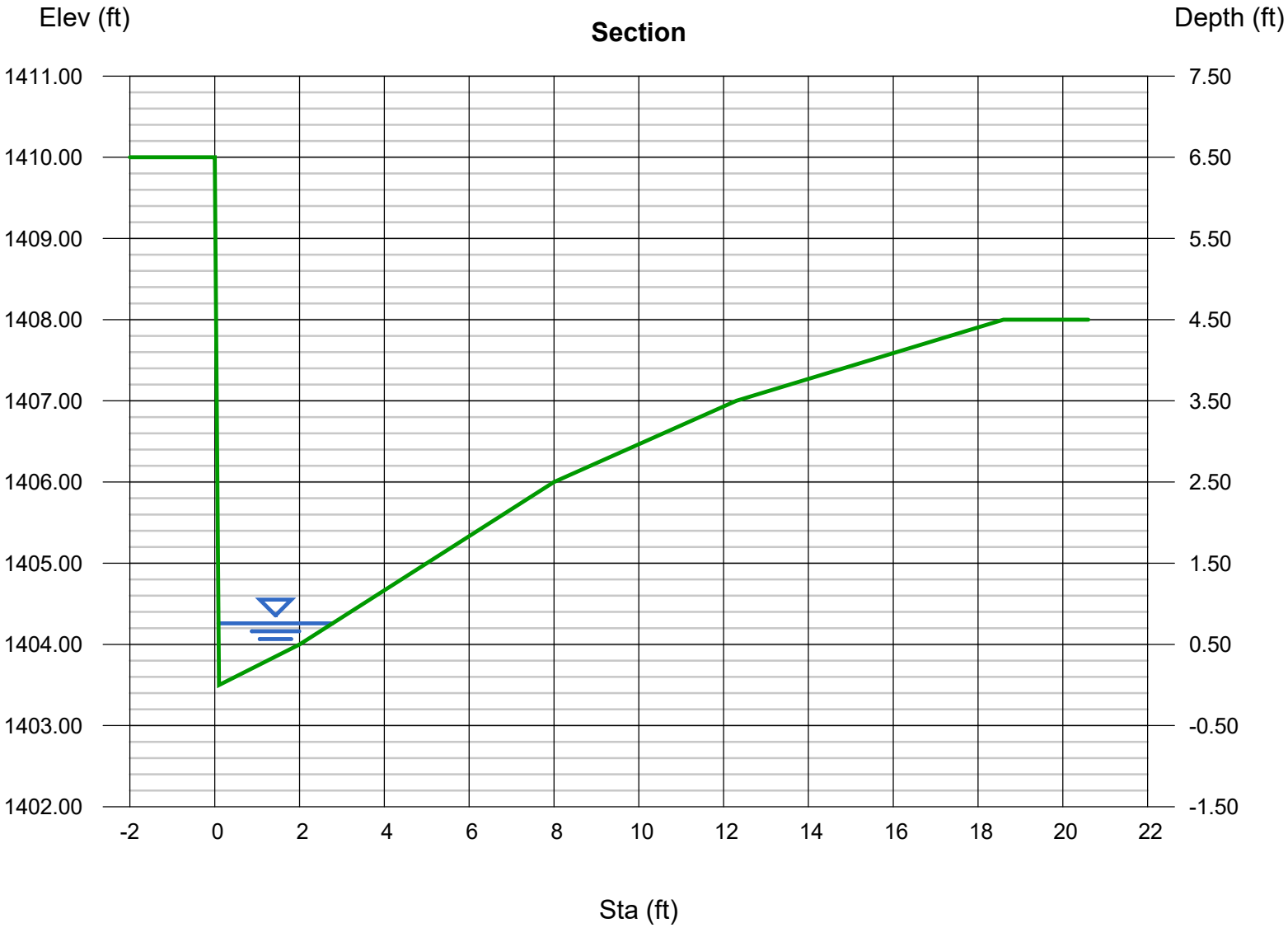
Compute by:	Known Q
Known Q (cfs)	= 8.70

Highlighted

Depth (ft)	= 0.76
Q (cfs)	= 8.700
Area (sqft)	= 1.07
Velocity (ft/s)	= 8.09
Wetted Perim (ft)	= 3.55
Crit Depth, Yc (ft)	= 1.07
Top Width (ft)	= 2.69
EGL (ft)	= 1.78

(Sta, El, n)-(Sta, El, n)...

(0.00, 1410.00)-(0.10, 1403.50, 0.035)-(2.00, 1404.00, 0.035)-(5.00, 1405.00, 0.035)-(8.00, 1406.00, 0.035)-(12.30, 1407.00, 0.035)-(18.60, 1408.00, 0.035)



Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Thursday, Sep 1 2016

Lot 37 Turquoise Hill - Section A Post

User-defined

Invert Elev (ft)	= 1404.00
Slope (%)	= 18.90
N-Value	= 0.035

Calculations

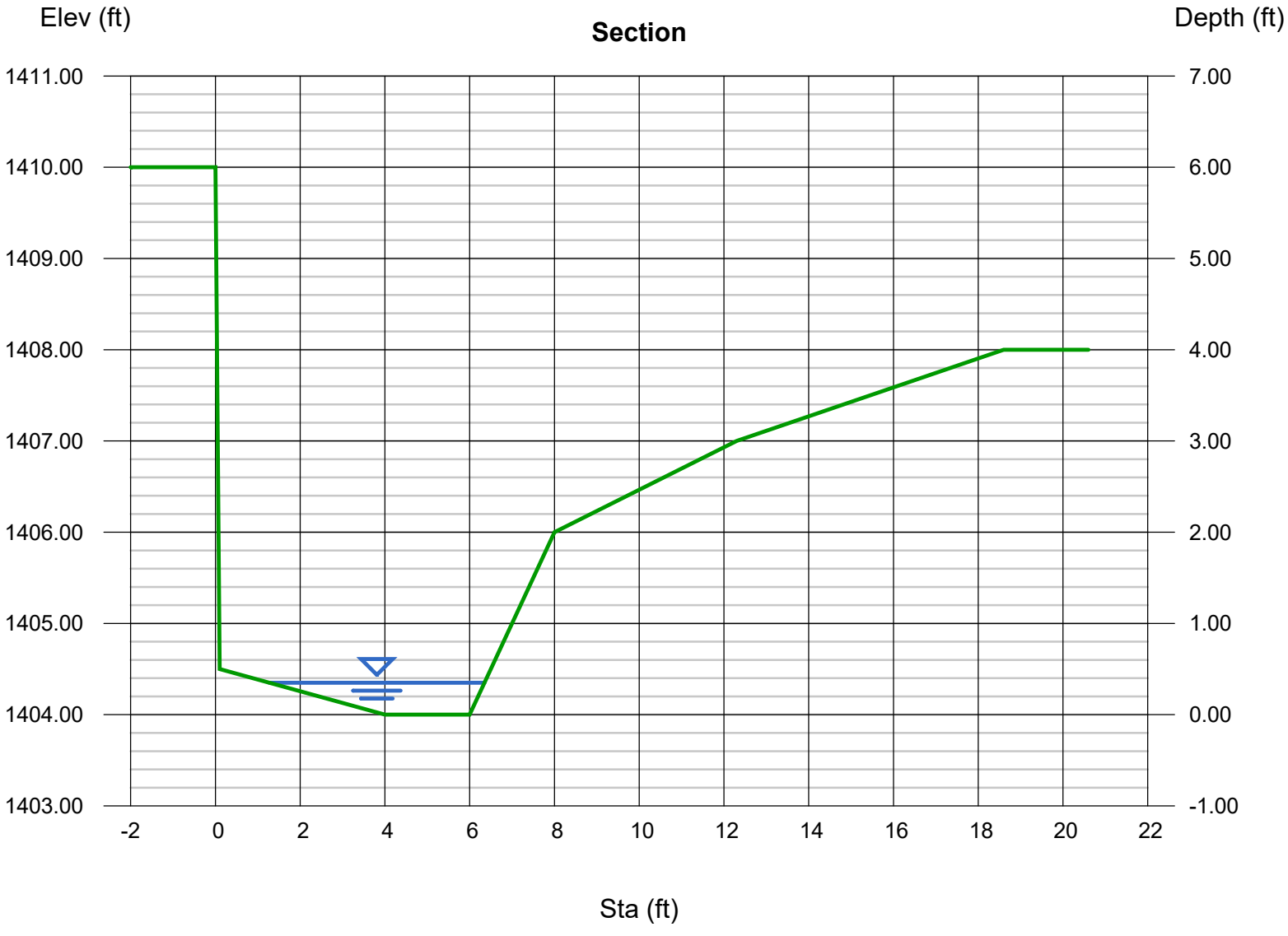
Compute by:	Known Q
Known Q (cfs)	= 8.70

Highlighted

Depth (ft)	= 0.35
Q (cfs)	= 8.700
Area (sqft)	= 1.24
Velocity (ft/s)	= 7.02
Wetted Perim (ft)	= 5.25
Crit Depth, Yc (ft)	= 0.56
Top Width (ft)	= 5.08
EGL (ft)	= 1.12

(Sta, El, n)-(Sta, El, n)...

(0.00, 1410.00)-(0.10, 1404.50, 0.035)-(4.00, 1404.00, 0.035)-(6.00, 1404.00, 0.035)-(8.00, 1406.00, 0.035)-(12.30, 1407.00, 0.035)-(18.60, 1408.00, 0.035)



APPENDIX E

SITE PHOTOGRAPHY

Terra Dynamic Engineering
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Phoenix, Arizona 85028

Lot 37 Turquoise Hills
Site Photographs

Viewing upstream along Watershed A' wash along the southeast portion of the site.

Viewing downstream along Watershed A' wash along the southeast portion of the site.

Lot 37 Turquoise Hills
Site Photographs

Viewing downstream along the east side of the house, January 2016.

Viewing downstream along the east side of the house, December 2015.

Lot 37 Turquoise Hills
Site Photographs

Viewing downstream along the east side of the house, near the door, January 2016.

Viewing downstream along the east side of the house, near the door, December 2015, Note debris on concrete slab

Lot 37 Turquoise Hills
Site Photographs

Viewing upstream along the east side of the house, January 2016.

Viewing along the west side of the property.

Lot 37 Turquoise Hills
Site Photographs

Viewing west at the “berm” from adjacent property along the eastern property line, note house and swale in the background

Viewing north at the “berm” from adjacent property along the eastern property line

APPENDIX F

EROSION CONTROL ANALYSIS

Terra Dynamic Engineering
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DESIGN FOR ROCK RIPRAP BANK STABILIZATION & EROSION SETBACK

Per Drainage Design Manual for Maricopa County: Hydraulics

100-Year Discharge
Per Drainage Study

$Q_{100} := 8.7 \cdot \frac{ft^3}{sec}$

Average Velocity
Per Drainage Study

$V_a := 6.33 \cdot \frac{ft}{sec}$

Maximum Velocity
Per Drainage Study

$V_{max} := 1.33 \cdot V_a$ $V_{max} = 8.4 \frac{ft}{sec}$

100-Year Flood Depth
Per Drainage Study

$D_{avg} := 0.5 \cdot ft$

Scour Depth
per Level 1 procedure in SS5 2-96

General Degradation
straight channel

$d_{gs} := 0.157 \cdot c_1 \cdot Q_{100}^{0.4}$

$d_{gs} = 0.37\,ft$

Long Term Degradation
straight channel

$d_{lts} := 0.02 \cdot c_2 \cdot Q_{100}^{0.6}$

$d_{lts} = 0.07\,ft$

Total Scour Depth
scour depth must be a minimum of 3 feet

$d_s := d_{gs} + d_{lts}$

$d_s = 0.45\,ft$

Erosion Setback
per SSA 5-96, straight channel, minimum is 20 feet

$Setback := 1 \cdot c_3 \cdot Q_{100}^{0.5}$ $Setback = 2.9\,ft$

Degradation Factors, *to maintain units consistency*

$c_1 \equiv 1 \cdot \frac{sec^{0.4}}{ft^{0.2}}$ $c_2 \equiv 1 \cdot \frac{sec^{0.6}}{ft^{0.8}}$ $c_3 \equiv 1 \cdot \frac{sec^{0.5}}{ft^{0.5}}$ $c_4 \equiv \frac{sec^3}{ft^{1.5}}$

Stone Specific Gravity
Per Section 6.6.3

$SG := 2.5$

Flow Turbulence Coefficient
1.2 for low, 0.86 for high

$C_{turb} := 1.2$

Bank Angle
with horizontal

$\Theta := atan\left(\frac{1}{3}\right)$ $\Theta = 18.43\,deg$

Channel Bank On Straight Reach - Riprap Stone Size
per Equation 6.33 FCDMC Hydraulics, bend angle less than 30 degrees

$d_{50\_bank} := \frac{V_{max}^2}{2 \cdot g \cdot C_{turb}^2 \cdot \cos(\Theta)} \cdot \left(\frac{1}{SG - 1}\right)$

$d_{50\_bank} = 0.54\,ft$ $d_{50\_bank} = 6.5\,in$

Channel Bed On Straight Reach - Riprap Stone Size
per Equation 6.33 FCDMC Hydraulics, bend angle less than 30 degrees

$d_{50\_channel} := \frac{V_{max}^2}{2 \cdot g \cdot C_{turb}^2} \cdot \left(\frac{1}{SG - 1}\right)$

$d_{50\_channel} = 0.51\,ft$ $d_{50\_channel} = 6.1\,in$

Recommended Channel Bank Stone Gradation

Minimum

$d_{min\_bank} := \frac{1}{3} \cdot d_{50\_bank}$

$d_{min\_bank} = 0.18\,ft$

$d_{min\_bank} = 2.2\,in$

Maximum

$d_{max\_bank} := 2 \cdot d_{50\_bank}$

$d_{max\_bank} = 1.08\,ft$

$d_{max\_bank} = 12.9\,in$

Recommended Channel Bed Stone Gradation

Minimum

$d_{min\_channel} := \frac{1}{3} \cdot d_{50\_channel}$

$d_{min\_channel} = 0.17\,ft$

$d_{min\_channel} = 2\,in$

Maximum

$d_{max\_channel} := 2 \cdot d_{50\_channel}$

$d_{max\_channel} = 1.02\,ft$

$d_{max\_channel} = 12.2\,in$

Provide the rip-rap with an Average Minimum d50 of 6.5 inches, ranging from a 2.2 inches minimum and a 12.9" maximum thickness

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APPENDIX G

EROSION CONTROL METHODS

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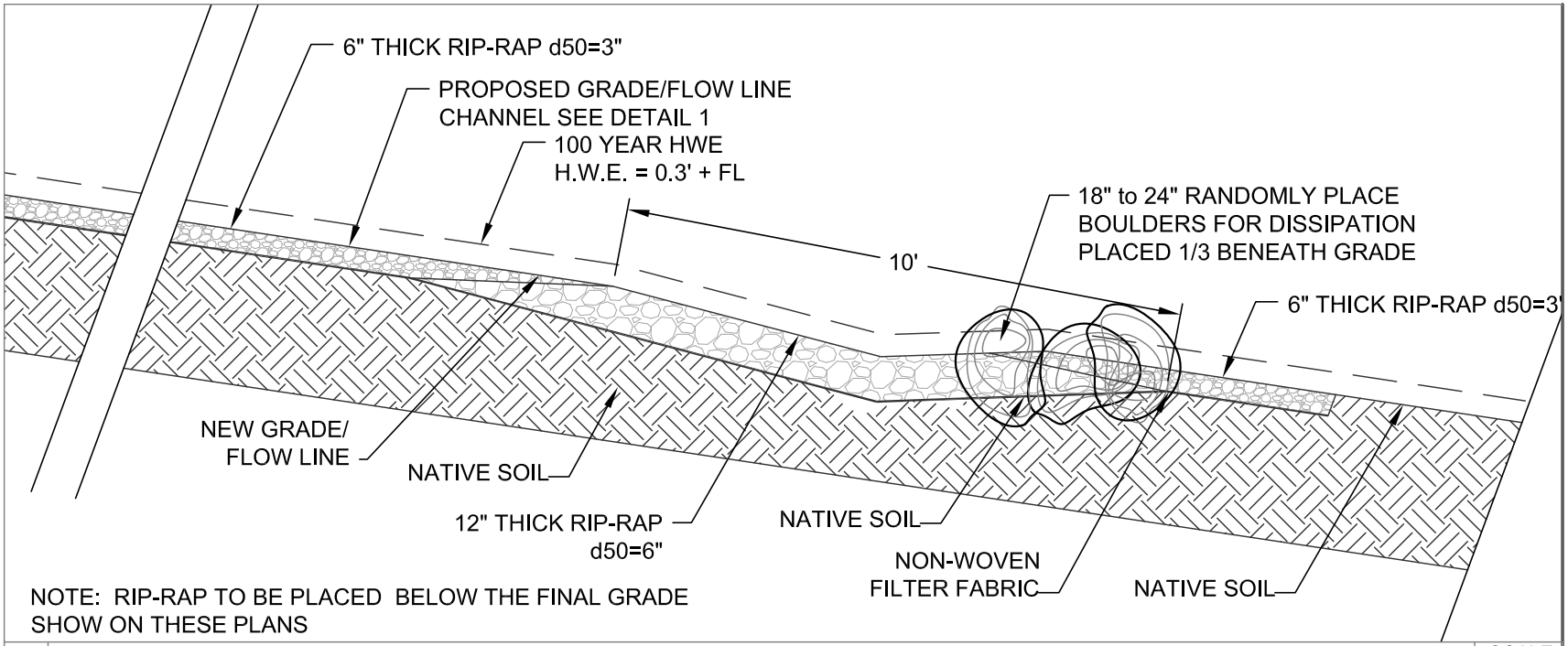

2	RIP-RAP BASIN WITH DISSIPATORS AT TRANSITION TO NATIVE SOIL	SCALE nts