Revised (PASS/FAIL) DRAINAGE ANALYSIS

USA Parkway
Existing Roadway

Project # 8480.001
Storey County,
Nevada

Prepared for:
Nevada Department of Transportation
1263 S. Stewart St.
Carson City, NV 89712

August 2012

Prepared by:

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1.0 INTRODUCTION

This report represents the preliminary hydrologic and hydraulic analysis of the facilities along the existing portion of USA Parkway. It is meant to provide guidance for future, more detailed design-level analysis at locations where issues may potentially exist. Analysis was performed in accordance with the Nevada Department of Transportation Drainage Manual (2006). Hydrologic and hydraulic analyses data and results are presented in Appendix A. Additional supporting data is presented in Appendix B.

2.0 HYDROLOGIC & HYDRAULIC ANALYSES

The hydrologic analysis consists of peak runoff flow computations for existing conditions. Based on the NDOT Drainage Manual and a roadway functional classification of "Minor Arterial", the 10-year and 25-year storm events were calculated to analyze roadway drainage facilities including culverts, channels, drop inlets, and curb & gutter. The following assumptions and methodology were applied to the hydrologic and hydraulic analyses:

- The Rational Method was utilized for the hydrologic analysis of watersheds under 100 acres.

- SCS methodology with a balanced frequency storm rainfall distribution was utilized for the hydrologic analysis of watersheds greater than 100 acres.

- USGS Regression Equations (Region 5) were also applied to the two largest watersheds (see Appendix A, Table 6 for notes regarding equation applicability). It is noted that peak flows were substantially higher for these watersheds using the SCS methodology. Refer to HEC-HMS results in Appendix B and Regression Equation results in Appendix A for a comparison.

- For the Rational Method, offsite areas were categorized as "unimproved areas" for runoff coefficient development (see Appendix A for C-value development).

- For SCS methodology, offsite areas were categorized as "sagebrush with grass understory – poor" for curve number development (see Appendix A for CN development).

- HEC-HMS was applied for SCS analysis.

- NOAA Atlas 14 point precipitation was used (see Appendix B).

- Representative precipitation points were used to provide precipitation values for multiple watersheds where applicable (see Figure 1 for precipitation points).

- Drop inlets were analyzed for capacity: stormdrain networks were not analyzed.

- A bypass analysis was not conducted: bypass flows were not added to downstream features.

- Culverts were analyzed using HY-8.

- Drop inlets, channels, and curb & gutter were analyzed using Flowmaster.

- The 25-year storm event peak flow was used to assess culvert and channel hydraulic capacity.

- The 10-year storm event was applied for drop inlet and curb & gutter analysis.

- Typical roadside channels were assigned a manning's coefficient of 0.035. Actual conditions vary based on field observation but 0.035 was found to be representative for most cases. A manning's coefficient of 0.045 was applied to a few larger roadside channels based on observed conditions as indicated in Appendix A, Table 10.

- Channel, drop inlet, and curb & gutter characteristics such as longitudinal slopes, side slopes, cross slopes, etc. were based on digital topography developed from aerial mapping in combination with field survey. Capacities were based on bank-full depth.

Please see the footnotes on the tables in Appendix A for further assumptions specific to analysis represented on each table.

3.0 RESULTS

The hydrologic and hydraulic results are presented in Appendix A. Preliminary analysis indicates that the following locations need further assessment (see Tables in Appendix A for detailed results and at the conclusion of this section for summary of deficient facilities):

- Culvert 8 – the 25-year peak flow exceeds the calculated 12" culvert capacity by 125%. Pipe elevation and size information was estimated due to an inability to remove the inlet grate and an outlet pipe was not found. A more detailed hydrologic analysis will be necessary to determine the additional improvements necessary to meet NDOT conveyance standards. Regardless of the capacity of the pipe, if the pipe size is verified to be 12”, it falls below the NDOT minimum size of 18”.

- Culvert 10 – the 25-year peak flow exceeds the calculated culvert capacity by 38%. Two hydrologic methods were used to calculate peaks for this set of culverts: SCS and Regression (see Appendix A). The SCS peaks were significantly higher (25-year peaks of 2,869 cfs using SCS and 750 cfs using Regression). However, even the calculated Regression peak exceeds capacity. In order to meet the minimum capacity to pass the 25-year event based on the Regression equations, it is estimated that an additional 2x54” CMPs are necessary. If the higher flows calculated based on SCS methodology are utilized, 8 times the existing capacity is necessary.

  Two input variables for the Regression analysis are outside of the applicable ranges: latitude of 39.52 degrees (range 36.44-39.50) and mean basin elevation of 5040 feet (range 5,770-10,500). Because the latitude is just outside of the applicable range and the mean basin elevation is below the range, and thus conservative, Regression peak flows were deemed appropriate. A more detailed analysis is necessary to determine the degree of additional improvements needed to meet NDOT standards

- Culvert 29 – the 25-year peak flow significantly exceeds the calculated culvert capacity. This culvert runs along USA Parkway under an unpaved access road. It is unlikely that it was designed to pass the 25-year event due to the severe degree of deficiency. Note that in very large flows, this culvert may not pose an impediment to flows as the dirt road may at some point wash out. However, prior to potential road wash out, flows will likely encroach into the travel-way.

- Channels as indicated in Appendix A, Table 10. A total of 10 channels were calculated to be undersized for the 25-year event. Because there is large variation in channel characteristics (varying slopes, depths, roughness, etc.), a more detailed analysis on a channel-by-channel basis is recommended to determine the degree of further action necessary. However, channels were found to be undersized by a range of 30% to 1400%.

- Drop inlets as indicated in Appendix A, Table 9. Existing spread exceeds the allowable spread of ½ travel lane width in 4 locations. Table 9 also summarizes inlet interception and bypass. Bypass flows at each inlet were calculated to be less than 1 cfs except at DI09, DI21, and DI24. A review is necessary to determine acceptable interception and bypass flows.

- Curb & gutter and barrier rail spread as indicated in Appendix A, Table 11. Existing spread exceeds the allowable spread of ½ travel lane width in 3 locations. A more detailed analysis is necessary to determine if action is needed at these locations.

Additional areas of interest include:

- Culvert 11 consists of four 36" CMP. Based on offsite contour topography and current field evidence of erosion, it appears that this culvert crossing receives much less flow than expected for four 36" CMPs. Historic aerial photos taken prior to current developed land improvements show some evidence of flow near this location. However, due to improvements in the area, flow paths have likely been altered. Extended coverage of onsite 1-foot topography (see extents of detailed topography in the area of Watersheds 33 and 34) would be useful in verifying offsite areas contributing to Culvert 11 flows.

Culvert Deficiency Summary

Existing Label	Culvert Description	Capacity (cfs)	Peak Flow (cfs)		% Deficient	Comment
			10-Year	25-Year		
C08	12" PVC	3.4	5.2	7.7	125	More detailed hydrologic analysis and verification of minimum required NDOT pipe size necessary.
C10a	52" CMP	526.9	301.1	750.3	42	Review applicable hydrologic methodology and verify estimate of an additional 2x52" CMPs necessary. See Appendix A, Table 7 notes regarding methodology.
C10b	52" CMP					
C10c	52" CMP					
C29	13.5" PVC	5.9	93.1	142.9	2339	Conduct more detailed analysis to verify potential travel-way encroachment of flow during large events.

Note: Highlighting indicates capacity deficiency

Channel Deficiency Summary

Existing Label	Channel Capacity (cfs)	25-Year Peak Flow (cfs)	% Deficient
CH03	1.4	21.6	1400
CH05	29.7	46.7	57
CH06	5.6	44.3	694
CH06a	11.2	34.1	204
CH06b	8.8	26.4	201
CH09	9.3	16.9	82
CH15	3.0	3.9	30
CH16	2.9	5.3	80
CH22	6.5	63.9	877
CH25	115.5	142.9	24

Note: Highlighting indicates capacity deficiency

Minimum Pipe Size Requirement Deficiency Summary

Existing Label	Culvert Description	Capacity (cfs)	Peak Flow (cfs)	
			10-Year	25-Year
C02	12" PVC	4.6	0.7	0.9
C03	12" PVC	6.3	1.4	1.9
C04	12" PVC	4.7	2.7	3.6
C05	12" PVC	6.5	4.0	5.4
C06	12" PVC	3.5	1.1	1.6
C07	12" PVC	6.7	1.2	1.5
C08*	12" PVC	3.4	5.2	7.7
C29	13.5" PVC	5.9	93.1	142.9

Notes: *pipe information estimated, unable to remove inlet grate, no outlet found
Highlighting indicates capacity deficiency

Curb and Gutter Deficiency Summary

Label	Length (ft)	10-Year			% Deficient
		Peak Flow (cfs)	Spread (ft)	Allowable Spread (ft)	
CG04	498	1.9	8.4	7.5	12
CG18	858	5.2	10.2	8.0	28

Notes: Highlighting indicates capacity deficiency

4.0 CONCLUSIONS

In order to meet NDOT minimum pipe size standards, eight culverts would need to be upsized at culvert locations C02, C03, C04, C05, C06, C07, C08, and C29. Additionally, culverts C08, C10, and C29 are significantly undersized from a capacity standpoint. See Appendix A for the Culvert Inlet/Outlet deficiencies table. Channels are undersized in ten locations as indicated in the Channel Deficiency Summary. Supplementary or replacement culvert and channel design (with supporting design-level hydraulic analysis) should be prepared and implemented in order to meet NDOT standards at these locations as noted. Additionally, curb and gutter, and barrier rail spread is exceeded in three locations (refer to Table 11).

Wood Rodgers analysis has been limited to an after-the-fact assessment without benefit of accurate design drawings and thus our evaluation has been limited to that field data which could readily be collected. Identification of construction defects are not within the Scope of Work. Thus, deficiencies other than inadequate sizing may exist due to improper materials or installation.

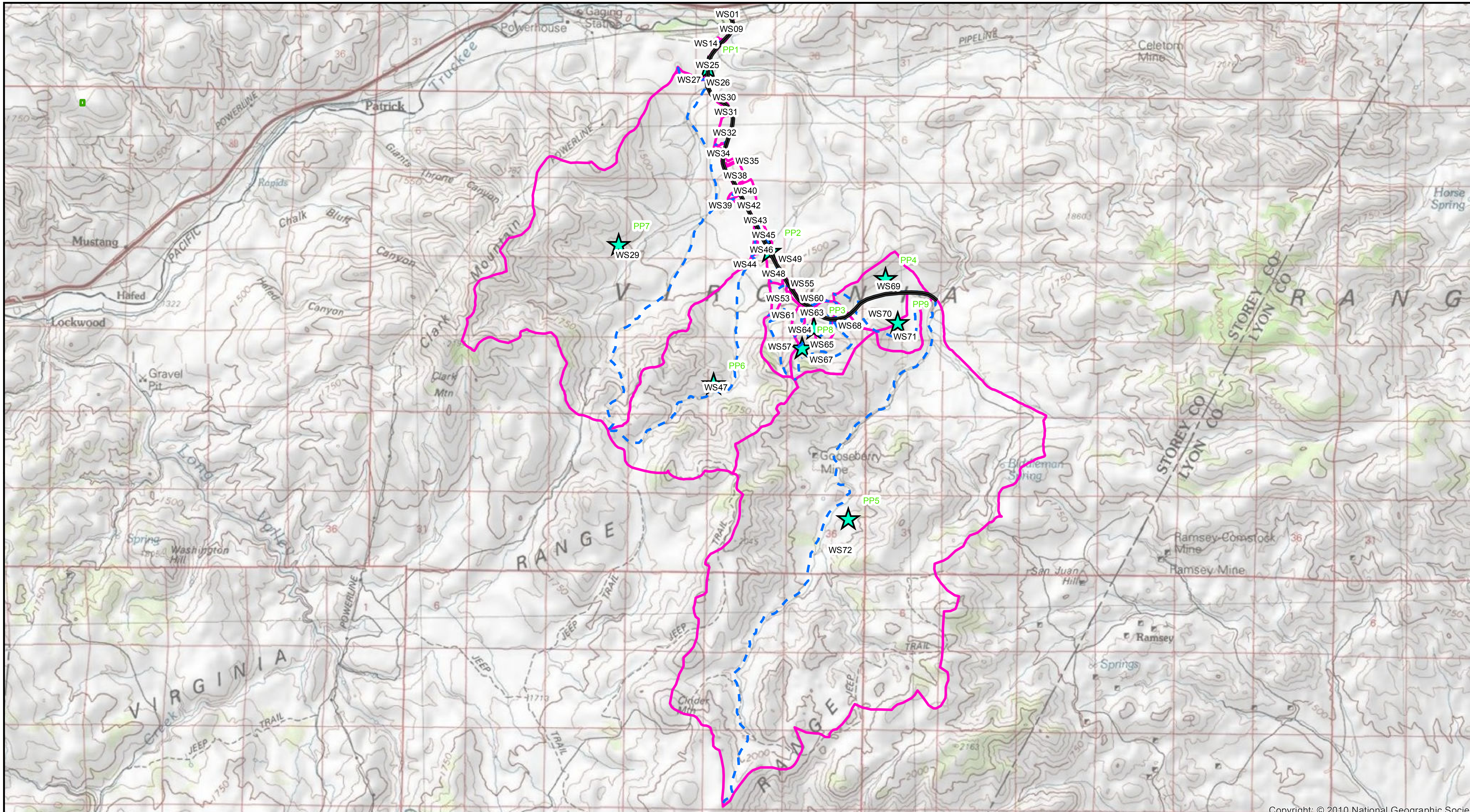

Figure 1a - Watershed Map
USA Parkway - Pass/Fail
Drainage Analysis
Storey County, Nevada
August 2012

NOTES:
BACKGROUND: USGS

Legend	
(black line)	USA Parkway
(blue dashed line)	Flowpath
(magenta line)	Watersheds
(star)	Precipitation Points

NORTH

0 3,000 6,000
FEET

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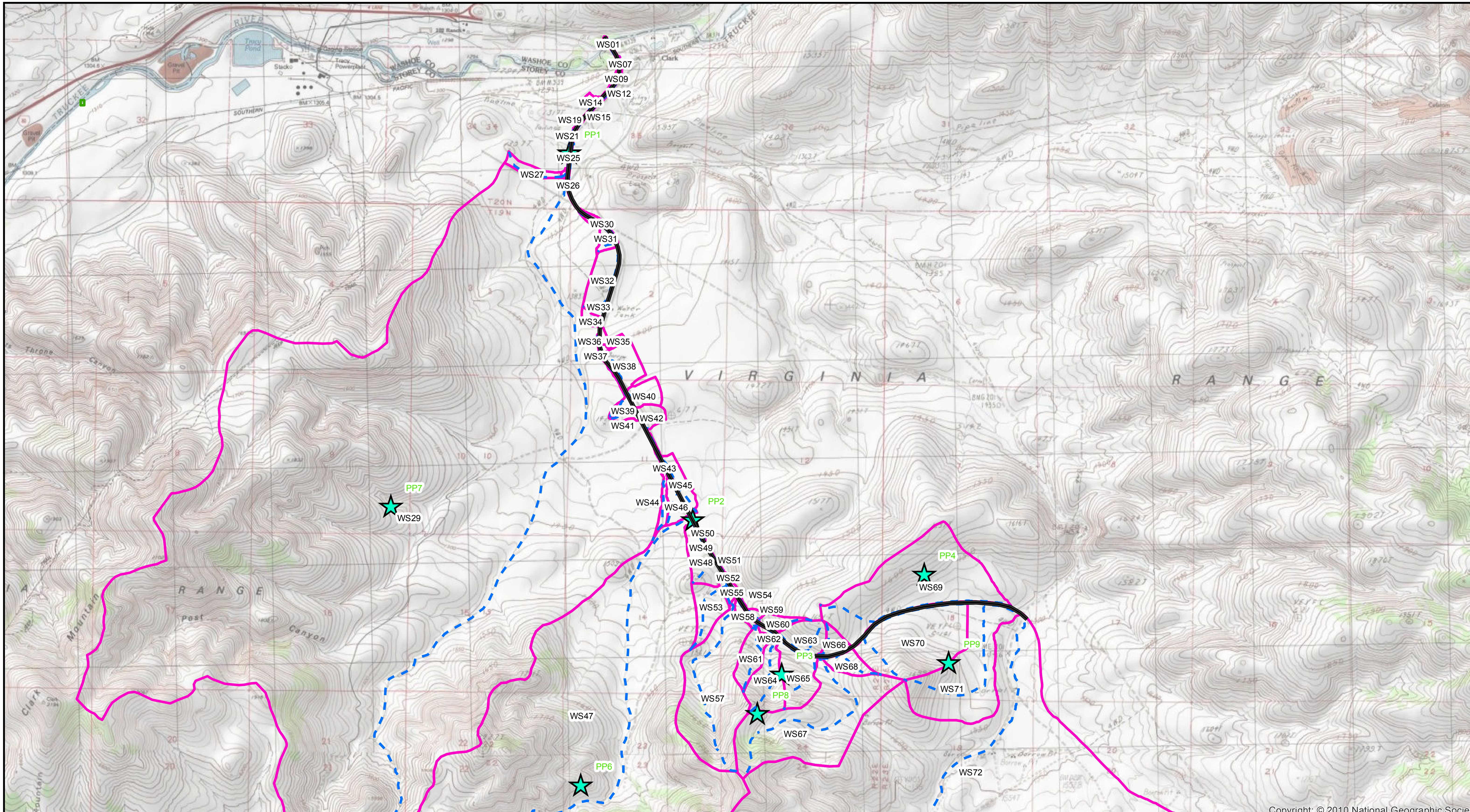

Figure 1b - Watershed Map
USA Parkway - Pass/Fail
Drainage Analysis
Storey County, Nevada
August 2012

NOTES:
BACKGROUND: USGS

Legend	
(solid black line)	USA Parkway
(dashed blue line)	Flowpath
(magenta line)	Watersheds
(star)	Precipitation Points

NORTH

0 1,500 3,000
FEET

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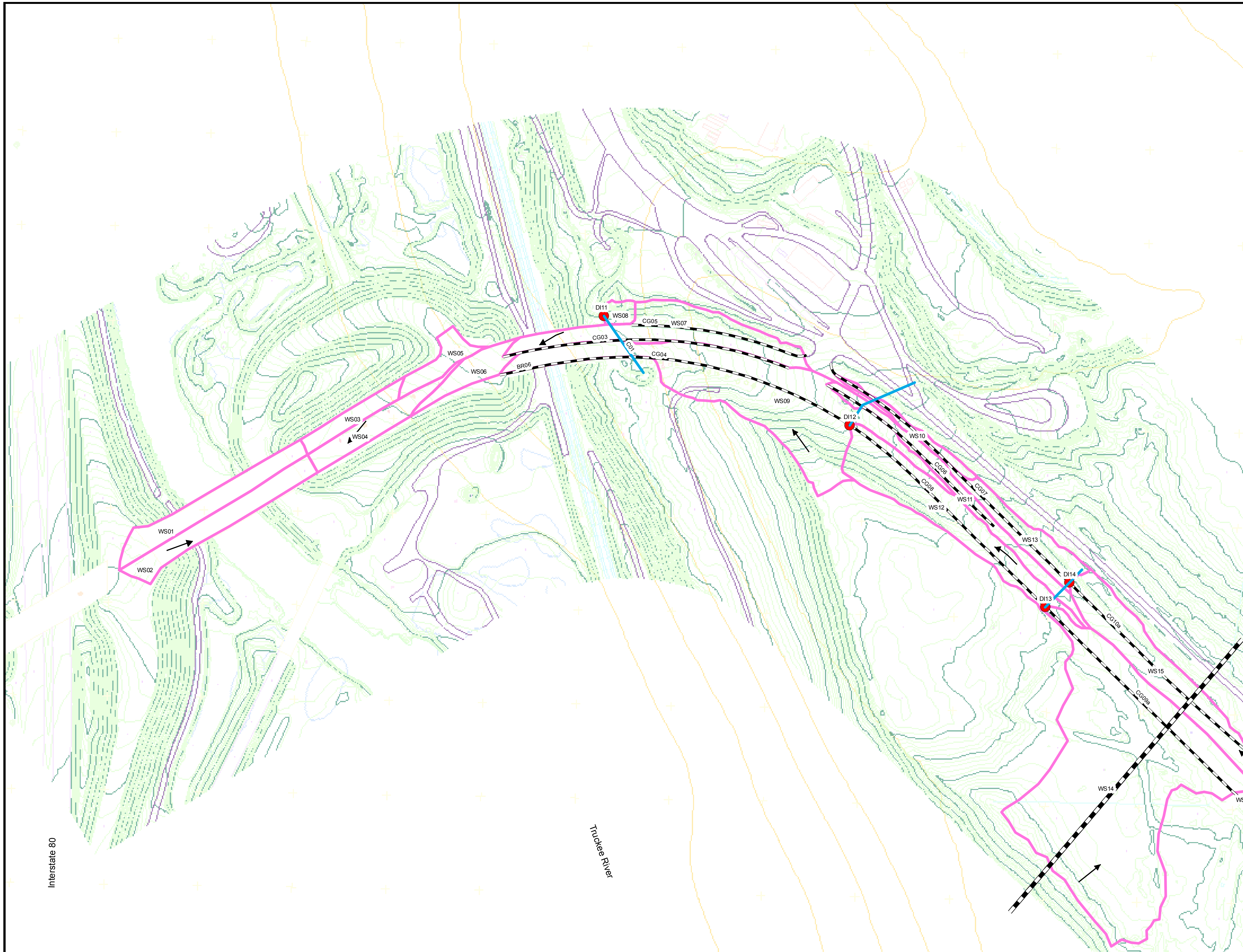

Figure 2.1 - Existing Features
USA Parkway-Pass/Fail Drainage Analysis
Storey County, Nevada
August 2012

NORTH

0 100 200
FEET

Legend

- Flow Direction
- Match Line
- Culverts
- Channels
- DIs
- Curb & Gutter
- Watersheds
- 20-foot contours

NOTES:
Aerial topography by AeroTech Mapping:
1-foot contour intervals
Background by USA Imagery

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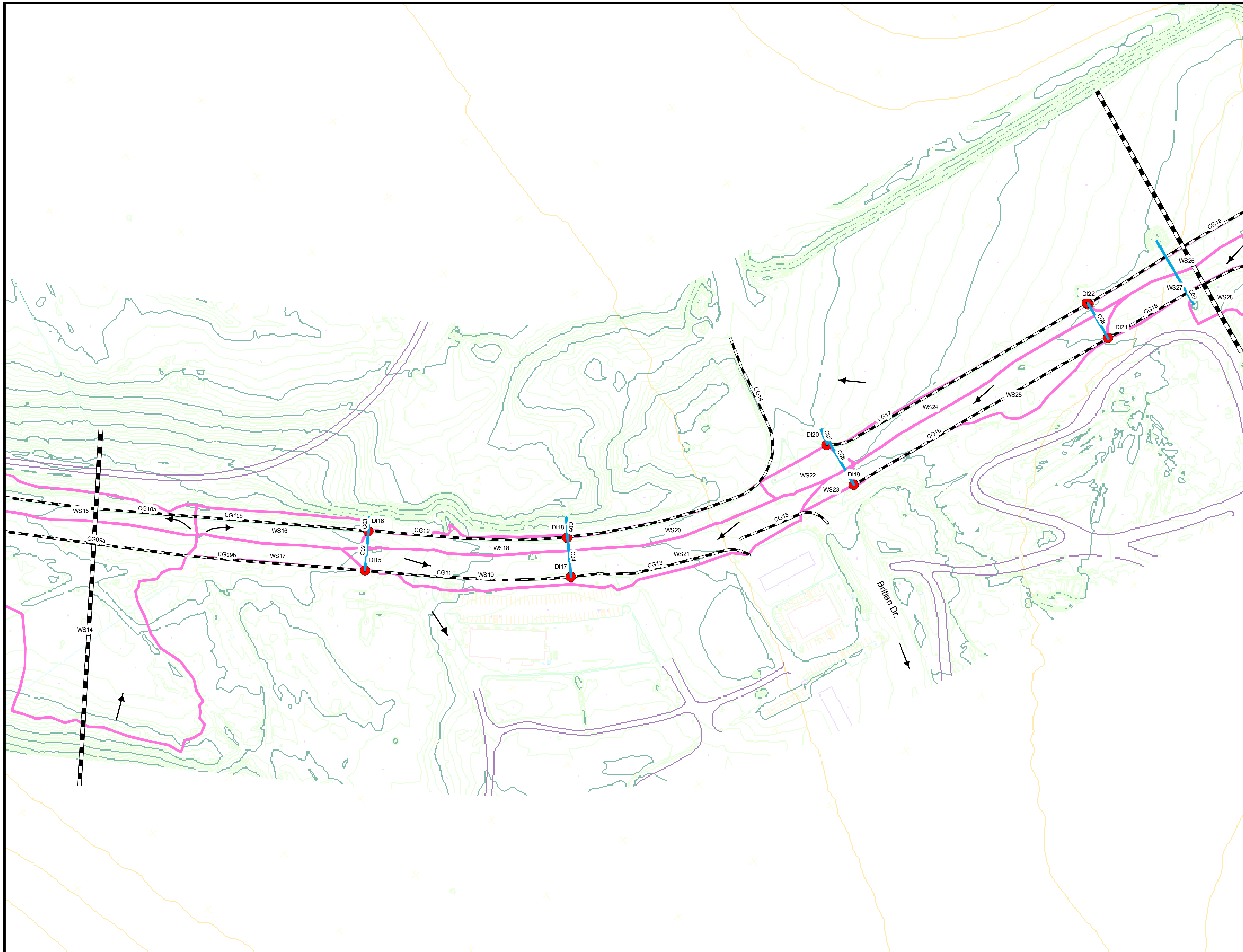

Figure 2.2 - Existing Features

USA Parkway-Pass/Fail Drainage Analysis
Storey County, Nevada
August 2012

NORTH

0 100 200
FEET

Legend

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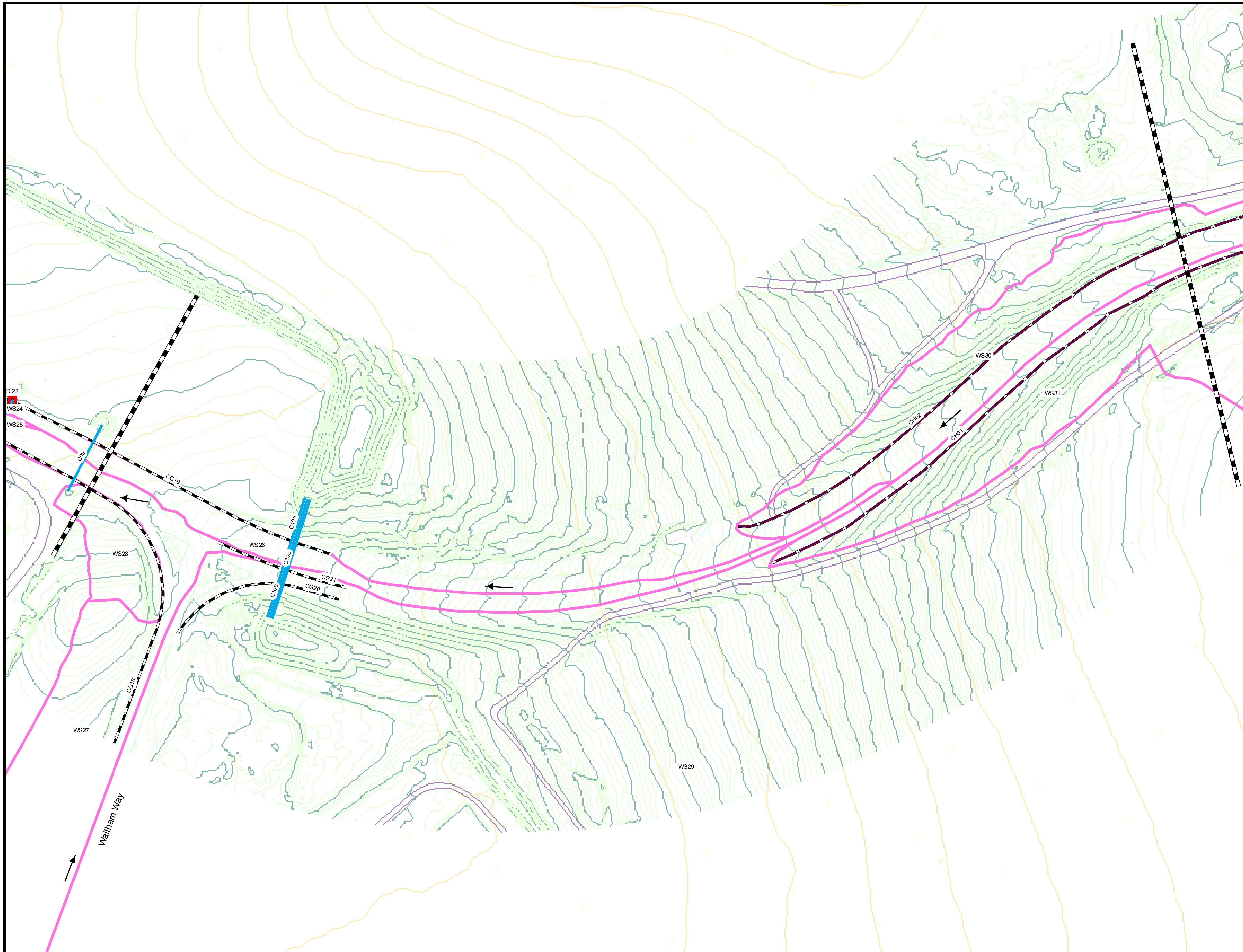

Figure 2.3 - Existing Features

USA Parkway-Pass/Fail Drainage Analysis

Storey County, Nevada

August 2012

NORTH

0 100 200

FEET

Legend

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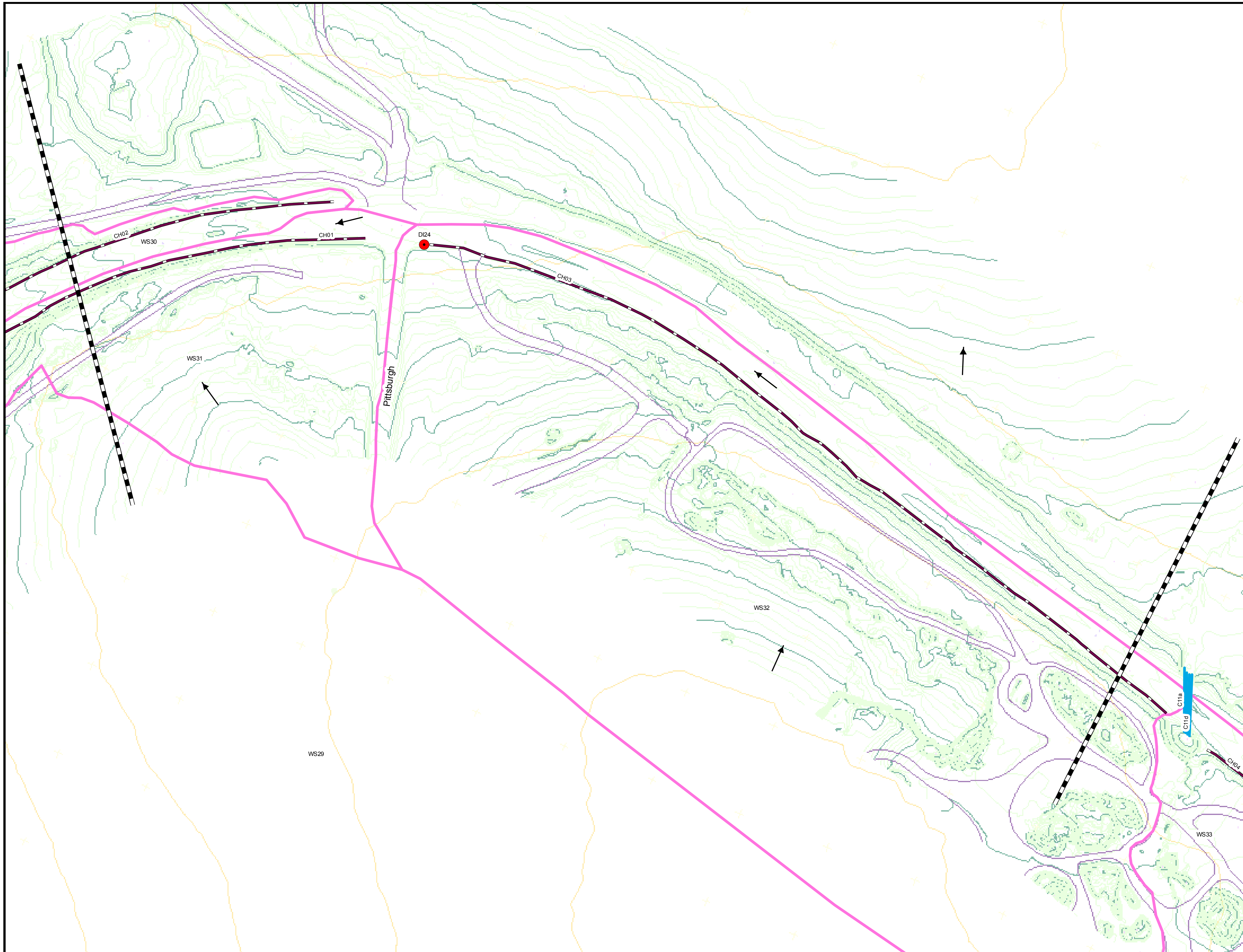

Figure 2.4 - Existing Features

USA Parkway-Pass/Fail Drainage Analysis
Storey County, Nevada
August 2012

NORTH

0 100 200
FEET

Legend

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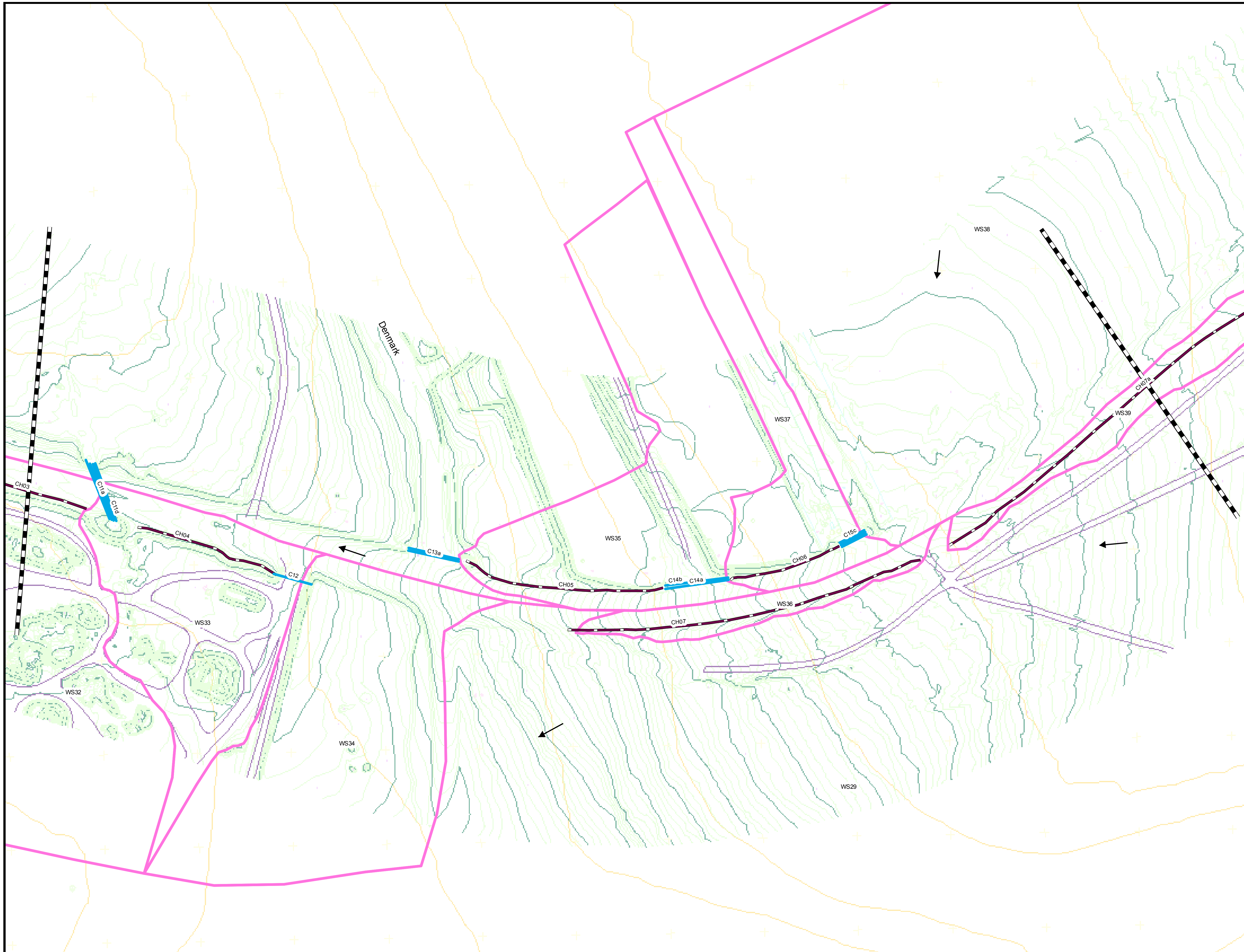

Figure 2.5 - Existing Features

USA Parkway-Pass/Fail Drainage Analysis

Storey County, Nevada

August 2012

NORTH

0 100 200

FEET

Legend

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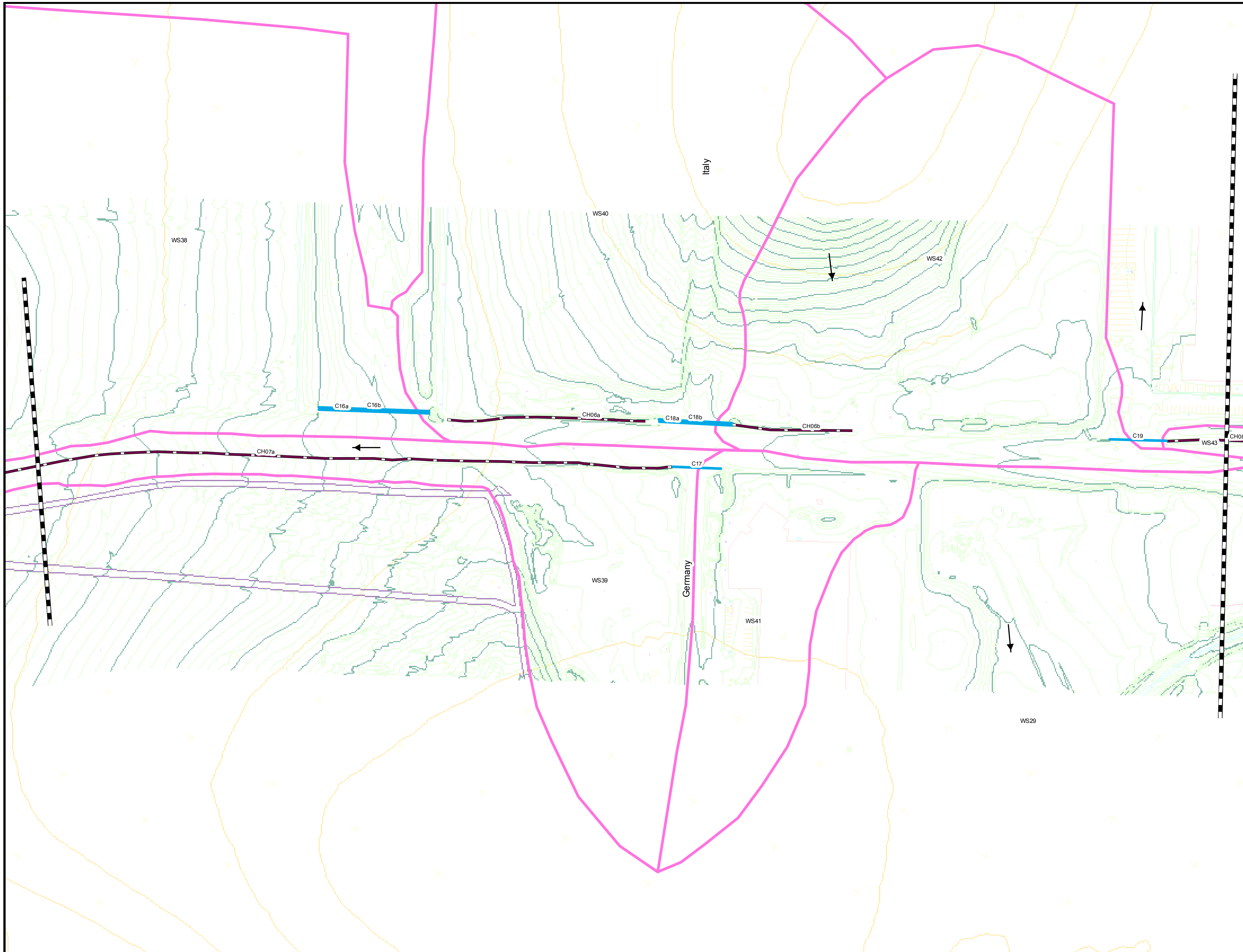

Figure 2.6 - Existing Features

USA Parkway-Pass/Fail Drainage Analysis

Storey County, Nevada

August 2012

NORTH

0 100 200

FEET

Legend

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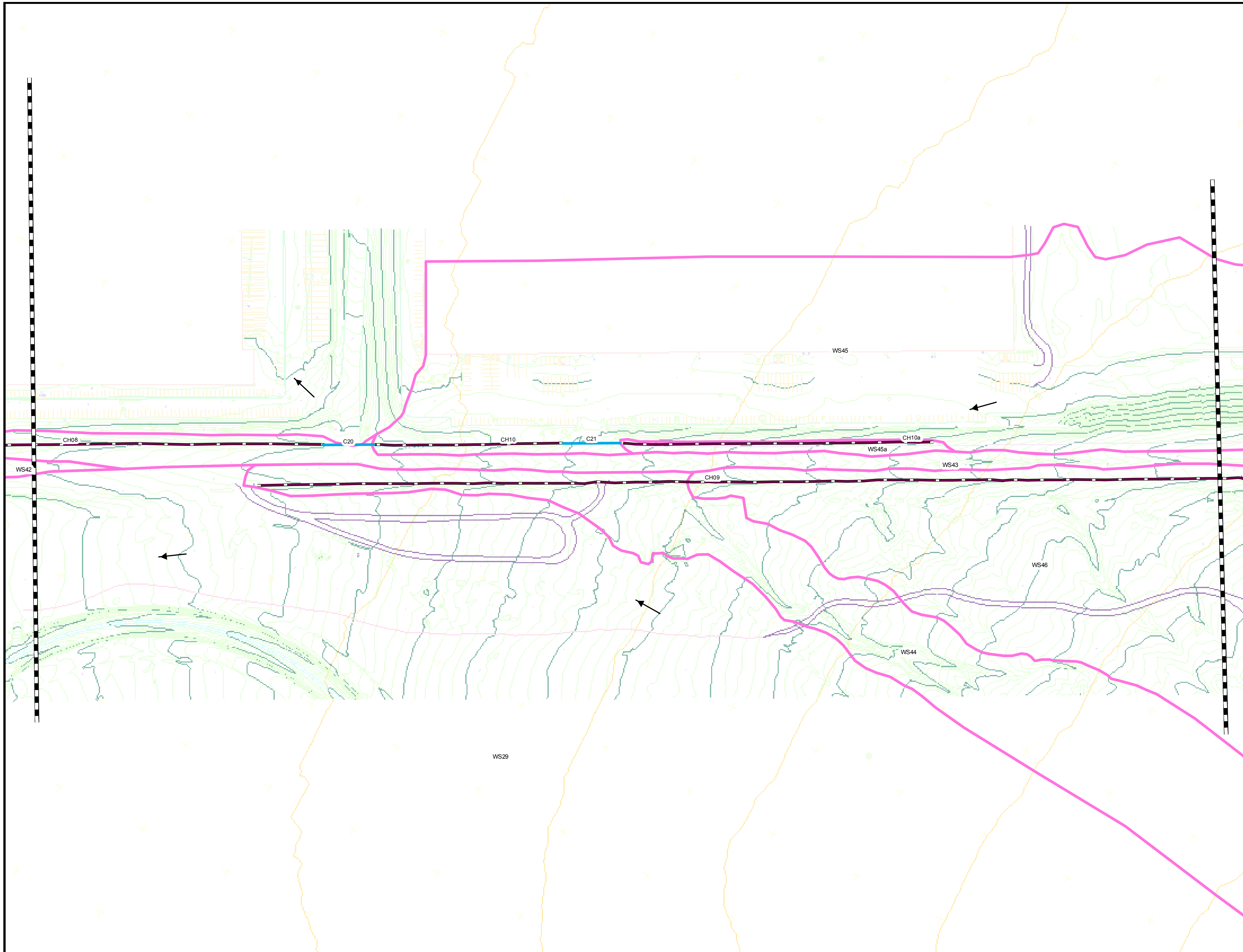
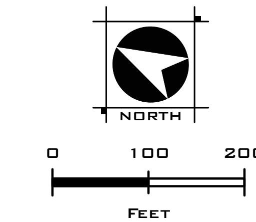
Figure 2.7 - Existing Features

USA Parkway-Pass/Fail Drainage Analysis
Storey County, Nevada
August 2012





Legend

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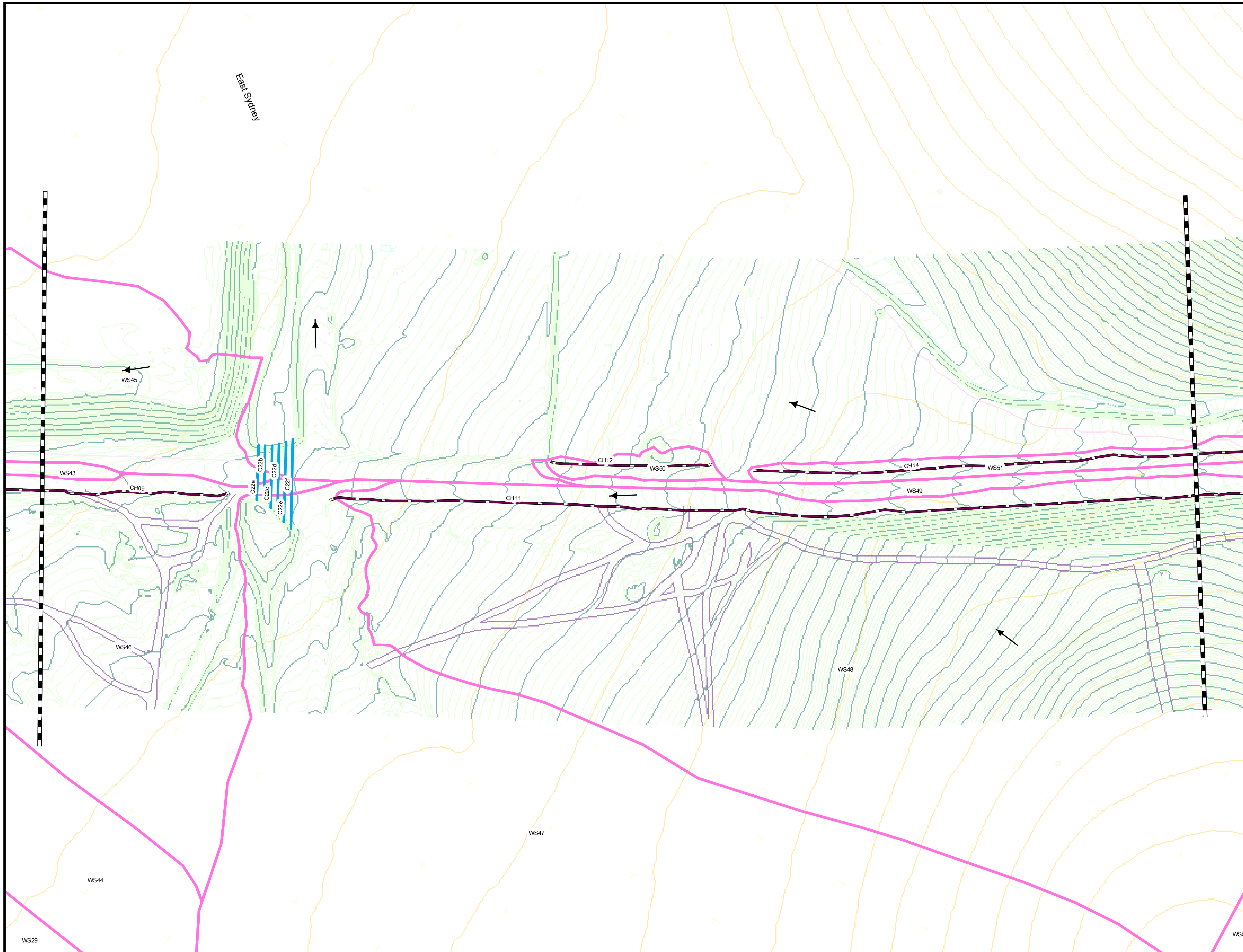

Figure 2.8 - Existing Features
USA Parkway-Pass/Fail Drainage Analysis
Storey County, Nevada
August 2012

NORTH

0 100 200
FEET

Legend

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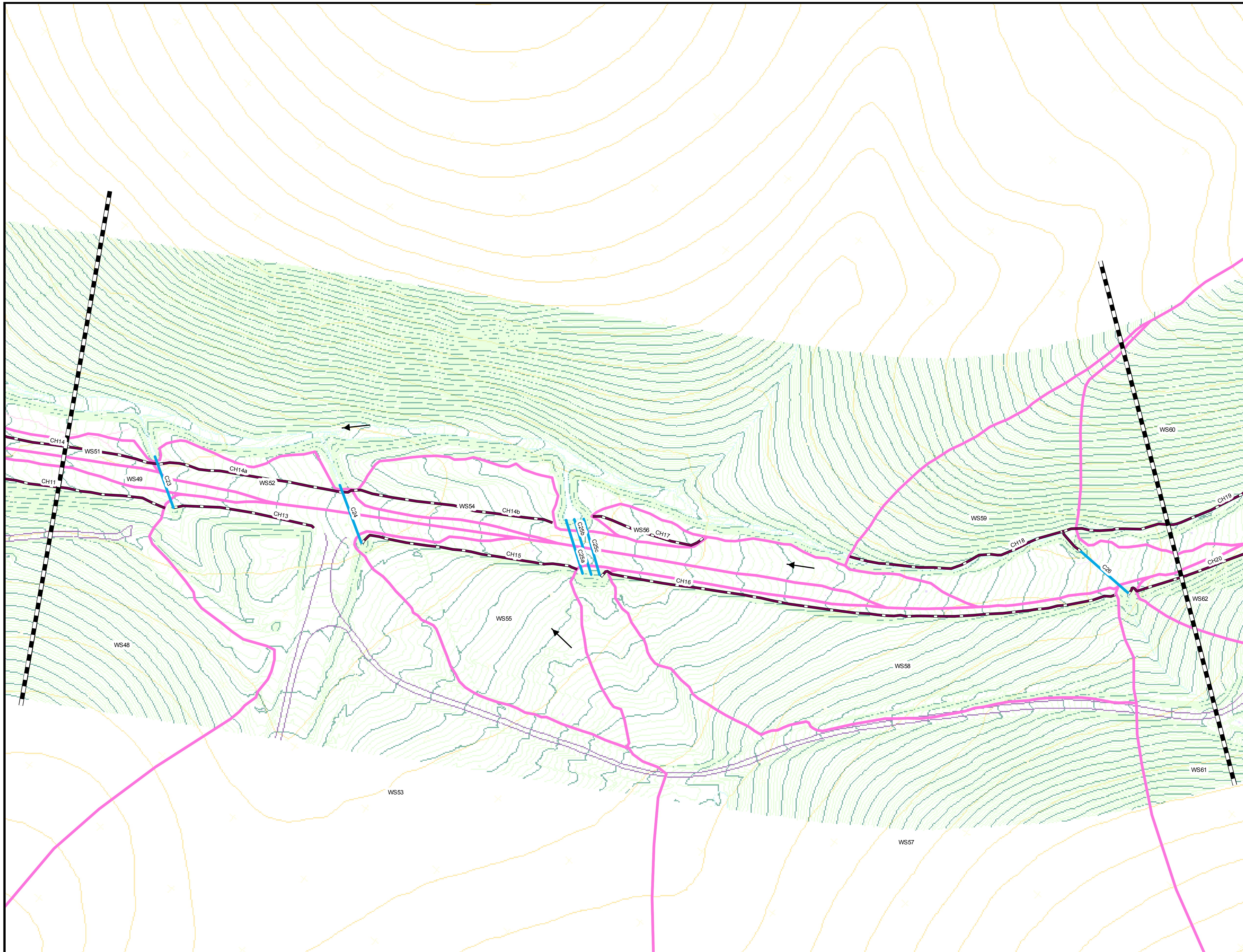

Figure 2.9 - Existing Features

USA Parkway-Pass/Fail Drainage Analysis

Storey County, Nevada

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0 100 200

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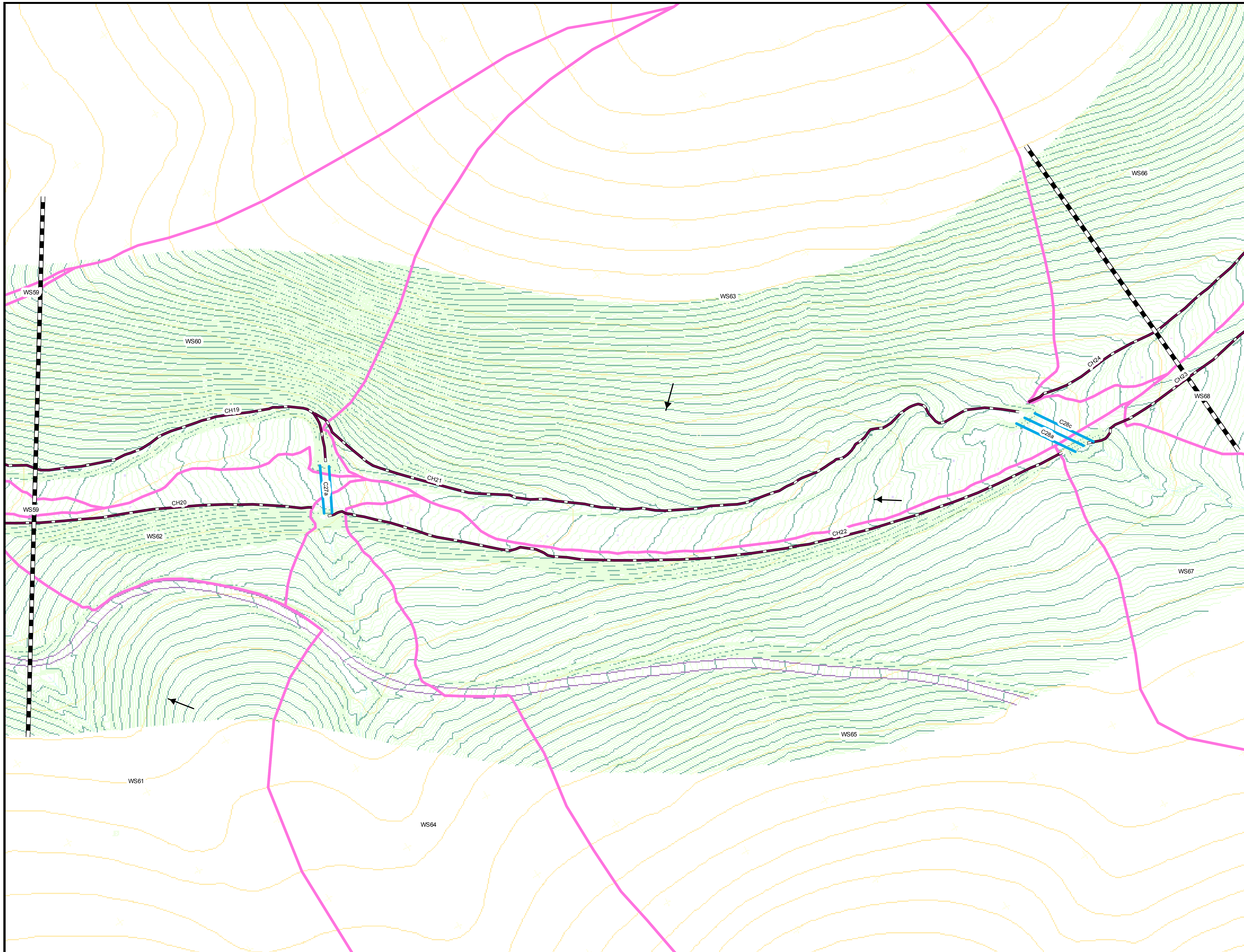

Figure 2.10- Existing Features

USA Parkway-Pass/Fail Drainage Analysis
Storey County, Nevada
August 2012

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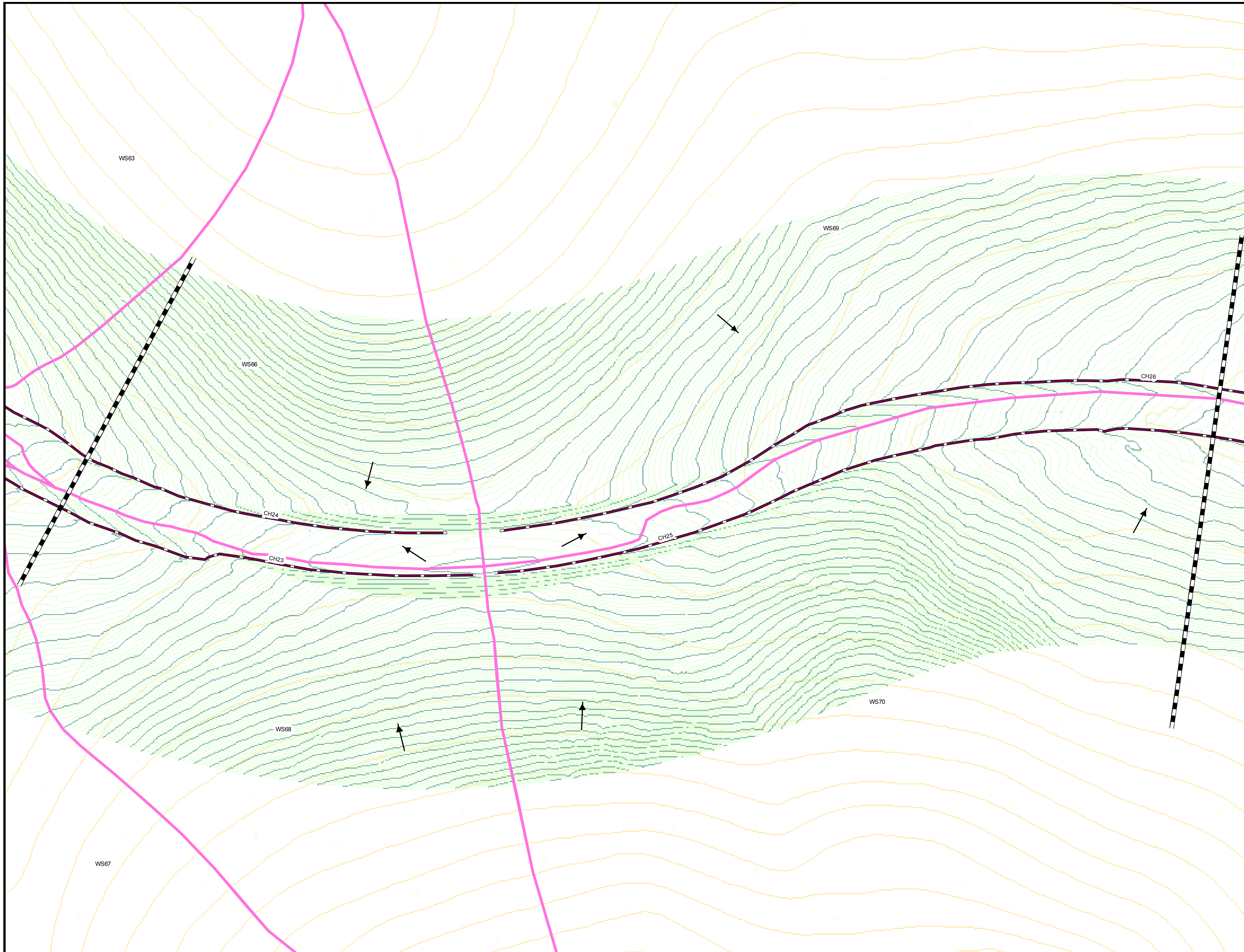

Figure 2.11 - Existing Features

USA Parkway-Pass/Fail Drainage Analysis
Storey County, Nevada
August 2012

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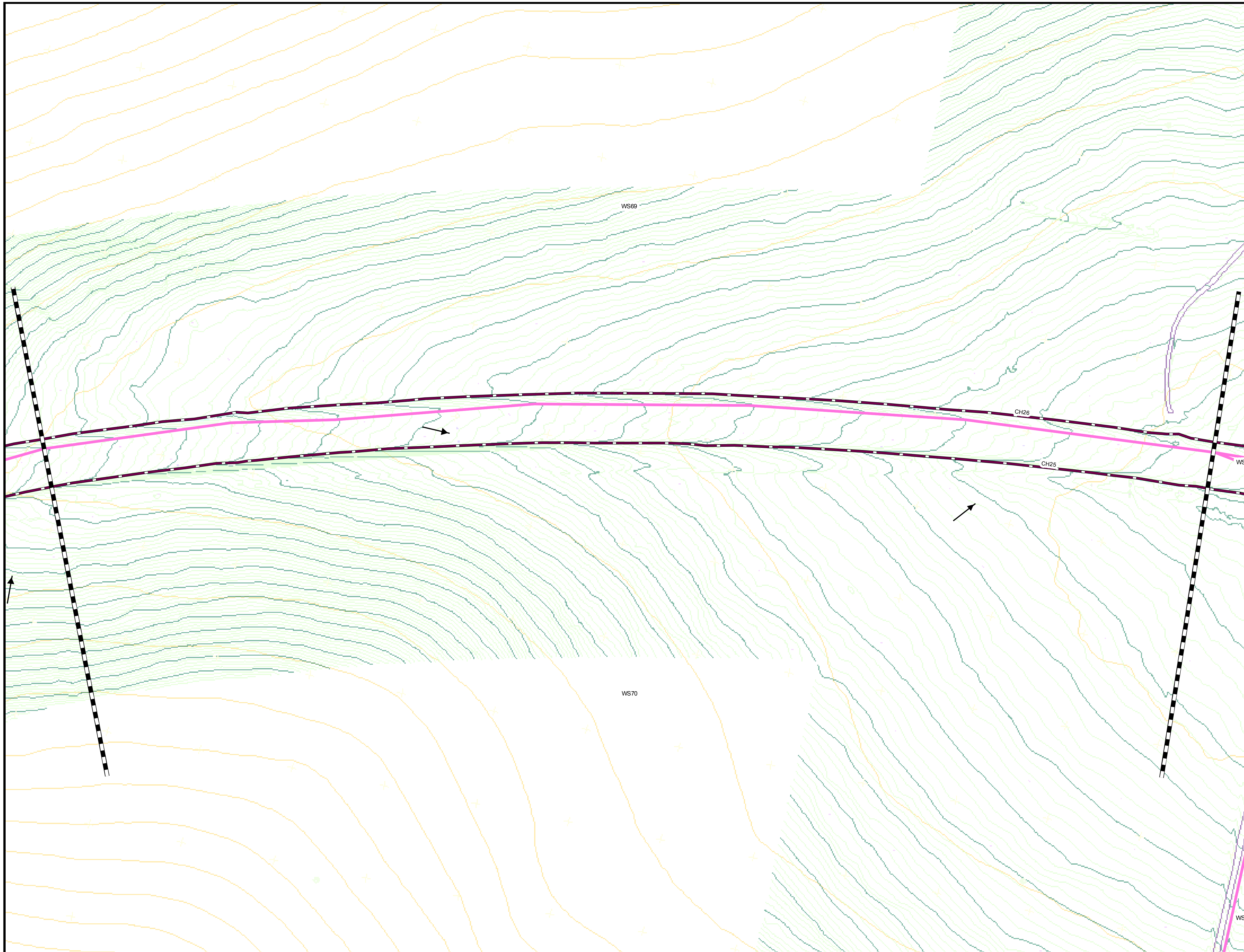

Figure 2.12- Existing Features

USA Parkway-Pass/Fail Drainage Analysis
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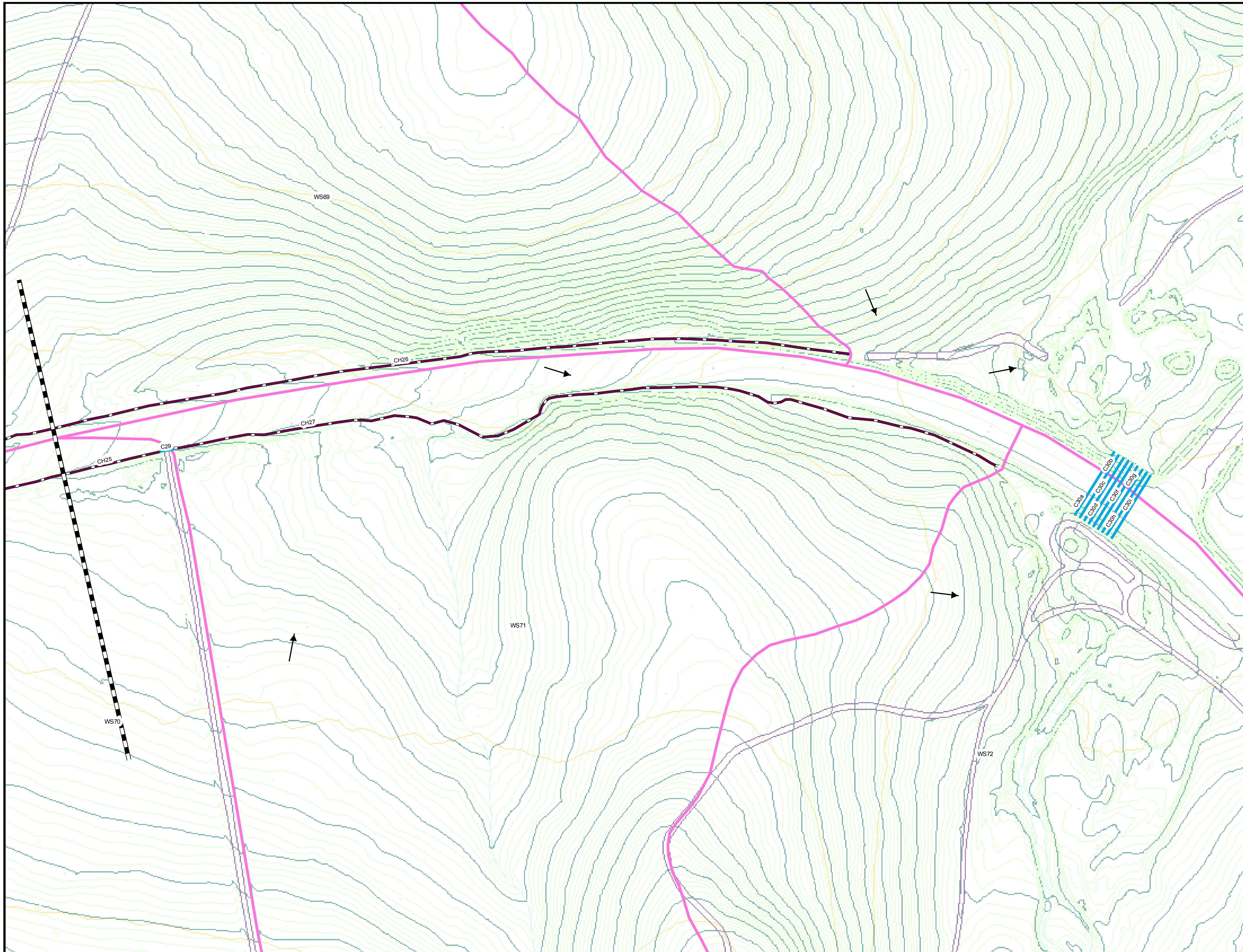

Figure 2.13- Existing Features

USA Parkway-Pass/Fail Drainage Analysis
Storey County, Nevada
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APPENDIX A

Hydrologic and Hydraulic Analysis

Table/Supporting Documentation No.	Table/Supporting Documentation Name
1	Hydrologic Soil Groups
2	Rational Method C Calculations
3	Combined Watersheds Rational Method C Calculations
4	SCS Curve Number Calculations
5	SCS Lag Time Calculations
6	USGS Regression Equations Calculations
7	Peak Flow Calculations
8	Culvert Analysis
9	Drop Inlet Analysis
10	Channel Analysis
11	Curb & Gutter/Barrier Rail Analysis
12	Culvert Inlet/Outlet Treatment Deficiencies

Table 1
Hydrologic Soil Groups

	Not Rated		Total	B		B Total	C	C Total	D									D Total	Grand Total
LABEL	Pits	Water		Patne	Perazzo		Sagouspe		Cleaver	Devada	Doorkiss	Fulstone	Lapon	Manogue	Olac	Old Camp	Xman		
WS01		0.13	0.13				0.04	0.04											0.17
WS02		0.15	0.15				0.03	0.03											0.18
WS03							0.19	0.19											0.19
WS04							0.30	0.30											0.30
WS05							0.19	0.19											0.19
WS06				0.05		0.05	0.17	0.17											0.22
WS07				0.78		0.78													0.78
WS08				0.07		0.07													0.07
WS09				1.83	0.00	1.83													1.83
WS10				0.10	0.03	0.13													0.13
WS11				0.36	0.02	0.38													0.38
WS12				0.92		0.92													0.92
WS13				0.37		0.37													0.37
WS14				3.73		3.73													3.73
WS15				0.85		0.85													0.85
WS16	0.05		0.05	0.48		0.48													0.53
WS17				0.33		0.33													0.33
WS18	0.36		0.36	0.01		0.01													0.37
WS19	0.52		0.52	0.22		0.22													0.74
WS20	0.39		0.39																0.39
WS21	0.88		0.88		0.00	0.00													0.88
WS22	0.13		0.13		0.10	0.10													0.24
WS23	0.03		0.03		0.06	0.06													0.09
WS24					0.28	0.28						0.27						0.27	0.55
WS25					0.27	0.27						0.68						0.68	0.95
WS26									0.68			0.89						1.57	1.57
WS27					0.92	0.92						8.38		4.60				12.97	13.89
WS28												0.82						0.82	0.82
WS29									101.46	1.07	428.03	499.88	1407.88	6.66	1843.84	1094.77		5383.58	5383.58
WS30									4.56									4.56	4.56
WS31									10.61									10.61	10.61
WS32									36.01									36.01	36.01
WS33									4.27									4.27	4.27
WS34									6.70									6.70	6.70
WS35									6.25									6.25	6.25
WS36									1.00									1.00	1.00
WS37									2.81									2.81	2.81
WS38									29.81									29.81	29.81
WS39									7.32				1.74					9.06	9.06
WS40									18.20				0.88					19.08	19.08
WS41												0.40	4.95					5.35	5.35
WS42									2.45			10.50	1.28					14.23	14.23
WS43												2.75						2.75	2.75
WS44												10.78						10.78	10.78
WS45												19.92	0.16					20.08	20.08
WS46												15.24	0.31					15.55	15.55
WS47											1922.50	6.34	360.05		0.13			2289.02	2289.02
WS48											24.88		8.60					33.47	33.47
WS49											0.93		0.16					1.10	1.10
WS50											0.01		0.41					0.42	0.42
WS51											1.10							1.10	1.10
WS52											0.92							0.92	0.92
WS53											39.76		0.00					39.76	39.76
WS54											2.24							2.24	2.24
WS55											3.56							3.56	3.56
WS56											0.26							0.26	0.26

Table 1
Hydrologic Soil Groups

	Not Rated		Total	B		B Total	C	C Total	D									D Total	Grand Total
LABEL	Pits	Water		Patna	Perazzo		Sagouspe		Cleaver	Devada	Doorkiss	Fulstone	Lapon	Manogue	Olac	Old Camp	Xman		
WS57											202.92							202.92	202.92
WS58											5.76							5.76	5.76
WS59											3.97							3.97	3.97
WS60											12.30							12.30	12.30
WS61											30.71							30.71	30.71
WS62											3.24							3.24	3.24
WS63											33.15							33.15	33.15
WS64											49.37							49.37	49.37
WS65											49.56							49.56	49.56
WS66											14.81							14.81	14.81
WS67											235.13							235.13	235.13
WS68											19.69							19.69	19.69
WS69											241.60							241.60	241.60
WS70											164.21							164.21	164.21
WS71											173.99							173.99	173.99
WS72											8753.25	847.43			167.77		168.57	9937.03	9937.03
Grand Total	2.36	0.28	2.64	10.10	1.68	11.78	0.92	0.92	232.13	1.07	12417.82	1424.28	1786.42	11.26	2011.74	1094.77	168.57	19148.07	19163.40

Note:
Values above are in acres

Table 2
Rational Method C Calculations

Watershed	Total Area (ac)	$C_{unimproved}$			$C_{impervious}$		$C_{combined}$	
		$C_{10\text{-}yr}$	$C_{25\text{-}yr}$	Unimproved Area (ac)	$C_{10,25\text{-}yr}$	Impervious Area (ac)	10-yr	25-yr
WS01	0.45	0.30	0.35	0.00	0.90	0.45	0.90	0.90
WS02	0.44	0.30	0.35	0.00	0.90	0.44	0.90	0.90
WS03	0.19	0.30	0.35	0.00	0.90	0.19	0.90	0.90
WS04	0.30	0.30	0.35	0.00	0.90	0.30	0.90	0.90
WS05	0.19	0.30	0.35	0.00	0.90	0.19	0.90	0.90
WS06	0.22	0.30	0.35	0.00	0.90	0.22	0.90	0.90
WS07	0.78	0.30	0.35	0.31	0.90	0.47	0.66	0.68
WS08	0.07	0.30	0.35	0.07	0.90	0.00	0.30	0.35
WS09	1.83	0.30	0.35	1.08	0.90	0.75	0.55	0.58
WS10	0.13	0.30	0.35	0.09	0.90	0.04	0.50	0.53
WS11	0.38	0.30	0.35	0.16	0.90	0.22	0.64	0.67
WS12	0.92	0.30	0.35	0.60	0.90	0.32	0.51	0.54
WS13	0.37	0.30	0.35	0.25	0.90	0.12	0.49	0.52
WS14	3.73	0.30	0.35	3.40	0.90	0.33	0.35	0.40
WS15	0.85	0.30	0.35	0.53	0.90	0.32	0.53	0.56
WS16	0.53	0.30	0.35	0.31	0.90	0.22	0.54	0.57
WS17	0.33	0.30	0.35	0.03	0.90	0.30	0.84	0.84
WS18	0.37	0.30	0.35	0.08	0.90	0.29	0.78	0.79
WS19	0.74	0.30	0.35	0.29	0.90	0.45	0.66	0.68
WS20	0.39	0.30	0.35	0.11	0.90	0.28	0.73	0.75
WS21	0.88	0.30	0.35	0.26	0.90	0.62	0.72	0.74
WS22	0.24	0.30	0.35	0.01	0.90	0.23	0.88	0.88
WS23	0.09	0.30	0.35	0.01	0.90	0.08	0.86	0.86
WS24	0.55	0.30	0.35	0.04	0.90	0.51	0.86	0.86
WS25	0.95	0.30	0.35	0.56	0.90	0.39	0.54	0.57
WS26	1.57	0.30	0.35	0.38	0.90	1.19	0.75	0.77
WS27	13.89	0.30	0.35	12.42	0.90	1.47	0.36	0.41
WS28	0.82	0.30	0.35	0.81	0.90	0.00	0.30	0.35
WS29	5383.58	NA	NA	NA	NA	NA	NA	NA
WS30	4.56	0.30	0.35	3.17	0.90	1.40	0.48	0.52
WS31	10.61	0.30	0.35	9.52	0.90	1.10	0.36	0.41
WS32	36.01	0.30	0.35	32.48	0.90	3.53	0.36	0.40
WS33	4.27	0.30	0.35	3.88	0.90	0.39	0.35	0.40
WS34	6.70	0.30	0.35	6.28	0.90	0.42	0.34	0.38

Table 2
Rational Method C Calculations

Watershed	Total Area (ac)	$C_{unimproved}$			$C_{impervious}$		$C_{combined}$	
		$C_{10\text{-}yr}$	$C_{25\text{-}yr}$	Unimproved Area (ac)	$C_{10,25\text{-}yr}$	Impervious Area (ac)	10-yr	25-yr
WS35	6.25	0.30	0.35	5.78	0.90	0.48	0.35	0.39
WS36	1.00	0.30	0.35	0.48	0.90	0.52	0.61	0.63
WS37	2.81	0.30	0.35	2.52	0.90	0.29	0.36	0.41
WS38	29.81	0.30	0.35	28.19	0.90	1.62	0.33	0.38
WS39	9.06	0.30	0.35	7.79	0.90	1.27	0.38	0.43
WS40	19.08	0.30	0.35	18.45	0.90	0.63	0.32	0.37
WS41	5.35	0.30	0.35	5.12	0.90	0.23	0.33	0.37
WS42	14.23	0.30	0.35	13.27	0.90	0.95	0.34	0.39
WS43	2.75	0.30	0.35	1.43	0.90	1.32	0.59	0.61
WS44	10.78	0.30	0.35	10.26	0.90	0.52	0.33	0.38
WS45	19.68	0.30	0.35	8.55	0.90	11.12	0.64	0.66
WS45a	0.41	0.30	0.35	0.12	0.90	0.29	0.73	0.74
WS46	15.55	0.30	0.35	14.70	0.90	0.85	0.33	0.38
WS47	2289.02	NA	NA	NA	NA	NA	NA	NA
WS48	33.47	0.30	0.35	32.39	0.90	1.08	0.32	0.37
WS49	1.10	0.30	0.35	0.50	0.90	0.60	0.63	0.65
WS50	0.42	0.30	0.35	0.29	0.90	0.13	0.49	0.52
WS51	1.10	0.30	0.35	0.75	0.90	0.34	0.49	0.52
WS52	0.92	0.30	0.35	0.48	0.90	0.44	0.59	0.61
WS53	39.76	0.30	0.35	39.35	0.90	0.41	0.31	0.36
WS54	2.24	0.30	0.35	1.43	0.90	0.80	0.52	0.55
WS55	3.56	0.30	0.35	3.02	0.90	0.54	0.39	0.43
WS56	0.26	0.30	0.35	0.26	0.90	0.00	0.30	0.35
WS57	202.92	NA	NA	NA	NA	NA	NA	NA
WS58	5.76	0.30	0.35	5.75	0.90	0.00	0.30	0.35
WS59	3.97	NA	NA	NA	NA	NA	NA	NA
WS60	12.30	NA	NA	NA	NA	NA	NA	NA
WS61	30.71	NA	NA	NA	NA	NA	NA	NA
WS62	3.24	NA	NA	NA	NA	NA	NA	NA
WS63	33.15	NA	NA	NA	NA	NA	NA	NA
WS64	49.37	NA	NA	NA	NA	NA	NA	NA
WS65	49.56	NA	NA	NA	NA	NA	NA	NA
WS66	14.81	NA	NA	NA	NA	NA	NA	NA
WS67	235.13	NA	NA	NA	NA	NA	NA	NA

Table 2
Rational Method C Calculations

Watershed	Total Area (ac)	$C_{unimproved}$			$C_{impervious}$		$C_{combined}$	
		$C_{10\text{-}yr}$	$C_{25\text{-}yr}$	Unimproved Area (ac)	$C_{10,25\text{-}yr}$	Impervious Area (ac)	10-yr	25-yr
WS68	19.69	NA	NA	NA	NA	NA	NA	NA
WS69	241.60	NA	NA	NA	NA	NA	NA	NA
WS70	164.21	NA	NA	NA	NA	NA	NA	NA
WS71	173.99	NA	NA	NA	NA	NA	NA	NA
WS72	9937.03	NA	NA	NA	NA	NA	NA	NA

Notes:
A runoff coefficient of 0.90 was applied for impervious areas.
A runoff coefficient of 0.30 was applied for unimproved areas in the 10-year event.
A runoff coefficient of 0.35 was applied for unimproved areas in the 25-year event.
Runoff coefficient development is not applicable for watersheds greater than 100 acres or watersheds that combine to greater than 100
See the Curve Number table for all watersheds labeled "NA" above.

Table 3
Combined Watersheds
Rational Method C Calculations

Feature	Contributing Watersheds	Combined Watersheds		
		Area (ac)	Weighted C 10-yr	Weighted C 25-yr
DI09, BR06, CG04	9, 11	2.21	0.56	0.59
CG07	10, 13	0.50	0.49	0.52
C03	16, 17	0.86	0.66	0.68
DI17, C04	19, 21	1.62	0.69	0.71
DI18	18, 20	0.76	0.75	0.77
C05	18, 19, 20, 21	2.37	0.71	0.73
C11, CH04	33, 34	10.97	0.34	0.39
C13, CH05	35, 37, 38, 40, 42, 43, 45, 45a	95.01	0.41	0.45
C14, CH06	37, 38, 40, 42, 43, 45, 45a	88.76	0.41	0.45
CH07a	39, 41	14.41	0.36	0.41
C15	38, 40, 42, 43, 45, 45a	85.95	0.41	0.45
C16, CH06a	40, 42, 43, 45, 45a	56.14	0.45	0.49
C18, CH06b	42, 43, 45, 45a	37.06	0.52	0.55
C19, CH08	43, 45, 45a	22.83	0.63	0.66
CH09	44, 46	26.34	0.33	0.38
C20, CH10	45, 45a	20.08	0.64	0.66
CH14	51, 52	2.02	0.53	0.56

Notes:
Example Calculation: C10yr(WS9+WS11) = ((0.55*1.83)+(0.64*0.38))/(1.83+0.38) = 0.56

Table 4
SCS Curve Number
Calculations

Watershed	Total Area (ac)	Total Area (sq. mi.)	$CN_{unimproved}$						$CN_{impervious}$			$CN_{combined}$
			Hydro Soil Group B	Hydro Soil Group B Area (ac)	Hydro Soil Group C	Hydro Soil Group C Area (ac)	Hydro Soil Group D	Hydro Soil Group D Area (ac)	Impervious	Impervious Area (ac)	Impervious Area (%)	
WS29+	5435.94	8.494	67	0.00	80	0.00	85	5384.51	98	51.43	0.9	85.0
WS47+	2322.50	3.629	67	0.00	80	0.00	85	2322.00	98	0.49	0.0	85.0
WS57+	208.68	0.326	67	0.00	80	0.00	85	208.68	98	0.00	0.0	85.0
WS59	3.97	0.006	67	0.00	80	0.00	85	3.33	98	0.63	16.0	85.0
WS60	12.30	0.019	67	0.00	80	0.00	85	12.05	98	0.25	2.0	85.0
WS61	30.71	0.048	67	0.00	80	0.00	85	30.71	98	0.01	0.0	85.0
WS62	3.24	0.005	67	0.00	80	0.00	85	2.79	98	0.44	13.7	85.0
WS63	33.15	0.052	67	0.00	80	0.00	85	31.51	98	1.64	4.9	85.0
WS64	49.37	0.077	67	0.00	80	0.00	85	49.24	98	0.13	0.3	85.0
WS65	49.56	0.077	67	0.00	80	0.00	85	49.35	98	0.22	0.4	85.0
WS66	14.81	0.023	67	0.00	80	0.00	85	13.63	98	1.17	7.9	85.0
WS67	235.13	0.367	67	0.00	80	0.00	85	235.13	98	0.00	0.0	85.0
WS68	19.69	0.031	67	0.00	80	0.00	85	19.66	98	0.03	0.1	85.0
WS69	241.60	0.377	67	0.00	80	0.00	85	240.94	98	0.65	0.3	85.0
WS70	164.21	0.257	67	0.00	80	0.00	85	159.74	98	4.47	2.7	85.0
WS71	173.99	0.272	67	0.00	80	0.00	85	171.54	98	2.44	1.4	85.0
WS72	9937.03	15.527	67	0.00	80	0.00	85	9936.12	98	0.91	0.0	85.0

Notes:
CN values based on Technical Release 55 Urban Hydrology for Small Watersheds manual.
Cover type of "Sagebrush with grass understory" was applied.
A Hydrologic Condition of "Poor - <30% ground cover" was applied.
See HMS Time of Concentration Table for all contributing watersheds for watersheds denoted above with a "+".

Table 5
Existing Conditions
SCS Lag Time Calculations

Concentration Point	Contributing Watersheds	Total Area (ac)	TLAG (Basins < 2000 acres)						TLAG (Basins >2000 acres)					
			L (ft)	CN	S	Slope (%)	Tlag (hr)	Tlag (min)	L (mi)	Lc (mi)	Kn	S (ft/mi)	Tlag (hr)	Tlag (min)
C10	29, 31, 36, 39, 41, 44, 46	5435.94	-	-	-	-	-	-	5.34	3.15	0.10	367.03	2.12	127.03
C22	47, 48	2322.50	-	-	-	-	-	-	3.92	2.16	0.10	408.07	1.66	99.47
C25	57, 58	208.68	7181	85.0	1.76	17.6	0.31	18.64	-	-	-	-	-	-
WS59	59	3.97	1005	87.08	1.48	16.0	0.06	3.76	-	-	-	-	-	-
WS60	60	12.30	1987	85.27	1.73	19.8	0.10	6.24	-	-	-	-	-	-
WS61	61	30.71	2578	85.00	1.76	23.5	0.12	7.12	-	-	-	-	-	-
WS62	62	3.24	874	86.77	1.52	68.0	0.03	1.65	-	-	-	-	-	-
WS63	63	33.15	2362	85.64	1.68	14.9	0.14	8.13	-	-	-	-	-	-
WS64	64	49.37	3085	85.03	1.76	24.0	0.14	8.12	-	-	-	-	-	-
WS65	65	49.56	3677	85.06	1.76	23.5	0.16	9.42	-	-	-	-	-	-
WS66	66	14.81	1405	86.03	1.62	18.6	0.08	4.74	-	-	-	-	-	-
WS67	67	235.13	7632	85.00	1.76	14.3	0.36	21.69	-	-	-	-	-	-
WS68	68	19.69	2230	85.02	1.76	16.2	0.13	7.63	-	-	-	-	-	-
WS69	69	241.60	6690	85.04	1.76	5.5	0.52	31.36	-	-	-	-	-	-
WS70	70	164.21	5764	85.35	1.72	10.6	0.33	19.88	-	-	-	-	-	-
WS71	71	173.99	6787	85.18	1.74	9.5	0.40	24.06	-	-	-	-	-	-
WS72	72	9937.03	-	-	-	-	-	-	7.94	3.52	0.10	249.33	2.67	160.16

Notes:
Peak flows to concentration points are a combination of offsite and onsite flows.
For basins < 2000 acres:
S= (1000/CN)-10
Tlag = $(L^{0.8}(S+1)^{0.7})/(1900*Slope^{0.5})$
For basins > 2000 acres:
Tlag = $22.1*Kn*(L*L_c/S^{0.5})^{0.33}$
Kn = 0.1 for shrub and brush

Table 6
USGS Regression Calculations

WS29

Area (sq. mi.)	8.5
Mean Basin Elevation (ft.)	5040
Latitude (Dec. Degrees)	39.52

Q2 =	28.14	cfs
Q5 =	128.74	cfs
Q10=	301.08	cfs
Q25=	750.33	cfs
Q50=	1312.20	cfs
Q100=	2103.23	cfs

WS70 thru 72

Area (sq. mi.)	16.1
Mean Basin Elevation (ft.)	5680
Latitude (Dec. Degrees)	39.47

Q2 =	65.59	cfs
Q5 =	241.13	cfs
Q10=	500.30	cfs
Q25=	1083.46	cfs
Q50=	1745.12	cfs
Q100=	2615.19	cfs

Notes:
Analysis based on USGS Fact Sheet 123-98, September, 1999
Region 5 Equations were applied.
The mean basin elevation for both watersheds 29 and 70-72 are located below the minimum
limit of 5770' (see applicable ranges in USGS Fact Sheet).
However, a physically lower mean elevation was considered to yield conservative peak flows.
The latitude for WS29 was just outside of the applicable range of 36.44-39.50 degrees.

Table 7
Existing Conditions
Peak Flow Calculations

Concentration Point	Feature	Contributing Watersheds	Total Area (ac)	Time of Concentration														Precipitation		Runoff				Methodology
				Initial Sheet Flow					Shallow Conc. Flow				Channel Flow				Total	Intensity (in/hr)		C		Q (cfs)		
				L_i (ft)	n	P_2 (in)	S (ft/ft)	T_i (min)	L_s(ft)	S (ft/ft)	V(ft/s)	T_{t1} (min)	L_t (ft)	S (ft/ft)	V (ft/s)	T_{t2} (min)	T_c(min)	10-yr	25-yr	10yr	25-yr	10-yr	25-yr	
DI01	DI01, BR01	1	0.45	57	0.011	1.25	0.025	1.13	0	0.000	0.0	0.00	394	0.017	2.6	2.50	5.00	2.52	3.31	0.90	0.90	1.0	1.3	Rational
DI02	DI02	Bypass 1, 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Rational
DI03	DI03, BR04	3	0.19	57	0.011	1.25	0.034	1.00	0	0.000	0.0	0.00	187	0.017	2.7	1.17	5.00	2.52	3.31	0.90	0.90	0.4	0.6	Rational
DI04	DI04, BR02	2	0.44	35	0.011	1.25	0.029	0.73	0	0.000	0.0	0.00	424	0.017	2.6	2.70	5.00	2.52	3.31	0.90	0.90	1.0	1.3	Rational
DI05	DI05	Bypass 2, 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Rational
DI06	DI06, BR03	4	0.30	99	0.011	1.25	0.032	1.59	74	0.034	3.7	0.33	188	0.014	2.4	1.28	5.00	2.52	3.31	0.90	0.90	0.7	0.9	Rational
DI07	DI07, CG02	5	0.19	99	0.011	1.25	0.019	1.97	20	0.030	3.5	0.10	98	0.031	3.6	0.46	5.00	2.52	3.31	0.90	0.90	0.4	0.6	Rational
DI08	DI08, BR05	6	0.22	99	0.011	1.25	0.035	1.53	22	0.027	3.3	0.11	168	0.029	3.5	0.81	5.00	2.52	3.31	0.90	0.90	0.5	0.7	Rational
DI09	DI09, BR06, CG04	9, 11	2.21	99	0.130	1.25	0.041	10.36	122	0.200	4.5	0.46	690	0.034	3.8	3.05	13.87	1.65	2.18	0.56	0.59	2.1	2.9	Rational
DI10	DI10, CG03	7	0.78	23	0.050	1.25	0.085	1.14	0	0.000	0.0	0.00	624	0.033	3.7	2.80	10.00	1.91	2.52	0.66	0.68	1.0	1.3	Rational
DI11	DI11, C01	8	0.07	36	0.130	1.25	0.318	2.04	0	0.000	0.0	0.00	58	0.058	2.4	0.40	10.00	1.91	2.52	0.30	0.35	0.0	0.1	Rational
DI12	DI12, CG08	12	0.92	12	0.011	1.25	0.099	0.19	0	0.000	0.0	0.00	565	0.044	4.2	2.22	10.00	1.91	2.52	0.51	0.54	0.9	1.2	Rational
CG06	CG06	11	0.38	47	0.011	1.25	0.042	0.79	0	0.000	0.0	0.00	723	0.041	4.1	2.91	5.00	2.52	3.31	0.64	0.67	0.6	0.8	Rational
CG07	CG07	10, 13	0.50	99	0.050	1.25	0.061	4.15	22	0.114	3.4	0.11	583	0.041	4.1	2.35	10.00	1.91	2.52	0.49	0.52	0.5	0.7	Rational
DI13	DI13, CG09a	14	3.73	99	0.130	1.25	0.050	9.59	556	0.005	0.7	13.73	198	0.026	3.2	1.02	24.34	1.26	1.66	0.35	0.40	1.7	2.5	Rational
DI14	DI14, CG10a	15	0.85	27	0.050	1.25	0.074	1.36	0	0.000	0.0	0.00	558	0.016	2.6	3.60	5.00	2.52	3.31	0.53	0.56	1.1	1.6	Rational
DI15	DI15, CG09b, C02	17	0.33	50	0.011	1.25	0.045	0.81	0	0.000	0.0	0.00	339	0.012	2.2	2.57	5.00	2.52	3.31	0.84	0.84	0.7	0.9	Rational
DI16	DI16, CG10b	16	0.53	26	0.050	1.25	0.076	1.30	0	0.000	0.0	0.00	366	0.011	2.2	2.82	5.00	2.52	3.31	0.54	0.57	0.7	1.0	Rational
C03	C03	16, 17	0.86	26	0.050	1.25	0.076	1.30	0	0.000	0.0	0.00	366	0.011	2.2	2.82	5.00	2.52	3.31	0.66	0.68	1.4	1.9	Rational
CG11	CG11	19	0.74	99	0.011	1.25	0.015	2.15	0	0.000	0.0	0.00	401	0.017	2.6	2.53	5.00	2.52	3.31	0.66	0.68	1.2	1.7	Rational
CG13	CG13	21	0.88	96	0.011	1.25	0.018	1.97	0	0.000	0.0	0.00	509	0.009	2.0	4.31	6.27	2.36	3.11	0.72	0.74	1.5	2.0	Rational
DI17	DI17, C04	19, 21	1.62	96	0.011	1.25	0.018	1.97	0	0.000	0.0	0.00	509	0.009	2.0	4.31	6.27	2.36	3.11	0.69	0.71	2.7	3.6	Rational
CG14	CG14	20	0.39	52	0.011	1.25	0.019	1.16	0	0.000	0.0	0.00	417	0.011	2.1	3.24	5.00	2.52	3.31	0.73	0.75	0.7	1.0	Rational
CG12	CG12	18	0.37	12	0.011	1.25	0.052	0.24	0	0.000	0.0	0.00	445	0.017	2.7	2.79	5.00	2.52	3.31	0.78	0.79	0.7	1.0	Rational
DI18	DI18	18, 20	0.76	52	0.011	1.25	0.019	1.16	0	0.000	0.0	0.00	417	0.011	2.1	3.24	5.00	2.52	3.31	0.75	0.77	1.4	1.9	Rational
C05	C05	18, 19, 20, 21	2.37	96	0.011	1.25	0.018	1.97	0	0.000	0.0	0.00	593	0.013	2.3	4.30	6.26	2.37	3.11	0.71	0.73	4.0	5.4	Rational
DI19	DI19, CG16, C06	25	0.95	99	0.011	1.25	0.010	2.53	186	0.013	1.9	1.65	421	0.012	2.2	3.21	7.40	2.23	2.93	0.54	0.57	1.1	1.6	Rational
DI20	DI20, CG17, C07	24	0.55	35	0.011	1.25	0.029	0.73	0	0.000	0.0	0.00	631	0.013	2.3	4.57	5.30	2.48	3.26	0.86	0.86	1.2	1.5	Rational
DI21	DI21, CG18, C08	27	13.89	99	0.130	1.25	0.051	9.57	2063	0.036	1.9	18.17	594	0.011	2.1	4.66	32.41	1.03	1.36	0.36	0.41	5.2	7.7	Rational
DI22	DI22, CG19	26	1.57	43	0.011	1.25	0.056	0.66	0	0.000	0.0	0.00	1991	0.047	4.4	7.52	8.18	2.13	2.81	0.75	0.77	2.5	3.4	Rational
C09	C09	28	0.82	99	0.130	1.25	0.030	11.78	61	0.181	4.2	0.24	361	0.020	1.8	3.40	15.41	1.57	2.06	0.30	0.35	0.4	0.6	Rational
C10	C10	29, 31, 36, 39, 41, 44, 46	5435.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	301.1	750.3 *	Regression
CH01	CH01	31	10.61	99	0.050	1.25	0.040	4.88	621	0.036	1.9	5.45	1790	0.038	3.7	8.15	18.49	1.46	1.92	0.36	0.41	5.6	8.3	Rational

Table 7
Existing Conditions
Peak Flow Calculations

Concentration Point	Feature	Contributing Watersheds	Total Area (ac)	Time of Concentration														Precipitation		Runoff				Methodology
				Initial Sheet Flow					Shallow Conc. Flow				Channel Flow				Total	Intensity (in/hr)		C		Q (cfs)		
				L_i (ft)	n	P_2 (in)	S (ft/ft)	T_i (min)	L_s(ft)	S (ft/ft)	V(ft/s)	T_{t1} (min)	L_t (ft)	S (ft/ft)	V (ft/s)	T_{t2} (min)	T_c(min)	10-yr	25-yr	10yr	25-yr	10-yr	25-yr	
CH02	CH02	30	4.56	22	0.050	1.25	0.053	1.31	0	0.000	0.0	0.00	1726	0.042	3.3	8.64	10.00	1.91	2.52	0.48	0.52	4.2	6.0	Rational
DI24	DI24, CH03	32	36.01	99	0.050	1.34	0.020	6.22	810	0.033	1.8	7.42	1820	0.006	2.0	15.17	28.81	1.13	1.48	0.36	0.40	14.6	21.6	Rational
C11	C11, CH04	33, 34	10.97	99	0.050	1.34	0.020	6.21	614	0.015	2.0	5.24	416	0.012	2.3	2.99	14.45	1.66	2.17	0.34	0.39	6.3	9.3	Rational
C12	C12	34	6.70	99	0.050	1.34	0.020	6.21	614	0.015	2.0	5.24	0	0.000	0.0	0.00	11.46	1.86	2.43	0.34	0.38	4.2	6.3	Rational
C13	C13, CH05	35, 37, 38, 40, 42, 43, 45, 45a	95.01	99	0.050	1.34	0.349	1.99	2029	0.006	1.2	28.08	5101	0.025	4.8	17.90	47.97	0.84	1.10	0.41	0.45	32.3	46.7	Rational
C14	C14, CH06	37, 38, 40, 42, 43, 45, 45a	88.76	99	0.050	1.34	0.349	1.99	2029	0.006	1.2	28.08	4533	0.021	4.3	17.45	47.52	0.84	1.11	0.41	0.45	30.7	44.3	Rational
CH07	CH07	36	1.00	85	0.011	1.34	0.041	1.24	0	0.000	0.0	0.00	756	0.053	2.8	4.51	5.75	2.48	3.25	0.61	0.63	1.5	2.1	Rational
CH07a	CH07a	39, 41	14.41	99	0.050	1.34	0.020	6.24	399	0.020	2.3	2.91	2409	0.020	3.7	11.00	20.16	1.44	1.88	0.36	0.41	7.5	11.0	Rational
C15	C15	38, 40, 42, 43, 45, 45a	85.95	99	0.050	1.34	0.349	1.99	2029	0.006	1.2	28.08	4228	0.019	5.1	13.95	44.02	0.89	1.17	0.41	0.45	31.6	45.6	Rational
C16	C16, CH06a	40, 42, 43, 45, 45a	56.14	99	0.050	1.34	0.349	1.99	2029	0.006	1.2	28.08	2644	0.014	4.2	10.54	40.61	0.94	1.24	0.45	0.49	23.9	34.0	Rational
C17	C17	41	5.35	99	0.050	1.34	0.020	6.24	399	0.020	2.3	2.91	406	0.005	1.8	3.87	13.02	1.75	2.29	0.33	0.37	3.1	4.6	Rational
C18	C18, CH06b	42, 43, 45, 45a	37.06	99	0.050	1.34	0.349	1.99	2029	0.006	1.2	28.08	2008	0.014	3.9	8.58	38.65	0.97	1.27	0.52	0.55	18.7	26.1	Rational
C19	C19, CH08	43, 45, 45a	22.83	99	0.050	1.34	0.349	1.99	2029	0.006	1.2	28.08	1036	0.019	4.1	4.24	34.31	1.03	1.35	0.63	0.66	14.9	20.3	Rational
CH09	CH09	44, 46	26.34	99	0.130	1.34	0.040	10.15	741	0.038	1.9	6.35		#VALUE!	4.3	#VALUE!	#VALUE!	1.29	1.69	0.33	0.38	11.3	16.9	Rational
C20	C20, CH10	45, 45a	20.08	99	0.050	1.34	0.349	1.99	2029	0.006	1.2	28.08	186	0.041	4.3	0.72	30.79	1.08	1.42	0.64	0.66	13.9	18.8	Rational
C21	C21, CH10a	45a	0.41	36	0.011	1.34	0.065	0.51	0	0.000	0.0	0.00	676	0.033	2.4	4.66	5.17	2.55	3.34	0.73	0.74	0.8	1.0	Rational
C22	C22	47, 48	2322.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	444.2	645.6	SCS
CH11	CH11	48	33.47	99	0.130	1.34	0.121	6.52	1182	0.166	4.1	4.85	1188	0.043	4.6	4.30	15.66	1.60	2.09	0.32	0.37	17.1	25.7	Rational
CH12	CH12	50	0.42	45	0.050	1.34	0.034	2.71	0	0.000	0.0	0.00	288	0.045	2.3	2.13	5.00	2.57	3.37	0.49	0.52	0.5	0.7	Rational
CH14	CH14	51, 52	2.02	99	0.011	1.34	0.069	1.13	416	0.048	4.5	1.56	1497	0.041	2.7	9.10	11.79	1.84	2.40	0.53	0.56	2.0	2.7	Rational
CH14a	CH14a	52	0.92	99	0.011	1.34	0.069	1.13	416	0.048	4.5	1.56	364	0.044	2.4	2.49	10.00	1.96	2.56	0.59	0.61	1.1	1.4	Rational
CH14b	CH14b	54	2.24	99	0.011	1.47	0.067	1.09	957	0.050	4.5	3.51	309	0.045	2.9	1.79	10.00	2.01	2.63	0.52	0.55	2.3	3.2	Rational
C23	C23, CH13	53	39.76	99	0.130	1.47	0.071	7.71	2059	0.123	3.5	9.83	961	0.087	4.7	3.44	20.97	1.45	1.89	0.31	0.36	17.6	26.8	Rational
C24	C24, CH15	55	3.56	99	0.130	1.47	0.089	7.04	632	0.066	2.6	4.12	60	0.166	3.2	0.32	11.48	1.91	2.50	0.39	0.43	2.7	3.9	Rational
C25	C25	57, 58	208.68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	121.8	186.2	SCS
CH16	CH16	58	5.76	99	0.050	1.47	0.232	2.23	169	0.169	4.1	0.69	967	0.054	3.4	4.77	10.00	2.01	2.63	0.30	0.35	3.5	5.3	Rational
CH17	CH17	56	0.26	37	0.050	1.47	0.054	1.81	0	0.000	0.0	0.00	220	0.045	1.8	2.09	10.00	2.01	2.63	0.30	0.35	0.2	0.2	Rational
CH18	CH18	59, 60, 61, 62, 63, 64, 65, 66, 67, 68	451.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	246.2	378.1	SCS
C26	C26	61, 62	33.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	31.5	48.2	SCS
CH19	CH19	60, 63, 64, 65, 66, 67, 68	414.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	217.7	334.7	SCS
CH20	CH20	62	3.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.9	7.3	SCS
C27	C27	64, 65	98.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	85.7	131.5	SCS
CH21	CH21	63, 66, 67, 68	302.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	146.7	223.6	SCS

Table 7
Existing Conditions
Peak Flow Calculations

Concentration Point	Feature	Contributing Watersheds	Total Area (ac)	Time of Concentration														Precipitation		Runoff				Methodology
				Initial Sheet Flow					Shallow Conc. Flow				Channel Flow				Total	Intensity (in/hr)		C		Q (cfs)		
				L_i (ft)	n	P_2 (in)	S (ft/ft)	T_i (min)	L_s(ft)	S (ft/ft)	V(ft/s)	T_{t1} (min)	L_t (ft)	S (ft/ft)	V (ft/s)	T_{t2} (min)	T_c(min)	10-yr	25-yr	10yr	25-yr	10-yr	25-yr	
CH22	CH22	65	49.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	41.7	63.9	SCS
C28	C28	67, 68	254.82	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	132.0	201.4	SCS
CH23	CH23	68	19.69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18.4	28.2	SCS
CH24	CH24	66	14.81	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17.5	26.4	SCS
C29	C29, CH25	70	164.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	93.1	142.9	SCS
CH26	CH26	69	241.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	94.8	147.0	SCS
CH27	CH27	71, 70	338.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	179.6	275.8	SCS
C30	C30	70, 71, 72	10275.22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	500.3	1083.5 **	Regression

Notes:
* Peak flow also analyzed with SCS methodology: Q_{25} = 2869 cfs
** Peak flow also analyzed with SCS methodology: Q_{25} = 4405 cfs
SCS methodology was applied for watersheds greater than 100 acres or watersheds that combine to greater than 100 acres. See SCS methodology tables for SCS data and results.
Rational Method was applied for watersheds under 100 acres.
USGS Regression Region 5 equations were applied where indicated.
P_2 equals the 2-yr, 24 hr rainfall depth.
Channel velocities were calculated using Manning's Formula in FlowMaster, under the following assumptions: Small Roadside channels - n=0.035, 3:1 side slopes, 1' depth;
Moderate Roadside/Offsite channels - n=0.045, 3' bottom width, 3:1 side slopes, 2' depth; Large Offsite channels - n=0.050, 5' bottom width, 3:1 side slopes, 3' depth.
$V_{shallowconc.\ nearly\ bare} = 9.965*S^{0.5}$
$V_{shallowconc.\ disturbed\ unpaved} = 16.135*S^{0.5}$
$V_{shallowconc.\ paved} = 20.328*S^{0.5}$
$T_i = (0.42*L_i*n)^{0.8}/P_2^{0.5}/S^{0.4}$
$T_{t1} = L_s/V/60$
$T_{t2} = L_t/(60*V)$
Manning's values for sheet flow: 0.011 for paved/smooth surfaces; 0.05 for disturbed surfaces (fallow); 0.13 for natural range surfaces.

Table 8
Culvert Analysis

Existing Label	Culvert Description	Invert Elevations		Slope (ft/ft)	Length (ft)	Maximum Allowable Headwater (ft)	Entrance Type	Capacity (cfs)	Peak Flow (cfs)	
		Upstream (ft)	Downstream (ft)						10-Year	25-Year
C01	36" CMP	4289.24	4286.11	0.021	148	4293.2	DI11	49.0	0.0	0.1
C02	12" PVC	4341.80	4341.02	0.009	83	4343.8	DI15	4.6	0.7	0.9
C03	12" PVC	4340.71	4340.04	0.023	29	4343.9	C02, DI16	6.3	1.4	1.9
C04	12" PVC	4334.97	4334.41	0.007	84	4337.2	DI17	4.7	2.7	3.6
C05	12" PVC	4334.04	4332.17	0.045	42	4337.4	C04, DI18	6.5	4.0	5.4
C06	12" PVC	4341.64	4338.27	0.025	136	4343.1	DI19	3.5	1.1	1.6
C07	12" PVC	4338.34	4337.37	0.031	32	4341.9	DI20	6.7	1.2	1.5
C08*	12" PVC	4347.64	4347.21	0.005	86	4349.1	DI21	3.4	5.2	7.7
C09	18" CMP	4347.62	4339.95	0.050	155	4351.3	Headwall	13.5	0.4	0.6
C10a	52" CMP	4339.97	4338.00	0.008	261	4355.0	Projected	526.9	301.1	750.3 **
C10b	52" CMP	4340.16	4338.00	0.008	261	4355.0	Projected			
C10c	52" CMP	4340.28	4338.00	0.009	261	4355.0	Projected			
C11a	36" CMP	4492.30	4492.00	0.002	135	4503.0	Projected	286.8	6.6	9.8
C11b	36" CMP	4492.40	4492.00	0.003	128	4503.0	Projected			
C11c	36" CMP	4492.24	4492.00	0.002	127	4503.0	Projected			
C11d	36" CMP	4492.28	4492.00	0.002	130	4503.0	Projected			
C12	18" RCP	4507.25	4505.90	0.016	83	4516.5	Projected	26.0	4.2	6.3
C13a	42" CMP	4524.00	4518.00	0.055	110	4529.0	Projected	139.7	34.1	49.3
C13b	42" CMP	4524.00	4518.00	0.055	109	4529.0	Projected			
C14a	42" CMP	4561.83	4553.79	0.059	135	4566.3	Headwall	144.7	32.3	46.6
C14b	42" CMP	4561.82	4555.38	0.048	135	4566.3	Headwall			
C15a	3X4 RCP	4577.67	4576.52	0.020	59	4581.0	Headwall	185.1	31.5	45.5
C15b	3X4 RCP	4577.70	4576.46	0.021	59	4581.0	Headwall			
C15c	3X4 RCP	4577.72	4576.48	0.021	59	4581.0	Headwall			
C16a	3X4 RCP	4620.10	4617.26	0.012	234	4622.7	Headwall	86.0	24.0	34.1
C16b	3X4 RCP	4620.16	4617.23	0.012	234	4622.7	Headwall			
C17	24" RCP	4630.72	4629.57	0.011	102	4633.5	Projected	21.0	3.1	4.6
C18a	36" Corr. Plastic	4629.03	4628.18	0.006	154	4633.5	Projected	81.1	18.9	26.4
C18b	36" Corr. Plastic	4628.90	4628.04	0.006	155	4633.5	Projected			
C19	24" RCP	4639.02	4638.23	0.007	121	4642.5	Projected	23.7	15.1	20.5
C20	24" RCP	4650.40	4647.96	0.022	109	4653.0	Projected	19.7	13.9	18.9
C21	24" CMP	4664.42	4661.11	0.027	122	4667.0	Projected	15.5	0.8	1.0
C22a	72" CMP	4700.53	4700.05	0.004	116	4711.0	Projected	1761.4	444.2	645.6
C22b	72" CMP	4700.85	4699.78	0.009	116	4711.0	Projected			
C22c	72" CMP	4700.72	4699.85	0.007	131	4711.0	Projected			
C22d	72" CMP	4700.60	4699.69	0.006	151	4711.0	Projected			
C22e	72" CMP	4701.23	4699.92	0.008	171	4711.0	Projected			
C22f	72" CMP	4702.87	4700.19	0.014	191	4711.0	Projected			

Table 8
Culvert Analysis

Existing Label	Culvert Description	Invert Elevations		Slope (ft/ft)	Length (ft)	Maximum Allowable Headwater (ft)	Entrance Type	Capacity (cfs)	Peak Flow (cfs)	
		Upstream (ft)	Downstream (ft)						10-Year	25-Year
C23	48" CMP	4796.29	4794.40	0.016	115	4803.5	Projected	117.6	18.2	27.7
C24	48" CMP	4813.65	4811.94	0.013	130	4821.0	Projected	116.6	2.7	3.9
C25a	72" CMP	4837.10	4835.18	0.016	119	4844.0	Projected	625.9	121.8	186.2
C25b	72" CMP	4837.24	4835.25	0.016	123	4844.0	Projected			
C25c	72" CMP	4837.14	4835.41	0.014	123	4844.0	Projected			
C26	72" CMP	4895.32	4892.00	0.025	132	4907.0	Projected	335.2	31.5	48.2
C27a	72" CMP	4941.39	4940.22	0.012	102	4949.0	Projected	471.5	85.7	131.5
C27b	72" CMP	4941.34	4940.62	0.007	100	4949.0	Projected			
C28a	72" CMP	5032.00	5022.00	0.072	139	5040.0	Projected	890.0	132.0	201.4
C28b	72" CMP	5029.00	5022.00	0.050	139	5040.0	Projected			
C28c	72" CMP	5030.00	5024.00	0.043	139	5040.0	Projected			
C29	13.5" PVC	4949.50	4949.25	0.009	27	4951.5	Projected	5.9	93.1	142.9
C30a	90" CMP	4909.00	4907.00	0.013	155	4925.5	Projected	5167.0	500.3	1083.5 **
C30b	90" CMP	4910.35	4907.25	0.020	155	4925.5	Projected			
C30c	90" CMP	4910.00	4908.00	0.013	155	4925.5	Projected			
C30d	90" CMP	4909.75	4908.00	0.011	156	4925.5	Projected			
C30e	90" CMP	4910.40	4907.90	0.016	156	4925.5	Projected			
C30f	90" CMP	4909.75	4908.10	0.011	156	4925.5	Projected			
C30g	90" CMP	4908.90	4908.05	0.005	156	4925.5	Projected			
C30h	90" CMP	4909.00	4908.15	0.005	156	4925.5	Projected			
C30i	90" CMP	4911.00	4907.80	0.021	155	4925.5	Projected			

Notes:
Calculated IE by giving pipe 1.5' of cover
Calculated IE to have 0.5% slope in specified direction
Based on topo
Yellow highlighting indicates locations where culvert capacity is exceeded by 25-year event.
*Pipe information estimated, unable to remove inlet grate, no outlet found.
See Table 7 for Peak Flow calculations.
Culverts with drop inlet entrances were modeled as headwall entrances.
Culverts were analyzed as un-clogged and with free outfall at outlet.
Culverts analyzed with HY-8 software.
** 25-yr peak flow reflects Regression Equation methodology. See Table 7 for notes regarding peaks using SCS methodology.

Table 9
Drop Inlet Calculations

Existing Label	Existing Type	Location	Gutter/ Roadway Longitudinal Slope (ft/ft)	Gutter Cross-Slope (ft/ft)	Gutter Width (ft)	Pavement Cross-Slope (ft/ft) or Channel Side Slope (H:V)	Manning's n	# of Grates	Grate Width (ft)	Grate Length (ft)	Slotted Drain Length (ft)	10-Year					
												Peak Flow (cfs)	Slotted Drain Interception (cfs)	Drop Inlet Interception (cfs)	Bypass (cfs)	Existing Spread (ft)	Allowable Spread (ft)
DI01	P 1-7/8 x 4	Barrier Rail	0.015	-	-	0.015	0.015	1	2.0	2.5	-	1.0	-	0.6	0.4	7.8	8.0
DI02	P 1-7/8 x 4	Barrier Rail	sag	-	-	0.015	0.015	1	2.0	2.5	-	0.5	-	0.5	0.0	9.0	8.0
DI03	P 1-7/8 x 4	Barrier Rail	0.010	-	-	0.015	0.015	1	2.0	2.5	-	0.4	-	0.3	0.1	6.0	8.0
DI04	P 1-7/8 x 4	Barrier Rail	0.015	-	-	0.015	0.015	1	2.0	2.5	-	1.0	-	0.6	0.4	7.8	8.0
DI05	P 1-7/8 x 4	Barrier Rail	sag	-	-	0.015	0.015	1	2.0	2.5	-	0.7	-	0.7	0.0	10.8	8.0
DI06	P 1-7/8 x 4	Barrier Rail	0.010	-	-	0.015	0.015	1	2.0	2.5	-	0.7	-	0.4	0.3	7.4	8.0
DI07	P 1-7/8 x 4	Median	0.023	-	-	0.024	0.015	1	2.0	2.5	6.5	0.4	0.3	0.1	0.0	3.8	8.0
DI08	P 1-7/8 x 4	Barrier Rail	0.034	-	-	0.015	0.015	1	2.0	2.5	13.0	0.5	0.4	0.1	0.0	5.2	8.0
DI09	45 Tilt	Barrier Rail	0.024	-	-	0.019	0.015	1	1.5	3.0	-	2.1	-	1.0	1.1	8.1	8.0
DI10	45 Tilt Combo	Median	0.025	-	-	0.021	0.015	1	1.5	3.0	-	1.0	-	0.6	0.4	5.8	8.0
DI11	24" diam.	Shoulder	0.033	-	-	10.0	0.025	1	1.8	1.8	-	0.0	-	0.0	0.0	2.3	8.0
DI12	45 Tilt Combo	Curb & Gutter	0.036	0.083	1.5	0.051	0.015	1	1.5	3.0	-	0.9	-	0.9	0.0	2.6	7.5
DI13	45 Tilt Combo	Curb & Gutter	0.034	0.083	1.5	0.064	0.015	1	1.5	3.0	-	1.7	-	1.5	0.2	3.2	7.5
DI14	45 Tilt Combo	Curb & Gutter	0.027	0.083	1.5	0.048	0.015	1	1.5	3.0	-	1.1	-	1.0	0.1	3.1	7.5
DI15	45 Tilt Combo	Curb & Gutter	0.018	0.083	1.5	0.016	0.015	1	1.5	3.0	-	0.7	-	0.6	0.1	4.8	7.5
DI16	45 Tilt Combo	Curb & Gutter	0.022	0.083	1.5	0.033	0.015	1	1.5	3.0	-	0.7	-	0.7	0.0	3.1	7.5
DI17	45 Tilt Combo	Curb & Gutter	sag	0.083	1.5	0.030	0.015	1	1.5	3.0	-	2.7	-	2.7	0.0	6.5	8.0
DI18	45 Tilt Combo	Curb & Gutter	sag	0.083	1.5	0.036	0.015	1	1.5	3.0	-	1.4	-	1.4	0.0	2.5	8.0
DI19	45 Tilt Combo	Curb & Gutter	0.011	0.083	1.5	0.046	0.015	1	1.5	3.0	-	1.1	-	1.0	0.1	3.9	7.5
DI20	45 Tilt Combo	Curb & Gutter	0.034	0.083	1.5	0.023	0.015	1	1.5	3.0	-	1.2	-	1.0	0.2	4.5	8.0
DI21	45 Tilt Combo	Curb & Gutter	0.011	0.083	1.5	0.032	0.015	1	1.5	3.0	-	5.2	-	2.8	2.5	9.3	8.0
DI22	45 Tilt Combo	Curb & Gutter	0.010	0.083	1.5	0.036	0.015	1	1.5	3.0	-	2.5	-	1.7	0.8	6.5	7.5
DI23	24" diam.	Shoulder	0.010	-	-	20.0	0.025	1	1.8	1.8	-	0.0	-	0.0	0.0	0.0	8.0

Table 9
Drop Inlet Calculations

Existing Label	Existing Type	Location	Gutter/ Roadway Longitudinal Slope (ft/ft)	Gutter Cross-Slope (ft/ft)	Gutter Width (ft)	Pavement Cross-Slope (ft/ft) or Channel Side Slope (H:V)	Manning's n	# of Grates	Grate Width (ft)	Grate Length (ft)	Slotted Drain Length (ft)	10-Year					
												Peak Flow (cfs)	Slotted Drain Interception (cfs)	Drop Inlet Interception (cfs)	Bypass (cfs)	Existing Spread (ft)	Allowable Spread (ft)
DI24	24" diam.	Shoulder	0.010	-	-	6.0	0.035	1	1.8	1.8	-	14.6	-	4.1	10.6	11.8	12.0

Notes:
Topography unavailable on roadway over the Truckee River. Feature data approximated.
25% clogging factor applied for inlets on grade. Multiple grates were observed to have debris during site visits.
50% clogging factor applied for inlets in sag.
1" depth and 3' length were applied for local depressions in combination grates.
Curb opening length of 2.83' was applied for combination grates.
DI23 observed to be inoperable: plugged with soil.
Highlighting indicates locations where allowable spread is exceeded.
See Table 7 for Peak Flow calculations.
Drop Inlets analyzed with FlowMaster software.

Table 10
Channel Calculations

Existing Label	Channel Length (ft)	Channel Slope (ft/ft)	Existing Bottom Width (ft)	Existing Left Side Slope (H:V)	Existing Right Side Slope (H:V)	Existing Manning's n	Channel Depth (ft)	Channel Capacity (cfs)	25-Year Peak Flow (cfs)	Hydraulic Radius* (ft)	Applied Shear Stress (lb/ft^3)
CH01	1714	0.059	0.00	6	15	0.035	0.50	10.7	8.7	0.2	0.8
CH02	1714	0.062	0.00	3	6	0.035	1.00	29.4	6.0	0.6	2.1
CH03	1885	0.006	0.00	3	6	0.035	0.50	1.4	21.6	0.2	0.1
CH04	316	0.012	0.00	3	3	0.035	3.00	158.9	9.8	0.5	0.4
CH05	433	0.063	0.00	6	3	0.035	1.00	29.7	49.3	0.5	1.9
CH06	245	0.050	0.00	9	3	0.035	0.50	5.6	46.6	0.3	0.8
CH06a	422	0.009	0.00	6	3	0.035	1.00	11.2	34.1	0.5	0.3
CH06b	256	0.007	0.00	4	4	0.035	1.00	8.8	26.4	0.5	0.2
CH07	774	0.059	0.00	4	4	0.035	1.00	25.5	2.1	0.2	0.7
CH07a	1898	0.028	0.00	9	6	0.035	0.75	15.5	11.0	0.3	0.6
CH08	746	0.014	0.00	6	4	0.035	1.50	46.0	20.5	0.5	0.5
CH09	2453	0.023	0.00	4	6	0.035	0.75	9.3	16.9	0.4	0.5
CH10	401	0.027	0.00	6	6	0.035	1.00	26.1	18.9	0.4	0.7
CH10a	661	0.028	0.00	3	3	0.035	0.50	2.0	1.0	0.2	0.3
CH11	2085	0.047	0.00	6	6	0.035	1.25	62.5	26.1	0.4	1.3
CH12	345	0.038	0.00	6	6	0.035	0.75	14.4	0.7	0.1	0.3
CH13	304	0.051	0.00	9	15	0.035	1.00	72.3	27.7	0.4	1.1
CH14	1147	0.042	0.00	6	9	0.035	1.00	40.9	2.9	0.2	0.5
CH14a	422	0.043	0.00	9	9	0.035	0.50	7.8	1.4	0.1	0.3
CH14b	430	0.048	0.00	6	4	0.035	0.50	4.6	3.2	0.2	0.6
CH15	473	0.044	0.00	3	4	0.035	0.50	3.0	3.9	0.2	0.7
CH16	1113	0.042	0.00	3	4	0.035	0.50	2.9	5.3	0.2	0.6
CH17	250	0.046	0.00	6	6	0.035	0.50	5.4	0.2	0.3	0.7
CH18	531	0.061	3.00	3	3	0.045	6.00	2173.9	378.1	1.6	6.1
CH19	957	0.058	2.00	3	3	0.045	7.00	2939.9	334.7	1.5	5.6
CH20	724	0.061	0.00	2	4	0.035	1.25	34.6	7.3	0.3	1.3
CH21	1651	0.050	1.00	3	3	0.045	4.50	818.6	223.6	1.4	4.2
CH22	1619	0.069	0.00	2	10	0.035	0.50	6.5	63.9	0.2	1.0
CH23	1173	0.044	0.00	4	4	0.035	3.00	411.7	28.2	0.5	1.5
CH24	1101	0.062	0.00	4	6	0.045	3.50	721.5	26.4	0.5	1.9
CH25	4261	0.019	0.00	4	6	0.035	2.00	115.5	142.9	1.0	1.2
CH26	5813	0.018	0.00	4	3	0.035	3.00	228.9	147.0	1.2	1.4
CH27	1839	0.010	0.00	3	4	0.035	5.00	666.3	275.8	1.7	1.1

Notes:
Channel features approximated based on digital topography.
Highlighting indicates locations where full-flow channel capacity is exceeded.
Highlighting indicates locations where channels require riprap protection
See Table 7 for Peak Flow calculations.
Channels analyzed with FlowMaster software.
*When 25-year Peak Flow exceeds the channel capacity the hydraulic radius is based on full flow capacity

Table 11
Curb and Gutter/Barrier Rail Calculations

Label	Length (ft)	Longitudinal Slope (ft/ft)	Gutter Width (ft)	Gutter Cross Slope (ft/ft)	Road Cross Slope (ft/ft)	Manning's n	10-Year		
							Peak Flow (cfs)	Spread (ft)	Allowable Spread (ft)
BR01	358	0.015	-	-	0.015	0.015	1.0	7.8	8.0
BR02	376	0.015	-	-	0.015	0.015	1.0	7.8	8.0
BR03	228	0.010	-	-	0.015	0.015	0.7	7.4	8.0
BR04	352	0.010	-	-	0.015	0.015	0.4	6.0	8.0
BR05	206	0.034	-	-	0.015	0.015	0.5	5.2	8.0
BR06	284	0.024	-	-	0.019	0.015	2.1	8.1	8.0
CG01	671	0.017	1.5	0.083	high side	0.015	0.0	0.0	7.0
CG02	102	0.023	1.5	0.083	0.024	0.015	0.4	2.4	8.0
CG03	619	0.025	1.5	0.083	0.021	0.015	1.0	4.7	8.0
CG04	498	0.029	1.5	0.083	0.013	0.015	1.9	8.4	7.5
CG05	381	0.033	1.5	0.083	high side	0.015	0.0	0.0	7.5
CG06	468	0.047	1.5	0.083	0.034	0.015	0.6	2.2	7.5
CG07	696	0.039	1.5	0.083	0.008	0.015	0.5	3.7	7.5
CG08	569	0.036	1.5	0.083	0.051	0.015	0.9	2.6	7.5
CG09a	565	0.034	1.5	0.083	0.064	0.015	1.7	3.2	7.5
CG09b	379	0.018	1.5	0.083	0.016	0.015	0.7	4.8	7.5
CG10a	575	0.024	1.5	0.083	0.026	0.015	1.1	4.4	7.5
CG10b	366	0.022	1.5	0.083	0.033	0.015	0.7	3.1	7.5
CG11	439	0.011	1.5	0.083	0.030	0.015	1.2	5.1	8.0
CG12	425	0.014	1.5	0.083	0.055	0.015	0.7	2.8	8.0
CG13	391	0.011	1.5	0.083	0.030	0.015	1.5	5.7	8.0
CG14	763	0.012	1.5	0.083	0.060	0.015	0.7	2.8	8.0
CG15	210	0.009	1.5	0.083	0.051	0.015	0.5	2.7	8.0
CG16	625	0.009	1.5	0.083	0.046	0.015	1.1	4.1	7.5
CG17	634	0.010	1.5	0.083	0.034	0.015	1.2	4.9	7.5
CG18	858	0.009	1.5	0.083	0.029	0.015	5.2	10.2	8.0
CG19	755	0.010	1.5	0.083	0.036	0.015	2.5	6.5	7.5
CG20	384	0.064	1.5	0.083	0.018	0.015	0.4	1.5	10.0
CG21	289	0.034	1.5	0.083	high side	0.015	0.0	0.0	7.5

Notes:
Topography unavailable on roadway over the Truckee River. Feature data approximated.
Highlighting indicates locations where allowable spread is exceeded.
See Table 7 for Peak Flow calculations.
Curb & Gutter and Barrier Rail analyzed with FlowMaster software.

Table 12
Culvert Inlet/Outlet Treatment Deficiencies

Culvert #	Inlet Treatment (Y/N)	Outlet Treatment (Y/N)	Culvert End Treatments (Y/N)	Photos (Y/N)	Low Point (Y/N)	Note
C01	N/A	N	N	N	N	DI at Invert, no protection needed
C02	N/A	N/A	N	N	N	DI at Inlet and Outlet, no protection needed
C03	N/A	N	N	N	N	DI at Invert, no protection needed
C04	N/A	N/A	N	N	Y	Flankers are needed (Per NDOT Standards), DI at Inlet and Outlet, no protection needed
C05	N/A	N	N	N	N	DI at Invert, no protection needed
C06	N/A	N	N	N	N	DI at Invert, no protection needed
C07	N/A	N	N	N	N	DI at Invert, no protection needed
C08	N/A	N/A	N	N	N	DI at Inlet and Outlet, no protection needed
C09	N	N	N	N	N	
C10	N	N	N	N	N	
C11	Y	Y	N	Y	N	
C12	Buried	Y	N	Y	N	Culvert Inlet is Buried
C13	N	N	N	Y	N	
C14	Y	Y	N	Y	N	
C15	Y	Y	Y	Y	N	
C16	Y	N	Y	Y	N	
C17	N	Y	N	Y	N	
C18	N	N	N	Y	N	
C19	Y	Y	N	Y	N	
C20	Y	Y	N	Y	N	
C21	N	N	N	N	N	
C22	N	Y	N	Y	N	
C23	N	N	N	Y	N	
C24	N	N	N	Y	N	
C25	N	N	N	Y	N	
C26	N	Y	N	Y	N	
C27	N	N	N	Y	N	
C28	N	Y	N	Y	N	
C29	N	N	N	Y	N	
C30	N	N	N	Y	N	

APPENDIX B

Supporting Hydrologic Data

Table/Supporting Documentation No.	Table/Supporting Documentation Name
-	HEC-HMS Results
-	SCS, Rational, and Regression Methodology Support
-	NOAA Atlas 14 Precipitation

Project: USA_Pkwy_P_F_20120828 Simulation Run: 29 10yr

Start of Run: 16Feb2012, 12:01 Basin Model: 29
End of Run: 17Feb2012, 12:02 Meteorologic Model: 29 10yr
Compute Time: 30Aug2012, 08:01:55 Control Specifications: 24hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
29	8.494	756.0	17Feb2012, 02:23	0.81

Project: USA_Pkwy_P_F_20120828 Simulation Run: 29 25yr

Start of Run:	16Feb2012, 12:01	Basin Model:	29
End of Run:	17Feb2012, 12:02	Meteorologic Model:	29 25yr
Compute Time:	30Aug2012, 08:02:27	Control Specifications:	24hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
29	8.494	1103.6	17Feb2012, 02:19	1.15

Project: USA_Pkwy_P_F_20120828 Simulation Run: 47 10yr

Start of Run: 16Feb2012, 12:01 Basin Model: 47
End of Run: 17Feb2012, 12:02 Meteorologic Model: 47 10yr
Compute Time: 30Aug2012, 08:02:49 Control Specifications: 24hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
47	3.629	444.2	17Feb2012, 01:50	0.99

Project: USA_Pkwy_P_F_20120828 Simulation Run: 47 25yr

Start of Run:	16Feb2012, 12:01	Basin Model:	47
End of Run:	17Feb2012, 12:02	Meteorologic Model:	47 25yr
Compute Time:	30Aug2012, 08:03:05	Control Specifications:	24hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
47	3.629	645.6	17Feb2012, 01:47	1.39

Project: USA_Pkwy_P_F_20120828 Simulation Run: 57 10yr

Start of Run: 16Feb2012, 12:01 Basin Model: 57
End of Run: 17Feb2012, 12:02 Meteorologic Model: 57 10yr
Compute Time: 30Aug2012, 08:03:30 Control Specifications: 24hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
57	0.326	121.8	17Feb2012, 00:22	1.01

Project: USA_Pkwy_P_F_20120828 Simulation Run: 57 25yr

Start of Run: 16Feb2012, 12:01 | Basin Model: 57
End of Run: 17Feb2012, 12:02 | Meteorologic Model: 57 25yr
Compute Time: 30Aug2012, 08:03:47 | Control Specifications: 24hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
57	0.326	186.2	17Feb2012, 00:22	1.42

Global Summary Results for Run "59 thru 68 10yr"

Project: USA_Pkwy_P_F_20120828 Simulation Run: 59 thru 68 10yr

Start of Run: 16Feb2012, 12:01 Basin Model: 59 thru 68
End of Run: 17Feb2012, 12:02 Meteorologic Model: 59 thru 68 10yr
Compute Time: 30Aug2012, 08:04:18 Control Specifications: 24hr

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
67	0.367	125.5	17Feb2012, 00:25	1.01
68	0.031	18.4	17Feb2012, 00:10	1.02
C-28	0.398	132.0	17Feb2012, 00:24	1.01
R-4	0.398	131.9	17Feb2012, 00:24	1.01
66	0.023	17.5	17Feb2012, 00:07	1.12
J-2	0.421	135.6	17Feb2012, 00:24	1.01
R-5	0.421	135.5	17Feb2012, 00:26	1.01
63	0.052	31.2	17Feb2012, 00:11	1.08
CH21	0.473	146.7	17Feb2012, 00:25	1.02
R-10	0.473	146.7	17Feb2012, 00:26	1.02
65	0.077	41.7	17Feb2012, 00:12	1.02
64	0.077	44.4	17Feb2012, 00:11	1.02
C-27	0.154	85.7	17Feb2012, 00:11	1.02
R-9	0.154	85.5	17Feb2012, 00:13	1.02
60	0.019	12.4	17Feb2012, 00:09	1.04
CH19	0.646	217.7	17Feb2012, 00:14	1.02
R-15	0.646	217.8	17Feb2012, 00:15	1.02
61	0.048	29.2	17Feb2012, 00:10	1.01
62	0.005	4.9	17Feb2012, 00:04	1.19
C-26	0.053	31.5	17Feb2012, 00:09	1.03
R-14	0.053	31.3	17Feb2012, 00:11	1.03
59	0.006	5.2	17Feb2012, 00:06	1.22
CH18	0.705	246.2	17Feb2012, 00:14	1.02

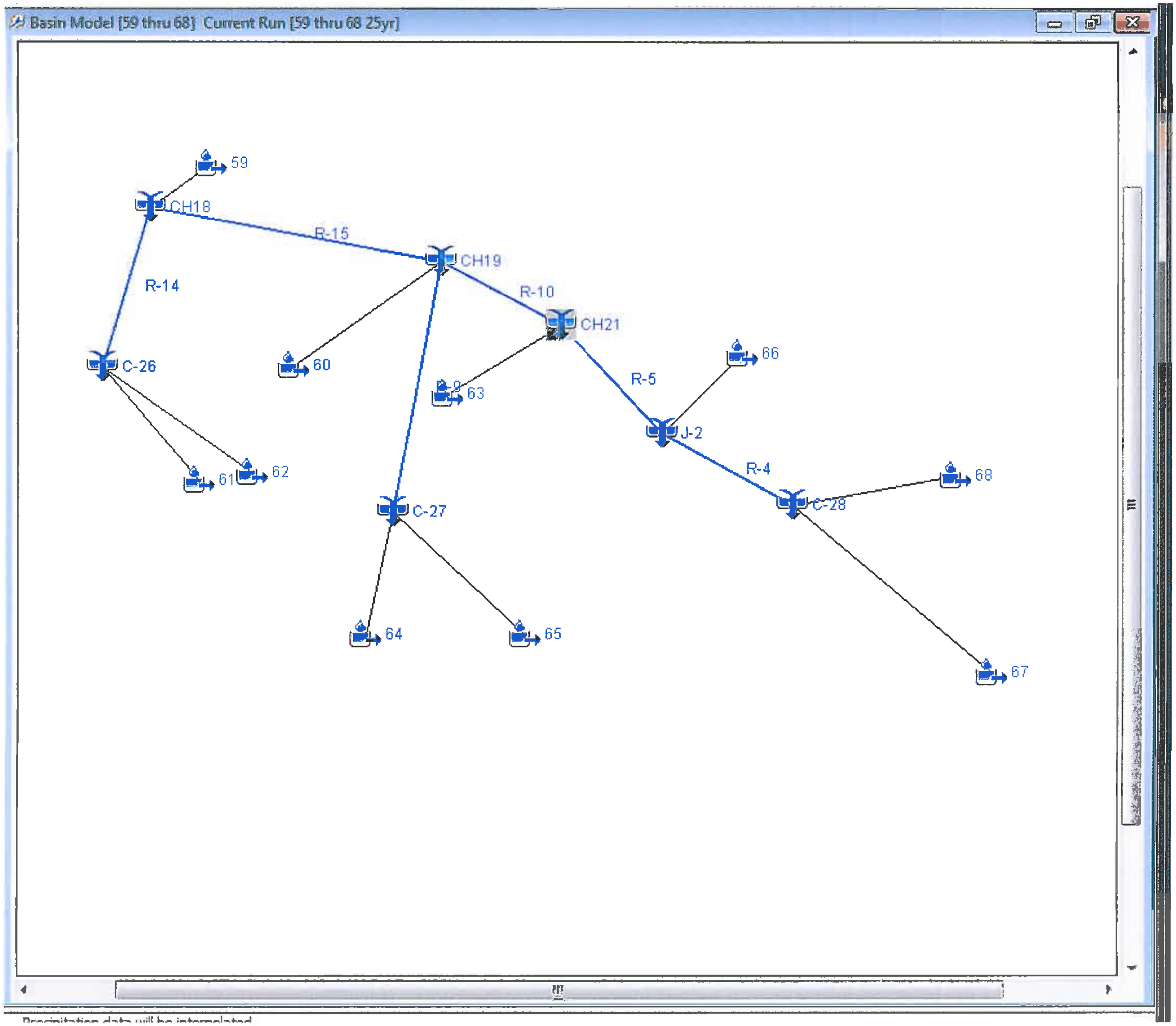
Global Summary Results for Run "59 thru 68 25yr"

Project: USA_Pkwy_P_F_20120828 Simulation Run: 59 thru 68 25yr

Start of Run: 16Feb2012, 12:01 Basin Model: 59 thru 68
End of Run: 17Feb2012, 12:02 Meteorologic Model: 59 thru 68 25yr
Compute Time: 30Aug2012, 08:06:15 Control Specifications: 24hr

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
67	0.367	191.7	17Feb2012, 00:25	1.42
68	0.031	28.2	17Feb2012, 00:10	1.43
C-28	0.398	201.4	17Feb2012, 00:24	1.42
R-4	0.398	201.4	17Feb2012, 00:24	1.42
66	0.023	26.4	17Feb2012, 00:07	1.54
J-2	0.421	206.8	17Feb2012, 00:24	1.43
R-5	0.421	206.7	17Feb2012, 00:26	1.43
63	0.052	47.3	17Feb2012, 00:11	1.50
CH21	0.473	223.6	17Feb2012, 00:24	1.43
R-10	0.473	223.6	17Feb2012, 00:25	1.43
65	0.077	63.9	17Feb2012, 00:12	1.44
64	0.077	68.1	17Feb2012, 00:11	1.44
C-27	0.154	131.5	17Feb2012, 00:11	1.44
R-9	0.154	131.1	17Feb2012, 00:13	1.43
60	0.019	19.0	17Feb2012, 00:09	1.46
CH19	0.646	334.7	17Feb2012, 00:14	1.43
R-15	0.646	334.2	17Feb2012, 00:15	1.43
61	0.048	44.8	17Feb2012, 00:10	1.43
62	0.005	7.3	17Feb2012, 00:04	1.63
C-26	0.053	48.2	17Feb2012, 00:09	1.45
R-14	0.053	48.0	17Feb2012, 00:10	1.45
59	0.006	7.7	17Feb2012, 00:06	1.66
CH18	0.705	378.1	17Feb2012, 00:14	1.44


Basin Model [59 thru 68] Current Run [59 thru 68 25yr]
59
CH18
R-15
CH19
R-14
R-10
CH21
C-26
60
66
63
R-5
J-2
R-4
61
62
68
C-27
C-28
64
65
67

Project: USA_Pkwy_P_F_20120828 Simulation Run: 69 10yr

Start of Run: 16Feb2012, 12:01 Basin Model: 69
End of Run: 17Feb2012, 12:02 Meteorologic Model: 69 10yr
Compute Time: 30Aug2012, 08:09:07 Control Specifications: 24hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
69	0.377	94.8	17Feb2012, 00:36	0.89

Project: USA_Pkwy_P_F_20120828 Simulation Run: 69 25yr

Start of Run:	16Feb2012, 12:01	Basin Model:	69
End of Run:	17Feb2012, 12:02	Meteorologic Model:	69 25yr
Compute Time:	30Aug2012, 08:09:24	Control Specifications:	24hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
69	0.377	147.0	17Feb2012, 00:36	1.26

Project: USA_Pkwy_P_F_20120828 Simulation Run: 71_70 10yr

Start of Run:	16Feb2012, 12:01	Basin Model:	70 thru 71
End of Run:	17Feb2012, 12:02	Meteorologic Model:	70 + 71 10yr
Compute Time:	28Aug2012, 15:35:43	Control Specifications:	24hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
71	0.272	86.7	17Feb2012, 00:28	0.98
70	0.257	93.1	17Feb2012, 00:23	1.00
Reach-1	0.257	93.0	17Feb2012, 00:27	1.00
70_71	0.529	179.6	17Feb2012, 00:27	0.99

Project: USA_Pkwy_P_F_20120828 Simulation Run: 71_70 25yr

Start of Run: 16Feb2012, 12:01 Basin Model: 70 thru 71
End of Run: 17Feb2012, 12:02 Meteorologic Model: 70 + 71 25yr
Compute Time: 28Aug2012, 15:36:38 Control Specifications: 24hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
71	0.272	133.3	17Feb2012, 00:28	1.40
70	0.257	142.9	17Feb2012, 00:23	1.42
Reach-1	0.257	142.6	17Feb2012, 00:26	1.41
70_71	0.529	275.8	17Feb2012, 00:27	1.40

Project: USA_Pkwy_P_F_20120828 Simulation Run: 72 10yr

Start of Run:	16Feb2012, 12:01	Basin Model:	72+70_71
End of Run:	17Feb2012, 12:02	Meteorologic Model:	72 10yr
Compute Time:	30Aug2012, 08:10:44	Control Specifications:	24hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
72	16.055	1527.3	17Feb2012, 03:01	1.05

Project: USA_Pkwy_P_F_20120828 Simulation Run: 72 25yr

Start of Run: 16Feb2012, 12:01 Basin Model: 72+70_71
End of Run: 17Feb2012, 12:02 Meteorologic Model: 72 25yr
Compute Time: 30Aug2012, 08:11:01 Control Specifications: 24hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
72	16.055	2147.8	17Feb2012, 02:57	1.47

Thick mulches in forests are associated with low retardance factors and reflect high degrees of retardance, as well as high infiltration rates. Hay meadows have relatively low retardance factors. Like thick mulches in forests, stem densities in meadows provide a high degree of retardance to overland flow in small watersheds. Conversely, bare surfaces with little retardance to overland flows are represented by high retardance factors.

The retardance factor is approximately the same as the curve number (CN) as defined in NEH630.09, Hydrologic Soil-Cover Complexes. In practical usage, CN is used as a surrogate for cn′, and the CN tables in NEH 630.09 may be used to approximate cn′ in equations 15–4a and 15–4b. A CN of less than 50, or greater than 95 should not be used in the solution of equations 15–4a and 15–4b (Mockus 1961).

Applications and limitations—The watershed lag equation was developed using data from 24 watersheds ranging in size from 1.3 acres to 9.2 square miles, with the majority of the watersheds being less than 2,000 acres in size (Mockus 1961). Folmar and Miller (2000) revisited the development of this equation using additional watershed data and found that a reasonable upper limit may be as much as 19 square miles.

(b) Velocity method

Another method for determining time of concentration normally used within the NRCS is called the velocity method. The velocity method assumes that time of concentration is the sum of travel times for segments along the hydraulically most distant flow path.

$$T_c = T_{t1} + T_{t2} + T_{t3} + \ldots T_{tn} \qquad \text{(eq. 15–7)}$$

where:

T_c = time of concentration, h
T_{tn} = travel time of a segment n, h
n = number of segments comprising the total hydraulic length

The segments used in the velocity method may be of three types: sheet flow, shallow concentrated flow, and open channel flow.

Sheet flow—Sheet flow is defined as flow over plane surfaces. Sheet flow usually occurs in the headwaters of a stream near the ridgeline that defines the watershed boundary. Typically, sheet flow occurs for no more than 100 feet before transitioning to shallow concentrated flow (Merkel 2001).

A simplified version of the Manning's kinematic solution may be used to compute travel time for sheet flow. This simplified form of the kinematic equation was developed by Welle and Woodward (1986) after studying the impact of various parameters on the estimates.

$$T_t = \frac{0.007(n\ell)^{0.8}}{(P_2)^{0.5} S^{0.4}} \qquad \text{(eq. 15–8)}$$

where:

T_t = travel time, h
n = Manning's roughness coefficient (table 15–1)
ℓ = sheet flow length, ft
P_2 = 2-year, 24-hour rainfall, in
S = slope of land surface, ft/ft

Table 15–1 Manning's roughness coefficients for sheet flow (flow depth generally ≤ 0.1 ft)

Surface description	n [1]
Smooth surface (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤ 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short-grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods: [3]	
Light underbrush	0.40
Dense underbrush	0.80

1 The Manning's n values are a composite of information compiled by Engman (1986).
2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
3 When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

This simplification is based on the following assumptions:

- shallow steady uniform flow
- constant rainfall excess intensity (that part of a rain available for runoff) both temporally and spatially
- 2-year, 24-hour rainfall assuming standard NRCS rainfall intensity-duration relations apply (Types I, II, and III)
- minor effect of infiltration on travel time

For sheet flow, the roughness coefficient includes the effects of roughness and the effects of raindrop impact including drag over the surface; obstacles such as litter, crop ridges, and rocks; and erosion and transport of sediment. These n values are only applicable for flow depths of approximately 0.1 foot or less, where sheet flow occurs. Table 15–1 gives roughness coefficient values for sheet flow for various surface conditions.

Kibler and Aron (1982) and others indicated the maximum sheet flow length is less than 100 feet. To support the sheet flow limit of 100 feet, Merkel (2001) reviewed a number of technical papers on sheet flow. McCuen and Spiess (1995) indicated that use of flow length as the limiting variable in the equation 15–8 could lead to less accurate designs, and proposed that the limitation should instead be based on:

$$\ell = \frac{100\sqrt{S}}{n} \qquad \text{(eq. 15–9)}$$

where:
n = Manning's roughness coefficient
ℓ = limiting length of flow, ft
S = slope, ft/ft

Table 15–2 provides maximum sheet flow lengths based on the McCuen-Spiess limiting criteria for various cover type—n value—slope combinations.

Table 15–2 Maximum sheet flow lengths using the McCuen-Spiess limitation criterion

Cover type	*n* values	Slope (ft/ft)	Length (ft)
Range	0.13	0.01	77
Grass	0.41	0.01	24
Woods	0.80	0.01	12.5
Range	0.13	0.05	172
Grass	0.41	0.05	55
Woods	0.80	0.05	28

Shallow concentrated flow—After approximately 100 feet, sheet flow usually becomes shallow concentrated flow collecting in swales, small rills, and gullies. Shallow concentrated flow is assumed not to have a well-defined channel and has flow depths of 0.1 to 0.5 feet. It is assumed that shallow concentrated flow can be represented by one of seven flow types. The curves in figure 15–4 were used to develop the information in table 15–3.

To estimate shallow concentrated flow travel time, velocities are developed using figure 15–4, in which average velocity is a function of watercourse slope and type of channel (Kent 1964). For slopes less than 0.005 foot per foot, the equations in table 15–3 may be used.

After estimating average velocity using figure 15–4, use equation 15–1 to estimate travel time for the shallow concentrated flow segment.

Open channel flow— Shallow concentrated flow is assumed to occur after sheet flow ends at shallow depths of 0.1 to 0.5 feet. Beyond that channel flow is assumed to occur. Open channels are assumed to begin where surveyed cross-sectional information has been obtained, where channels are visible on aerial photographs, or where bluelines (indicating streams) appear on U.S. Geological Survey (USGS) quadrangle sheets.

Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for the bankfull elevation.

Manning's equation is:

$$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n} \qquad \text{(eq. 15–10)}$$

Figure 15–4 Velocity versus slope for shallow concentrated flow

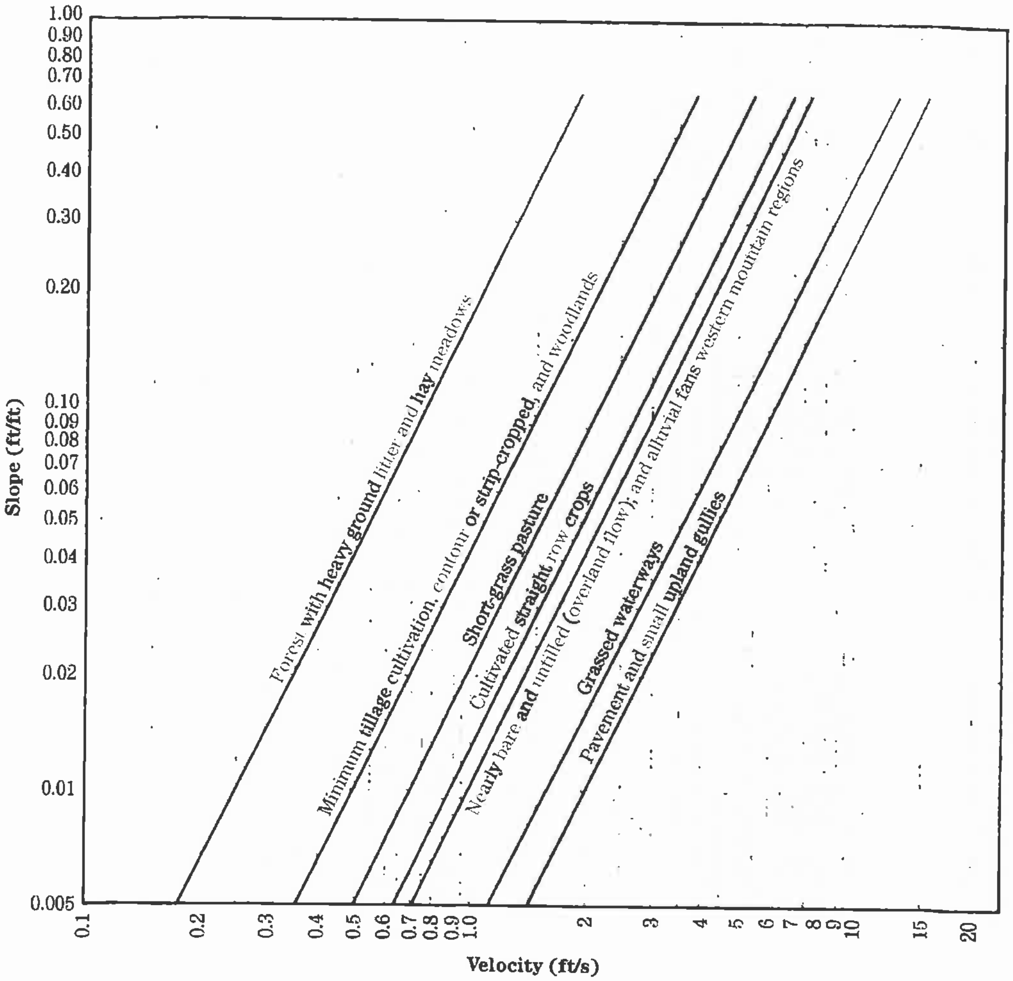


Table 15–3 Equations and assumptions developed from figure 15–4

Flow type	Depth (ft)	Manning's *n*	Velocity equation (ft/s)
Pavement and small upland gullies	0.2	0.025	$V = 20.328(s)^{0.5}$
Grassed waterways	0.4	0.050	$V = 16.135(s)^{0.5}$
Nearly bare and untilled (overland flow); and alluvial fans in western mountain regions	0.2	0.051	$V = 9.965(s)^{0.5}$
Cultivated straight row crops	0.2	0.058	$V = 8.762(s)^{0.5}$
Short-grass pasture	0.2	0.073	$V = 6.962(s)^{0.5}$
Minimum tillage cultivation, contour or strip-cropped, and woodlands	0.2	0.101	$V = 5.032(s)^{0.5}$
Forest with heavy ground litter and hay meadows	0.2	0.202	$V = 2.516(s)^{0.5}$

where:

V = average velocity, ft/s

r = hydraulic radius, ft

$= \frac{a}{P_w}$

a = cross-sectional flow area, ft^2

P_w = wetted perimeter, ft

s = slope of the hydraulic grade line (channel slope), ft/ft

n = Manning's n value for open channel flow

Manning's n values for open channel flow can be obtained from standard hydraulics textbooks, such as Chow (1959), and Linsley, Kohler, and Paulhus (1982). Publications dealing specifically with Manning's n values are Barnes (1967); Arcement and Schneider (1989); Phillips and Ingersoll (1998); and Cowen (1956). For guidance on calculating Manning's n values, see NEH630.14, Stage Discharge Relations.

Applications and limitations—The velocity method of computing time of concentration is hydraulically sound and provides the opportunity to incorporate changes in individual flow segments if needed. The velocity method is the best method for calculating time of concentration for an urbanizing watershed or if hydraulic changes to the watercourse are being considered.

Often, the average velocity and valley length of a reach are used to compute travel time through the reach using equation 15–1. If the stream is quite sinuous, the channel length and valley length may be significantly different and it is up to the modeler to determine which is the appropriate length to use for the depth of flow of the event under consideration.

The role of channel and valley storage is important in the development and translation of a flood wave and the estimation of lag. Both the hydraulics and storage may change from storm to storm and the velocity distribution may vary considerably both horizontally and vertically. As a result, actual lag for a watershed may have a large variation. In practice, calculations are typically based on the 2-year frequency discharge event since it is normally assumed that the time of concentration computed using these characteristics is representative of travel time conditions for a wide range of storm events. Welle and Woodward's simplification of Manning's kinematic equation was developed assuming the 2-year, 24-hour precipitation value.

630.1503 Other considerations

(a) Field observations

At the time field surveys to obtain channel data are made, there is a need to observe the channel system and note items that may affect channel efficiency. Observations such as the type of soil materials in the banks and bottoms of the channel; an estimate of Manning's roughness coefficients; the apparent stability or lack of stability of channel; indications of debris flows as evidenced by deposition of coarse sediments adjacent to channels, size of deposited materials, etc., may be significant.

(b) Multiple subarea watersheds

For multiple subarea watersheds, the time of concentration must be computed for each subarea individually, and consideration must be given to the travel time through downstream subareas from upstream subareas. Travel time and attenuation of hydrographs in valley reaches and reservoirs are accounted for using channel and reservoir routing procedures addressed in NEH630.17.

(c) Surface flow

Both of the standard methods for estimating time of concentration, as well as most other methods, assume that flow reaching the channel as surface flow or quick return flow adds directly to the peak of the subarea hydrograph. Locally derived procedures might be developed from data where a major portion of the contributing flow is other than surface flow. This is normally determined by making a site visit to the watershed.

(d) Travel time through bodies of water

The potential for detention is the factor that most strongly influences travel time through a body of water. It is best to divide the watershed such that any potential storage area is modeled as storage.

Table 2-2d Runoff curve numbers for arid and semiarid rangelands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition [2]	A [3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

1 Average runoff condition, and $I_a = 0.2S$. For range in humid regions, use table 2-2c.
2 Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.
3 Curve numbers for group A have been developed only for desert shrub.

RATIONAL FORMULA METHOD
RUNOFF COEFFICIENTS

Land Use or Surface Characteristics	Aver. % Impervious Area	Runoff Coefficients 5-Year (C_5)	Runoff Coefficients 100-Year (C_{100})
Business/Commercial:			
Downtown Areas	85	.82	.85
Neighborhood Areas	70	.65	.80
Residential:			
(Average Lot Size)			
⅛ Acre or Less (Multi-Unit)	65	.60	.78
¼ Acre	38	.50	.65
⅓ Acre	30	.45	.60
½ Acre	25	.40	.55
1 Acre	20	.35	.50
Industrial:	72	.68	.82
Open Space:			
(Lawns, Parks, Golf Courses)	5	.05	.30
Undeveloped Areas:			
Range	0	.20	.50
Forest	0	.05	.30
Streets/Roads:			
Paved	100	.88	.93
Gravel	20	.25	.50
Drives/Walks:	95	.87	.90
Roof:	90	.85	.87

Notes:

1. Composite runoff coefficients shown for Residential, Industrial, and Business/Commercial Areas assume irrigated grass landscaping for all pervious areas. For development with landscaping other than irrigated grass, the designer must develop project specific composite runoff coefficients from the surface characteristics presented in this table.

The regression equations, the average standard errors of prediction, and the equivalent years of record for regions 1, 2, 3, and 5 are given in table 1. The average standard errors of prediction are an average measure of the accuracy of the regression equations when estimating peak-discharge values for ungaged watersheds similar to those that were used to derive the regression equations. The equivalent years of record is the number of years of streamflow record needed to achieve the same accuracy as the regression equation.

Table 1. Flood-peak discharge regression equations and associated statistics for regions 1, 2, 3, and 5 in Nevada (modified from Thomas and others, 1997)

[QT, peak discharge for recurrence interval T, 2 to 100 years, in cubic feet per second; AREA, drainage area, in square miles; PREC, mean annual precipitation, in inches; ELEV, mean basin elevation, in feet above sea level (NGVD of 1929); LAT, latitude in decimal degrees]

Regression equation	Average standard error of prediction, in percent	Equivalent years of record
Region 1 - 165 stations (For sites located at elevations greater than elevation threshold from figure 2)		
$Q_2 = 0.124AREA^{0.845}PREC^{1.44}$	59	0.16
$Q_5 = 0.629AREA^{0.807}PREC^{1.12}$	52	.62
$Q_{10} = 1.43AREA^{0.786}PREC^{0.958}$	48	1.34
$Q_{25} = 3.08AREA^{0.768}PREC^{0.811}$	46	2.50
$Q_{50} = 4.75AREA^{0.758}PREC^{0.732}$	46	3.37
$Q_{100} = 6.78AREA^{0.750}PREC^{0.668}$	46	4.19
Region 2 - 108 stations		
$Q_2 = 13.1AREA^{0.713}$	72	0.96
$Q_5 = 22.4AREA^{0.723}$	66	1.80
$Q_{10} = 55.7AREA^{0.727}(ELEV/1{,}000)^{-0.353}$	61	3.07
$Q_{25} = 84.7AREA^{0.737}(ELEV/1{,}000)^{-0.438}$	61	4.64
$Q_{50} = 113AREA^{0.746}(ELEV/1{,}000)^{-0.511}$	64	5.47
$Q_{100} = 148AREA^{0.752}(ELEV/1{,}000)^{-0.584}$	68	6.05
Region 3 - 35 stations		
$Q_2 = 0.444AREA^{0.649}PREC^{1.15}$	86	0.29
$Q_5 = 1.21AREA^{0.639}PREC^{0.995}$	83	.49
$Q_{10} = 1.99AREA^{0.633}PREC^{0.924}$	80	.77
$Q_{25} = 3.37AREA^{0.627}PREC^{0.849}$	78	1.23
$Q_{50} = 4.70AREA^{0.625}PREC^{0.802}$	77	1.57
$Q_{100} = 6.42AREA^{0.621}PREC^{0.757}$	78	1.92
Region 5 - 37 stations		

$Q_2 = 0.0333AREA^{0.853}(ELEV/1,000)^{2.68}[(LAT - 28)/10]^{4.1}$	135	0.21
$Q_5 = 2.42AREA^{0.823}(ELEV/1,000)^{1.01}[(LAT - 28)/10]^{4.1}$	101	.73
$Q_{10} = 28.0AREA^{0.826}[(LAT - 28)/10]^{4.3}$	84	1.69
$Q_{25} = 426AREA^{0.812}(ELEV/1,000)^{-1.10}[(LAT - 28)/10]^{4.3}$	87	2.62
$Q_{50} = 2,030AREA^{0.798}(ELEV/1,000)^{-1.71}[(LAT - 28)/10]^{4.4}$	91	3.26
$Q_{100} = 7,000AREA^{0.782}(ELEV/1,000)^{-2.18}[(LAT - 28)/10]^{4.6}$	95	3.80

The regression equations for regions 6 and 10 were developed using an iterative regression method (Hjalmarson and Thomas, 1992) and a modified form of the station year statistical analysis method (Fuller, 1914). The regression equations, the estimated average standard errors of regression, and the equivalent years of record for regions 6 and 10 are given in table 2. The average standard error of regression is an estimate of the predictive accuracy of these regression equations and is determined by a direct sampling method.

Table 2. Flood-peak discharge equations and associated statistics for regions 6 and 10 in Nevada (modified from Thomas and others, 1994)

[Q, peak discharge for recurrence interval T, 2 to 100 years, in cubic feet per second; AREA, drainage area, in square miles; ELEV, mean basin elevation, in feet above sea level (NGVD of 1929)]

Estimated average standard error of regression for these equations includes much of the within-station residual variance and therefore is not comparable to standard error of estimate from an ordinary-least-squares regression.

Regression equation	Estimated average standard error of regression, in log units	Equivalent years of record
Region 6 - 80 stations		
$Q_2 = 0$	--	--
$Q_5 = 32AREA^{0.80}(ELEV/1,000)^{-0.66}$	1.47	0.233
$Q_{10} = 590AREA^{0.62}(ELEV/1,000)^{-1.6}$	1.12	.748
$Q_{25} = 3,200AREA^{0.62}(ELEV/1,000)^{-2.1}$	.796	2.52
$Q_{50} = 5,300AREA^{0.64}(ELEV/1,000)^{-2.1}$	1.10	1.75
$Q_{100} = 20,000AREA^{0.51}(ELEV/1,000)^{-2.3}$	1.84	.794
Region 10 - 104 stations		
$Q_2 = 12\ AREA^{0.58}$	1.14	0.618
$Q_5 = 85\ AREA^{0.59}$	.602	3.13
$Q_{10} = 200\ AREA^{0.62}$	.675	3.45
$Q_{25} = 400\ AREA^{0.65}$	.949	2.49
$Q_{50} = 590\ AREA^{0.67}$	.928	3.22
$Q_{100} = 850\ AREA^{0.69}$	1.23	2.22

The approximate ranges of the explanatory watershed variables over which the equations are applicable are shown in table 3. Thomas and others (1997) presented the actual ranges of applicability as two-dimensional clusters of explanatory variables plotted against one another. The ranges shown in table 3 define a rectangular space that brackets the clusters and, therefore, include pairs of values of the explanatory variables near the corners of the rectangle that are outside of the clusters. Application of the equations for values of the variables near the extremes of a range should be done cautiously. The standard errors increase appreciably when any explanatory watershed variable is near or outside the quoted range.

Table 3. Range of explanatory variables for which regression equations are applicable

[--, not applicable.]

Hydrologic study region	Drainage area, in square miles[1]	Mean basin elevation, in feet above sea level[2]	Mean annual precipitation, in inches	Latitude in decimal degrees
Region 1	0.6-1,060	--	11-43	--
Region 2	0.8–1,680	3,540-7,950	--	--
Region 3	2.2-1,450	--	10-41	--
Region 5	4.1-360	5,770-10,500	--	36.44-39.50
Region 6	0.2-210	4,770–9,960	--	--
Region 10	0.1-1,000	--	--	--

[1]For best results, applications should be limited to basins of less than 200 square miles.
[2]NGVD of 1929.

Improving Estimates With Gaged Data

The U.S. Water Resources Council (1981, appendix 8) described weighting techniques to improve estimates of peak discharge at gaged locations by combining the estimates derived from analysis of gage records with estimates derived by other means, including regression equations.

The weights for these two estimates are based on the length of the stream gage record (in years) and the equivalent years of record of the applicable regression equation. The weighted estimate of peak discharge is computed as:

$$\log Q_T(W) = \frac{N \cdot \log Q_T(G) + EQ \cdot \log Q_T(R)}{N + EQ}$$

where

$Q_T(W)$ is the weighted estimate for recurrence interval T at the gaged site,

$Q_T(G)$ is the estimate of Q_T derived from analysis of the gage records,

$Q_T(R)$ is the estimate of Q_T derived from application of the regression equation,

WS 1 - 31

Point precipitation frequency estimates (inches)

NOAA Atla Volume 1 Version 5

Data type: Precipitation depth

Time series type: Partial duration

Project area: Southwest

Latitude (decimal degrees): 39.5550

Longitude (decimal degrees): -119.4900

PRECIPITATION FREQUENCY ESTIMATES

by duration	1	2	5	10	25	50	100	200	500	1000 years
5-min:	0.1	0.13	0.17	0.21	0.28	0.34	0.41	0.49	0.64	0.76
10-min:	0.15	0.19	0.26	0.32	0.42	0.51	0.62	0.75	0.97	1.16
15-min:	0.19	0.24	0.32	0.4	0.52	0.64	0.77	0.93	1.2	1.44
30-min:	0.26	0.32	0.43	0.53	0.7	0.85	1.04	1.26	1.61	1.94
60-min:	0.32	0.4	0.53	0.66	0.87	1.06	1.28	1.56	2	2.4
2-hr:	0.41	0.51	0.66	0.79	0.98	1.15	1.36	1.61	2.06	2.47
3-hr:	0.48	0.6	0.76	0.89	1.07	1.23	1.42	1.68	2.1	2.5
6-hr:	0.64	0.8	1.01	1.17	1.38	1.53	1.7	1.92	2.29	2.63
12-hr:	0.82	1.03	1.31	1.53	1.82	2.05	2.28	2.51	2.82	3.12
24-hr:	0.99	1.25	1.6	1.88	2.27	2.59	2.92	3.26	3.73	4.11
2-day:	1.15	1.46	1.88	2.22	2.7	3.08	3.49	3.92	4.51	4.99
3-day:	1.26	1.6	2.08	2.47	3.02	3.46	3.93	4.43	5.13	5.7
4-day:	1.37	1.74	2.28	2.71	3.33	3.83	4.38	4.94	5.76	6.42
7-day:	1.6	2.04	2.68	3.2	3.94	4.53	5.17	5.84	6.79	7.57
10-day:	1.8	2.3	3.03	3.61	4.41	5.05	5.72	6.43	7.41	8.19
20-day:	2.21	2.83	3.7	4.37	5.28	5.99	6.72	7.47	8.49	9.29
30-day:	2.52	3.22	4.21	4.97	6	6.8	7.62	8.46	9.59	10.47
45-day:	3	3.85	5.02	5.91	7.09	8	8.92	9.84	11.09	12.05
60-day:	3.44	4.43	5.78	6.76	8.01	8.94	9.85	10.74	11.9	12.76

Date/time (GMT): Wed Feb 8 19:02:42 2012

pyRunTime: 0.0778210163116

WS 1 - 31
Point precipitation frequency estimates (inches/hour)
NOAA Atla Volume 1 Version 5
Data type: Precipitation intensity
Time series type: Partial duration
Project area: Southwest
Latitude (decimal degrees): 39.5550
Longitude (decimal degrees): -119.4900

PRECIPITATION FREQUENCY ESTIMATES

by duration	1	2	5	10	25	50	100	200	500	1000 years
5-min:	1.21	1.51	2.03	2.52	3.31	4.03	4.9	5.94	7.62	9.17
10-min:	0.92	1.15	1.54	1.91	2.52	3.07	3.73	4.52	5.8	6.98
15-min:	0.76	0.95	1.28	1.58	2.08	2.54	3.08	3.74	4.79	5.76
30-min:	0.51	0.64	0.86	1.06	1.4	1.71	2.07	2.52	3.23	3.88
60-min:	0.32	0.4	0.53	0.66	0.87	1.06	1.28	1.56	2	2.4
2-hr:	0.2	0.25	0.33	0.39	0.49	0.57	0.68	0.81	1.03	1.23
3-hr:	0.16	0.2	0.25	0.3	0.36	0.41	0.47	0.56	0.7	0.83
6-hr:	0.11	0.13	0.17	0.19	0.23	0.26	0.28	0.32	0.38	0.44
12-hr:	0.07	0.09	0.11	0.13	0.15	0.17	0.19	0.21	0.23	0.26
24-hr:	0.04	0.05	0.07	0.08	0.09	0.11	0.12	0.14	0.16	0.17
2-day:	0.02	0.03	0.04	0.05	0.06	0.06	0.07	0.08	0.09	0.1
3-day:	0.02	0.02	0.03	0.03	0.04	0.05	0.05	0.06	0.07	0.08
4-day:	0.01	0.02	0.02	0.03	0.03	0.04	0.05	0.05	0.06	0.07
7-day:	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.05
10-day:	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03
20-day:	0	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
30-day:	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
45-day:	0	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01
60-day:	0	0	0	0	0.01	0.01	0.01	0.01	0.01	0.01

Date/time (GMT): Wed Feb 8 19:02:11 2012
pyRunTime: 0.0735769271851

WS 29
Point precipitation frequency estimates (inches)
NOAA Atla Volume 1 Version 5
Data type: Precipitation depth
Time series type: Partial duration
Project area: Southwest
Latitude (decimal degrees): 39.5230
Longitude (decimal degrees): -119.5110

PRECIPITATION FREQUENCY ESTIMATES

by duration	1	2	5	10	25	50	100	200	500	1000 years
5-min:	0.1	0.13	0.17	0.21	0.28	0.34	0.41	0.5	0.64	0.77
10-min:	0.16	0.2	0.26	0.33	0.43	0.52	0.63	0.76	0.98	1.18
15-min:	0.19	0.24	0.33	0.4	0.53	0.64	0.78	0.94	1.21	1.46
30-min:	0.26	0.33	0.44	0.54	0.71	0.87	1.05	1.27	1.63	1.96
60-min:	0.32	0.4	0.54	0.67	0.88	1.07	1.3	1.57	2.02	2.43
2-hr:	0.42	0.52	0.68	0.81	1	1.18	1.39	1.65	2.1	2.51
3-hr:	0.5	0.62	0.79	0.92	1.1	1.27	1.47	1.72	2.16	2.56
6-hr:	0.68	0.86	1.07	1.24	1.46	1.62	1.8	2.02	2.39	2.74
12-hr:	0.9	1.13	1.44	1.67	1.99	2.24	2.49	2.74	3.08	3.38
24-hr:	1.12	1.42	1.82	2.14	2.6	2.96	3.35	3.74	4.3	4.75
2-day:	1.33	1.69	2.19	2.6	3.18	3.65	4.14	4.67	5.41	6.01
3-day:	1.46	1.86	2.43	2.9	3.57	4.11	4.69	5.3	6.18	6.89
4-day:	1.59	2.03	2.67	3.2	3.96	4.57	5.24	5.94	6.95	7.78
7-day:	1.87	2.4	3.18	3.81	4.72	5.46	6.26	7.1	8.31	9.3
10-day:	2.11	2.72	3.61	4.32	5.31	6.1	6.95	7.83	9.07	10.08
20-day:	2.68	3.44	4.53	5.38	6.54	7.44	8.38	9.35	10.69	11.75
30-day:	3.12	4.02	5.3	6.29	7.64	8.7	9.79	10.93	12.47	13.69
45-day:	3.75	4.83	6.34	7.51	9.09	10.31	11.58	12.88	14.66	16.07
60-day:	4.31	5.58	7.34	8.62	10.28	11.53	12.78	14.02	15.67	16.94

Date/time (GMT): Wed Feb 8 21:51:49 2012
pyRunTime: 0.0826070308685

WS 32 - 52

Point precipitation frequency estimates (inches)

NOAA Atla Volume 1 Version 5

Data type: Precipitation depth

Time series type: Partial duration

Project area: Southwest

Latitude (decimal degrees): 39.5220

Longitude (decimal degrees): -119.4750

PRECIPITATION FREQUENCY ESTIMATES

by duration	1	2	5	10	25	50	100	200	500	1000 years
5-min:	0.1	0.13	0.17	0.21	0.28	0.34	0.41	0.5	0.64	0.77
10-min:	0.16	0.2	0.26	0.33	0.43	0.52	0.63	0.76	0.98	1.18
15-min:	0.2	0.24	0.33	0.4	0.53	0.65	0.78	0.95	1.21	1.46
30-min:	0.26	0.33	0.44	0.54	0.71	0.87	1.05	1.27	1.63	1.96
60-min:	0.32	0.41	0.55	0.67	0.88	1.07	1.3	1.58	2.02	2.43
2-hr:	0.42	0.52	0.67	0.8	1	1.18	1.38	1.64	2.09	2.51
3-hr:	0.49	0.62	0.78	0.91	1.1	1.26	1.46	1.71	2.15	2.54
6-hr:	0.67	0.84	1.04	1.21	1.43	1.59	1.76	1.99	2.35	2.7
12-hr:	0.86	1.09	1.38	1.61	1.92	2.16	2.4	2.65	2.98	3.28
24-hr:	1.06	1.34	1.72	2.02	2.45	2.79	3.15	3.52	4.04	4.46
2-day:	1.25	1.58	2.05	2.43	2.97	3.4	3.85	4.33	5.01	5.56
3-day:	1.37	1.74	2.27	2.7	3.32	3.81	4.35	4.91	5.71	6.35
4-day:	1.49	1.9	2.49	2.98	3.67	4.23	4.84	5.48	6.4	7.15
7-day:	1.75	2.24	2.95	3.54	4.37	5.04	5.76	6.53	7.62	8.51
10-day:	1.98	2.54	3.35	4.01	4.92	5.64	6.41	7.21	8.34	9.24
20-day:	2.49	3.19	4.19	4.96	6.01	6.83	7.69	8.56	9.76	10.71
30-day:	2.87	3.68	4.84	5.73	6.94	7.89	8.86	9.87	11.23	12.3
45-day:	3.43	4.42	5.79	6.84	8.25	9.35	10.46	11.61	13.18	14.4
60-day:	3.95	5.11	6.7	7.85	9.34	10.45	11.55	12.66	14.1	15.21

Date/time (GMT): Wed Feb 8 19:03:23 2012

pyRunTime: 0.0781569480896

WS 32 - 52
Point precipitation frequency estimates (inches/hour)
NOAA Atla Volume 1 Version 5
Data type: Precipitation intensity
Time series type: Partial duration
Project area: Southwest
Latitude (decimal degrees): 39.5220
Longitude (decimal degrees): -119.4750

PRECIPITATION FREQUENCY ESTIMATES

by duration	1	2	5	10	25	50	100	200	500	1000 years
5-min:	1.24	1.55	2.08	2.57	3.37	4.1	4.97	6.02	7.72	9.28
10-min:	0.94	1.18	1.58	1.96	2.56	3.12	3.78	4.58	5.87	7.06
15-min:	0.78	0.97	1.31	1.62	2.12	2.58	3.12	3.78	4.85	5.83
30-min:	0.52	0.65	0.88	1.09	1.43	1.74	2.1	2.55	3.26	3.93
60-min:	0.32	0.41	0.55	0.67	0.88	1.07	1.3	1.58	2.02	2.43
2-hr:	0.21	0.26	0.34	0.4	0.5	0.59	0.69	0.82	1.05	1.25
3-hr:	0.16	0.21	0.26	0.3	0.37	0.42	0.49	0.57	0.71	0.85
6-hr:	0.11	0.14	0.17	0.2	0.24	0.27	0.29	0.33	0.39	0.45
12-hr:	0.07	0.09	0.11	0.13	0.16	0.18	0.2	0.22	0.25	0.27
24-hr:	0.04	0.06	0.07	0.08	0.1	0.12	0.13	0.15	0.17	0.19
2-day:	0.03	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1	0.12
3-day:	0.02	0.02	0.03	0.04	0.05	0.05	0.06	0.07	0.08	0.09
4-day:	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.06	0.07	0.07
7-day:	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.04	0.05	0.05
10-day:	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04
20-day:	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
30-day:	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
45-day:	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
60-day:	0	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Date/time (GMT): Wed Feb 8 19:03:55 2012
pyRunTime: 0.0847890377045

WS 47
Point precipitation frequency estimates (inches)
NOAA Atla Volume 1 Version 5
Data type: Precipitation depth
Time series type: Partial duration
Project area: Southwest
Latitude (decimal degrees): 39.4970
Longitude (decimal degrees): -119.4880

PRECIPITATION FREQUENCY ESTIMATES

by duration	1	2	5	10	25	50	100	200	500	1000 years
5-min:	0.11	0.13	0.18	0.22	0.29	0.35	0.42	0.51	0.66	0.79
10-min:	0.16	0.2	0.27	0.34	0.44	0.54	0.65	0.78	1	1.2
15-min:	0.2	0.25	0.34	0.42	0.55	0.66	0.8	0.97	1.24	1.49
30-min:	0.27	0.34	0.46	0.56	0.74	0.89	1.08	1.3	1.67	2
60-min:	0.34	0.42	0.56	0.7	0.91	1.1	1.33	1.61	2.06	2.48
2-hr:	0.44	0.55	0.7	0.84	1.04	1.22	1.43	1.69	2.15	2.58
3-hr:	0.52	0.65	0.82	0.96	1.15	1.32	1.52	1.79	2.23	2.64
6-hr:	0.73	0.92	1.14	1.31	1.55	1.72	1.9	2.14	2.51	2.87
12-hr:	0.98	1.23	1.56	1.82	2.17	2.44	2.71	2.98	3.35	3.67
24-hr:	1.24	1.57	2.02	2.38	2.89	3.3	3.73	4.18	4.8	5.3
2-day:	1.5	1.9	2.48	2.95	3.62	4.17	4.75	5.37	6.24	6.95
3-day:	1.65	2.1	2.77	3.31	4.08	4.71	5.39	6.11	7.14	7.98
4-day:	1.8	2.3	3.05	3.66	4.54	5.25	6.03	6.85	8.04	9.01
7-day:	2.13	2.73	3.64	4.39	5.45	6.31	7.25	8.24	9.67	10.85
10-day:	2.42	3.12	4.16	4.99	6.15	7.08	8.07	9.11	10.58	11.77
20-day:	3.15	4.05	5.34	6.35	7.72	8.8	9.93	11.09	12.69	13.97
30-day:	3.73	4.81	6.36	7.57	9.21	10.5	11.85	13.24	15.15	16.65
45-day:	4.49	5.8	7.66	9.09	11.02	12.55	14.13	15.78	18.07	19.9
60-day:	5.19	6.74	8.89	10.46	12.5	14.05	15.61	17.18	19.3	20.95

Date/time (GMT): Wed Feb 8 19:07:53 2012
pyRunTime: 0.0823230743408

WS 53 - 68
Point precipitation frequency estimates (inches)
NOAA Atla Volume 1 Version 5
Data type: Precipitation depth
Time series type: Partial duration
Project area: Southwest
Latitude (decimal degrees): 39.5070
Longitude (decimal degrees): -119.4650

PRECIPITATION FREQUENCY ESTIMATES

by duration	1	2	5	10	25	50	100	200	500	1000 years
5-min:	0.11	0.13	0.18	0.22	0.29	0.35	0.42	0.51	0.65	0.79
10-min:	0.16	0.2	0.27	0.34	0.44	0.53	0.64	0.78	0.99	1.2
15-min:	0.2	0.25	0.34	0.41	0.54	0.66	0.8	0.96	1.23	1.48
30-min:	0.27	0.34	0.45	0.56	0.73	0.89	1.07	1.3	1.66	2
60-min:	0.34	0.42	0.56	0.69	0.91	1.1	1.33	1.61	2.06	2.47
2-hr:	0.43	0.54	0.69	0.83	1.03	1.21	1.42	1.68	2.13	2.56
3-hr:	0.51	0.64	0.81	0.94	1.14	1.3	1.5	1.76	2.2	2.61
6-hr:	0.71	0.89	1.1	1.27	1.5	1.67	1.85	2.08	2.46	2.81
12-hr:	0.93	1.17	1.49	1.74	2.07	2.32	2.58	2.85	3.2	3.52
24-hr:	1.16	1.47	1.89	2.23	2.7	3.08	3.48	3.9	4.48	4.95
2-day:	1.38	1.75	2.29	2.71	3.33	3.83	4.35	4.91	5.7	6.34
3-day:	1.52	1.94	2.54	3.03	3.74	4.31	4.92	5.57	6.5	7.25
4-day:	1.65	2.12	2.8	3.35	4.15	4.79	5.49	6.23	7.29	8.16
7-day:	1.96	2.51	3.33	4	4.96	5.73	6.57	7.46	8.73	9.78
10-day:	2.22	2.86	3.79	4.54	5.58	6.42	7.31	8.24	9.55	10.61
20-day:	2.85	3.67	4.82	5.73	6.95	7.91	8.91	9.94	11.36	12.48
30-day:	3.35	4.31	5.69	6.75	8.2	9.34	10.52	11.73	13.4	14.71
45-day:	4.02	5.19	6.83	8.1	9.8	11.13	12.52	13.94	15.91	17.48
60-day:	4.65	6.03	7.93	9.32	11.12	12.47	13.84	15.21	17.04	18.45

Date/time (GMT): Wed Feb 8 18:57:48 2012
pyRunTime: 0.0789940357208

WS 53 - 68
Point precipitation frequency estimates (inches/hour)
NOAA Atla Volume 1 Version 5
Data type: Precipitation intensity
Time series type: Partial duration
Project area: Southwest
Latitude (decimal degrees): 39.5070
Longitude (decimal degrees): -119.4650

PRECIPITATION FREQUENCY ESTIMATES

by duration	1	2	5	10	25	50	100	200	500	1000 years
5-min:	1.28	1.6	2.15	2.64	3.46	4.2	5.08	6.13	7.84	9.42
10-min:	0.97	1.22	1.63	2.01	2.63	3.19	3.86	4.67	5.97	7.17
15-min:	0.8	1	1.35	1.66	2.18	2.64	3.19	3.86	4.93	5.93
30-min:	0.54	0.68	0.91	1.12	1.46	1.78	2.15	2.6	3.32	3.99
60-min:	0.34	0.42	0.56	0.69	0.91	1.1	1.33	1.61	2.06	2.47
2-hr:	0.22	0.27	0.35	0.41	0.51	0.6	0.71	0.84	1.07	1.28
3-hr:	0.17	0.21	0.27	0.31	0.38	0.43	0.5	0.59	0.73	0.87
6-hr:	0.12	0.15	0.18	0.21	0.25	0.28	0.31	0.35	0.41	0.47
12-hr:	0.08	0.1	0.12	0.14	0.17	0.19	0.21	0.24	0.27	0.29
24-hr:	0.05	0.06	0.08	0.09	0.11	0.13	0.15	0.16	0.19	0.21
2-day:	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1	0.12	0.13
3-day:	0.02	0.03	0.04	0.04	0.05	0.06	0.07	0.08	0.09	0.1
4-day:	0.02	0.02	0.03	0.03	0.04	0.05	0.06	0.06	0.08	0.08
7-day:	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.06
10-day:	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04
20-day:	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03
30-day:	0	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
45-day:	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
60-day:	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Date/time (GMT): Wed Feb 8 19:00:30 2012
pyRunTime: 0.0697660446167

WS 57 and 67
Point precipitation frequency estimates (inches)
NOAA Atla Volume 1 Version 5
Data type: Precipitation depth
Time series type: Partial duration
Project area: Southwest
Latitude (decimal degrees): 39.5040
Longitude (decimal degrees): -119.4670

PRECIPITATION FREQUENCY ESTIMATES

by duration	1	2	5	10	25	50	100	200	500	1000 years
5-min:	0.11	0.14	0.18	0.22	0.29	0.35	0.42	0.51	0.66	0.79
10-min:	0.16	0.2	0.28	0.34	0.44	0.54	0.65	0.78	1	1.2
15-min:	0.2	0.25	0.34	0.42	0.55	0.66	0.8	0.97	1.24	1.49
30-min:	0.27	0.34	0.46	0.56	0.74	0.89	1.08	1.3	1.67	2
60-min:	0.34	0.42	0.57	0.7	0.91	1.11	1.34	1.61	2.06	2.48
2-hr:	0.44	0.55	0.7	0.84	1.04	1.22	1.43	1.7	2.15	2.58
3-hr:	0.52	0.65	0.82	0.96	1.15	1.32	1.53	1.79	2.23	2.64
6-hr:	0.73	0.91	1.13	1.3	1.53	1.71	1.89	2.13	2.5	2.87
12-hr:	0.96	1.21	1.54	1.79	2.13	2.4	2.67	2.94	3.3	3.63
24-hr:	1.21	1.53	1.97	2.32	2.82	3.22	3.64	4.08	4.69	5.18
2-day:	1.45	1.84	2.4	2.85	3.51	4.03	4.59	5.19	6.04	6.72
3-day:	1.59	2.03	2.67	3.19	3.94	4.55	5.2	5.89	6.88	7.69
4-day:	1.74	2.22	2.94	3.53	4.38	5.07	5.81	6.6	7.73	8.66
7-day:	2.06	2.64	3.51	4.23	5.25	6.07	6.97	7.92	9.29	10.41
10-day:	2.34	3.01	4.01	4.8	5.91	6.8	7.75	8.75	10.15	11.29
20-day:	3.02	3.89	5.13	6.09	7.4	8.43	9.5	10.61	12.13	13.35
30-day:	3.58	4.61	6.09	7.24	8.81	10.04	11.32	12.64	14.45	15.88
45-day:	4.3	5.55	7.32	8.69	10.53	11.98	13.49	15.05	17.22	18.96
60-day:	4.98	6.46	8.52	10.02	11.97	13.44	14.93	16.43	18.44	20.02

Date/time (GMT): Wed Feb 8 19:10:23 2012
pyRunTime: 0.0927259922028

WS 69
Point precipitation frequency estimates (inches)
NOAA Atla Volume 1 Version 5
Data type: Precipitation depth
Time series type: Partial duration
Project area: Southwest
Latitude (decimal degrees): 39.5170
Longitude (decimal degrees): -119.4480

PRECIPITATION FREQUENCY ESTIMATES

by duration	1	2	5	10	25	50	100	200	500	1000 years
5-min:	0.11	0.13	0.18	0.22	0.29	0.35	0.42	0.51	0.65	0.78
10-min:	0.16	0.2	0.27	0.34	0.44	0.53	0.64	0.78	0.99	1.19
15-min:	0.2	0.25	0.34	0.41	0.54	0.66	0.8	0.96	1.23	1.48
30-min:	0.27	0.34	0.45	0.56	0.73	0.89	1.07	1.3	1.66	1.99
60-min:	0.33	0.42	0.56	0.69	0.91	1.1	1.33	1.6	2.05	2.47
2-hr:	0.43	0.54	0.69	0.83	1.03	1.21	1.42	1.68	2.13	2.56
3-hr:	0.51	0.64	0.8	0.94	1.13	1.3	1.5	1.76	2.2	2.6
6-hr:	0.7	0.87	1.09	1.26	1.48	1.65	1.83	2.06	2.44	2.79
12-hr:	0.91	1.15	1.46	1.7	2.03	2.28	2.53	2.79	3.13	3.45
24-hr:	1.13	1.43	1.84	2.17	2.63	3	3.39	3.79	4.36	4.81
2-day:	1.34	1.7	2.21	2.63	3.23	3.7	4.21	4.75	5.51	6.13
3-day:	1.47	1.87	2.46	2.94	3.62	4.17	4.77	5.4	6.29	7.02
4-day:	1.6	2.05	2.71	3.25	4.02	4.65	5.32	6.04	7.07	7.91
7-day:	1.9	2.43	3.23	3.88	4.81	5.57	6.38	7.25	8.48	9.5
10-day:	2.15	2.77	3.68	4.4	5.42	6.23	7.09	8	9.27	10.3
20-day:	2.74	3.53	4.64	5.51	6.69	7.62	8.58	9.57	10.94	12.02
30-day:	3.2	4.12	5.44	6.46	7.85	8.94	10.07	11.23	12.83	14.09
45-day:	3.84	4.96	6.53	7.74	9.38	10.66	11.99	13.36	15.27	16.79
60-day:	4.43	5.75	7.58	8.91	10.64	11.94	13.25	14.58	16.35	17.73

Date/time (GMT): Wed Feb 8 19:06:08 2012
pyRunTime: 0.0771069526672

WS 70 and 71
Point precipitation frequency estimates (inches)
NOAA Atla Volume 1 Version 5
Data type: Precipitation depth
Time series type: Partial duration
Project area: Southwest
Latitude (decimal degrees): 39.5090
Longitude (decimal degrees): -119.4450

PRECIPITATION FREQUENCY ESTIMATES

by duration	1	2	5	10	25	50	100	200	500	1000 years
5-min:	0.11	0.14	0.18	0.22	0.29	0.35	0.43	0.51	0.66	0.79
10-min:	0.16	0.21	0.28	0.34	0.44	0.54	0.65	0.78	1	1.2
15-min:	0.2	0.26	0.34	0.42	0.55	0.67	0.8	0.97	1.24	1.49
30-min:	0.27	0.34	0.46	0.57	0.74	0.9	1.08	1.31	1.67	2
60-min:	0.34	0.42	0.57	0.7	0.92	1.11	1.34	1.62	2.06	2.48
2-hr:	0.44	0.55	0.71	0.84	1.05	1.23	1.44	1.71	2.16	2.59
3-hr:	0.52	0.65	0.82	0.96	1.15	1.32	1.53	1.79	2.23	2.64
6-hr:	0.72	0.9	1.12	1.29	1.52	1.7	1.88	2.11	2.49	2.85
12-hr:	0.94	1.19	1.51	1.77	2.1	2.36	2.63	2.9	3.25	3.58
24-hr:	1.18	1.49	1.93	2.27	2.77	3.16	3.57	4	4.6	5.08
2-day:	1.41	1.79	2.34	2.79	3.43	3.94	4.49	5.08	5.91	6.58
3-day:	1.55	1.98	2.61	3.13	3.87	4.47	5.11	5.79	6.77	7.57
4-day:	1.69	2.17	2.88	3.47	4.31	4.99	5.73	6.51	7.63	8.55
7-day:	2.01	2.58	3.44	4.16	5.17	6	6.89	7.85	9.21	10.34
10-day:	2.28	2.94	3.93	4.72	5.82	6.71	7.66	8.66	10.07	11.21
20-day:	2.93	3.78	4.99	5.93	7.22	8.23	9.29	10.39	11.9	13.12
30-day:	3.44	4.45	5.9	7.02	8.56	9.77	11.03	12.34	14.13	15.55
45-day:	4.14	5.36	7.08	8.43	10.25	11.69	13.2	14.77	16.97	18.75
60-day:	4.78	6.22	8.24	9.71	11.64	13.11	14.59	16.11	18.17	19.8

Date/time (GMT): Wed Feb 8 19:11:20 2012
pyRunTime: 0.0849831104279

WS 72
Point precipitation frequency estimates (inches)
NOAA Atla Volume 1 Version 5
Data type: Precipitation depth
Time series type: Partial duration
Project area: Southwest
Latitude (decimal degrees): 39.4720
Longitude (decimal degrees): -119.4560

PRECIPITATION FREQUENCY ESTIMATES

by duration	1	2	5	10	25	50	100	200	500	1000 years
5-min:	0.11	0.14	0.18	0.23	0.29	0.36	0.43	0.52	0.66	0.79
10-min:	0.17	0.21	0.28	0.35	0.45	0.54	0.66	0.79	1	1.2
15-min:	0.21	0.26	0.35	0.43	0.56	0.68	0.81	0.98	1.24	1.49
30-min:	0.28	0.35	0.47	0.58	0.75	0.91	1.09	1.31	1.67	2
60-min:	0.35	0.44	0.58	0.72	0.93	1.12	1.35	1.63	2.07	2.48
2-hr:	0.45	0.57	0.73	0.87	1.08	1.26	1.47	1.74	2.19	2.61
3-hr:	0.55	0.68	0.86	1	1.2	1.38	1.58	1.85	2.29	2.69
6-hr:	0.78	0.97	1.2	1.39	1.63	1.82	2.01	2.26	2.64	3
12-hr:	1.05	1.32	1.67	1.95	2.32	2.6	2.9	3.19	3.58	3.92
24-hr:	1.34	1.7	2.19	2.58	3.14	3.59	4.05	4.54	5.23	5.78
2-day:	1.63	2.07	2.72	3.24	4	4.61	5.26	5.96	6.95	7.76
3-day:	1.79	2.29	3.04	3.64	4.52	5.23	5.99	6.81	7.98	8.94
4-day:	1.95	2.51	3.35	4.04	5.04	5.84	6.72	7.66	9.01	10.11
7-day:	2.32	2.99	4.02	4.86	6.06	7.05	8.11	9.26	10.9	12.25
10-day:	2.64	3.41	4.58	5.51	6.81	7.87	8.99	10.18	11.86	13.23
20-day:	3.45	4.46	5.91	7.04	8.59	9.8	11.08	12.4	14.24	15.71
30-day:	4.15	5.37	7.15	8.53	10.42	11.91	13.47	15.09	17.32	19.09
45-day:	4.99	6.47	8.59	10.23	12.47	14.25	16.12	18.07	20.81	23.03
60-day:	5.81	7.58	10.06	11.88	14.26	16.09	17.94	19.83	22.41	24.47

Date/time (GMT): Wed Feb 8 19:06:38 2012
pyRunTime: 0.0881628990173

APPENDIX C
Preliminary Report Comments

REVIEW COMMENTS

Project Name: USA Parkway (Pass/Fail) Drainage Analysis
Project No./EA: 73708E1P
Reviewer: NDOT
Consultant: Wood Rodgers

Date: August 2012
Submittal Level: Revised

COMMENT #	SHEET #	REVIEW COMMENTS	RESPONSE
Drainage Report Comments			
1	App A Table 7	Some of the Channel Flow velocity appears to be supercritical. Typically a majority of steep sloped natural channels adjust themselves to be critical velocity either on a macro (pool and drop) or micro scale (boulders act as weir). This would result in longer Lag Times and thus reduced flows. Please verify velocities and corresponding Lag Times.	The Velocities for each channel with supercritical flow has been adjusted so flow is subcritical.
2	App A Table 7	Regarding the note on Channel Velocity, is the assumption of constant channel geometry and depth reasonable for all large offsite channels no matter what the overall drainage basin area is? After determining preliminary flows, initial assumptions should be verified to be reasonable or not.	For the flows determined by HMS the TLAG was recalculated using the SCS methodology and the methodology presented in the Truckee Meadows Regional Drainage Manual.
3	App A Table 10	Please evaluate channel velocity to identify unstable channels requiring rip-rap protection and note as an additional deficiency. Those channels requiring rip-rap protection would have a smaller cross sectional area, higher roughness coefficient and thus lower capacity than shown.	The shear stresses have been calculated for the channels and areas where riprap lining is needed have been highlighted in the Table 10 in Appendix A.
4	Figures	Are there original construction plans available that show the drainage facilities and storm drain connectivity. We have been told that plans are available. Many DI's shown in the existing features figure don't have any connecting pipes shown. This connectivity will be important for us to know and including the plans would help fill in the gaps.	Per the Plan set given to Wood Rodgers on 5/22/12, culverts and connectivity were added to the Pass/Fail drainage report.
5	3.0 Results	It is current NDOT standard practice and policy to always provide culvert end treatments (end-sections or headwalls) as well as outlet protection (riprap if needed) on all culverts. Please note any deficiencies here and in a summary table.	A table showing the deficiencies has been added to the drainage report.
6	3.0 Results	Please note any deficiencies in culvert or storm drain system geometry or minimum slopes.	The Culvert and storm drain geometry deficiencies are listed in the report. There appear to be no culvert and storm drain slope deficiencies.

NEVADA DOT

REVIEW COMMENTS

Project Name: USA Parkway (Pass/Fail) Drainage Analysis
Project No./EA: 73708E1P
Reviewer: NDOT
Consultant: Wood Rodgers

Date: August 2012
Submittal Level: Revised

COMMENT #	SHEET #	REVIEW COMMENTS	RESPONSE
7	3.0 Results	Please note any deficiencies of hydraulic facilities acting as roadside obstructions unless this will be covered elsewhere.	This will be noted in the report from Jacobs.
8	3.0 Results	Please verify that drop inlets have been placed in all critical areas such as Flankers at low points, super reversals, etc., and note non-standard drop inlets.	There is one low point in the project area and there are DI's on the left and right side of the road, however, there are no flankers. This area is noted in the appendices.
9	3.0 Results	Additional Areas of Interest – We have been told; although, no one knows where the drainage report is for the constructed portion of USA Parkway, a watershed map does exist and is available. Can the issues discussed in the additional areas of interest be compared to this water shed map to verify the hydrology and your assumptions for the post development condition?	Per the REC Engineering master drainage plan sheets Wood Rodgers was provided it is still unclear as to the reasoning for the existing C11design. The culvert C11 appears to be C-H3 in the REC plan and is shown as 2-96" RCP's which are not what was constructed. The REC master drainage plan shows that the flow for watersheds 57, 61, 64, 65, and 67 (Basin H-300 in REC plan) drains over the parallel road and therefore the "Additional Area Of Interest" comment regarding Watersheds 57, 61, 64, 65, and 67 has been removed.
10	3.0 Results	The roadway and drainage improvements located between I-80 and the Railroad Bridge were constructed as part of the USA Parkway Interchange Project which was overseen by NDOT unlike the rest of the USA Parkway alignment. Additional information and analysis of these facilities can be found in the plans and report for the interchange project (Contract 3320) prepared by Carter Burgess.	Features from Contract 3320 have been removed from the drainage report since they are downstream of the project area and therefore do not affect the design.
11	3.0 Results	A Summary table of Spread violations would be helpful here so as to highlight all deficiencies quickly, in one place, and in the same format.	A table for spread violations was added to the Drainage Report.

NEVADA DOT

REVIEW COMMENTS

Project Name: USA Parkway (Pass/Fail) Drainage Analysis
Project No./EA: 73708E1P
Reviewer: NDOT
Consultant: Wood Rodgers

Date: August 2012
Submittal Level: Revised

COMMENT #	SHEET #	REVIEW COMMENTS	RESPONSE
12	3.0 Results	Please note damage or poorly installed facilities that have been noted. One Item that we are aware of are damaged (deformed and perforated) CMP's at C30.	A table specifying the Culvert Inlet and Outlet deficiencies has been added to Appendix A
13	3.0 Results	C15 and C16 – Are these 3' x 4' culverts RCP's (pipes) or RCB's (box culverts).	Culverts C15 and C16 were modeled as RCBs but were labeled wrong in the appendices. The appendices have been updated.
14	3.0 Results	Remove the opinions from the text and just stick to the facts.	The opinions have been removed from the drainage report.

NEVADA DOT