Agenda Item No: 18.A

STAFF REPORT

Report To: Board of Supervisors **Meeting Date:** July 15, 2021

Staff Contact: Darren Schulz, Public Works Director

Agenda Title: For Possible Action: Discussion and possible action regarding a proposed acceptance of the West Carson City Area Drainage Plan and direction to staff concerning the exploration of funding opportunities for the drainage project in the West Carson City area. (Dan Stucky, dstucky@carson.org and Robert Fellows, rfellows@carson.org)

Staff Summary: As directed in the City's Hazard Mitigation Plan, Area Drainage Plan studies help identify improvements that reduce or eliminate damage and loss caused by flooding. The West Area Drainage Plan offers one potential project in the western portion of the City to reduce or eliminate high-risk flood areas. The plan will be presented for consideration and direction from the Board of Supervisors ("Board").

Agenda Action: Formal Action / Motion **Time Requested:** 20 minutes

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Proposed Motion

I move to accept the West Carson City Area Drainage Plan and to direct staff to explore funding opportunities for the priority drainage project.

Board's Strategic Goal

Safety

Previous Action

N/A

Background/Issues & Analysis

In 2016, the Carson City Hazard Mitigation Plan was adopted by the Board. The plan set forth goals to reduce damage and loss due to flooding in the City. Staff has been working with the Carson Water Subconservancy District, a Cooperative Technical Partner for the Federal Emergency Management Agency (FEMA), to evaluate areas in the Carson River Watershed for possible flood control projects through Area Drainage Plan studies. The West Carson City Area Drainage Plan (WCCADP) is the fifth study sponsored through the Subconservancy District. The Carson City Plan was funded through the Carson Water Subconservancy through funding from FEMA. The WCCADP identified one project with various options in the study area to consider based on downstream benefits. A basin and infrastructure that mitigates the 10-year storm is the preferred project.

Applicable Statute, Code, Policy, Rule or Regulation

Carson City Hazard Mitigation Plan 2016; Goal 5-Reduce the possibility of damage and loss due to floods; Goal 5.A-Identify flood-prone areas using Geographical Information Systems (GIS).

Financial Information

Is there a fiscal impact? No

If yes, account name/number: N/A

Is it currently budgeted? No

Explanation of Fiscal Impact: N/A

Alternatives

Choose a larger basin project from the study for further study and funding opportunities and/or provide alternative direction to staff.

Attachments:

WestCarsonCityADP_20210701.pdf

Board Action Taken:

Motion: ________________ 1) ________________ Aye/Nay

2) ________________ __________

____

____

____

____

____

(Vote Recorded By)

In Association With:

Carson City Public Works

Carson Water Subconservancy District

West Carson City
Area Drainage Plan

Prepared By:
Kimley»Horn

Draft | July 2021

U.S. Department of Homeland Security

FEMA

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Appendix

1 Purpose and Project Area

The purpose for the West Carson City Area Drainage Plan (WCCADP) is to define the existing flood hazards for Ash Canyon and Kings Canyon Creeks in Carson City, Nevada, and develop a proposed drainage mitigation project to reduce flooding through this portion of the City. The study area is located in Carson City, Nevada, and is approximately bounded by Longview Way to the west, Saliman Road to the east, King Street to the south, and Winne Lane to the north. The study is affected by runoff from Ash Canyon and King Canyon Creeks that ultimately flows through downtown Carson City. Ash Canyon and King Canyon Creeks come off the Snow Valley Peak in the Carson Range of the Toiyabe National Forest to the west and flow into Carson City storm conveyance systems, discharging downstream of Saliman Road. The creeks ultimately combine upstream of Interstate 580 and outfall to the Carson River. The Vicinity, Location and Aerial Maps can be seen in Figure 1, Figure 2, and Figure 3, respectively.

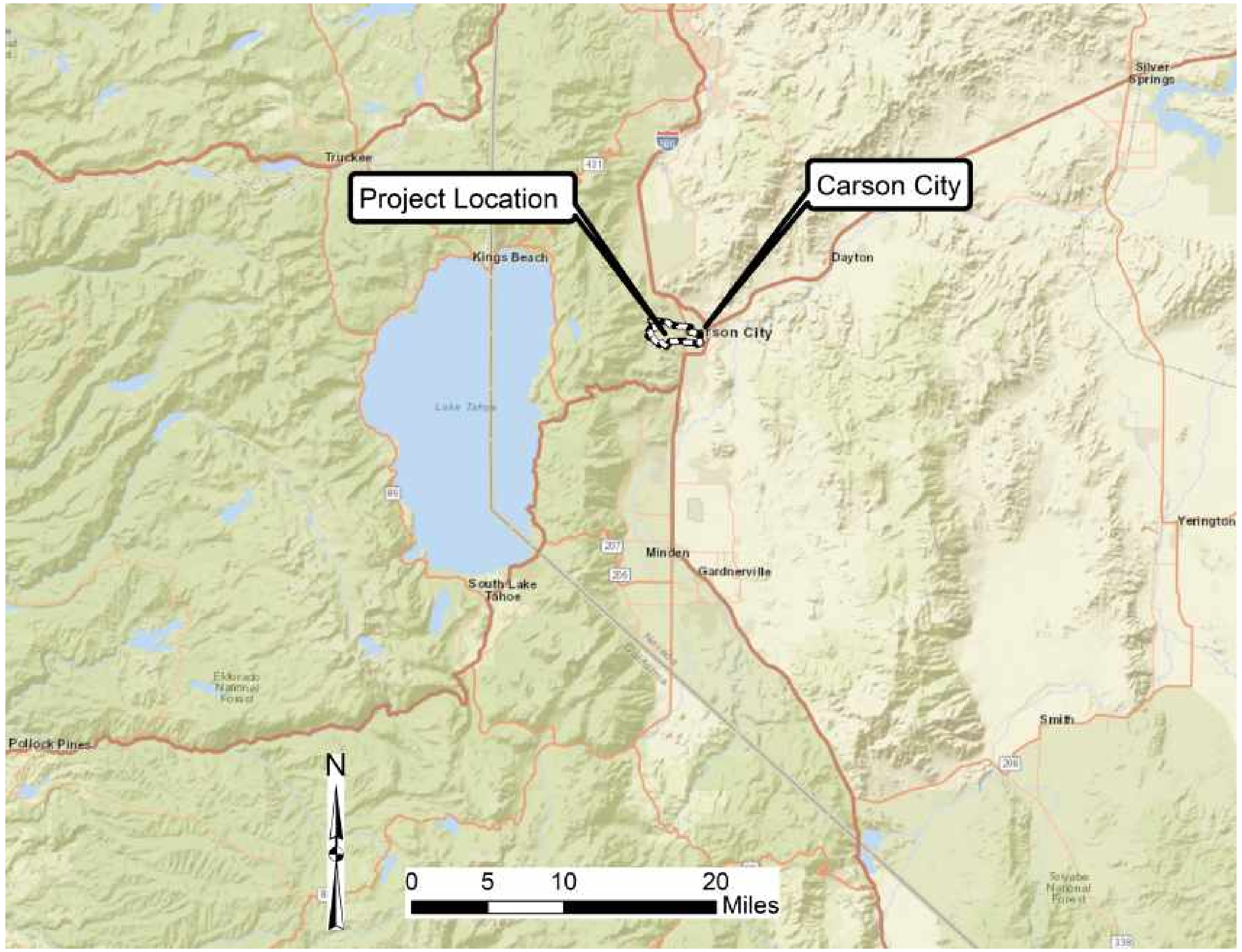


Figure 1: Vicinity Map

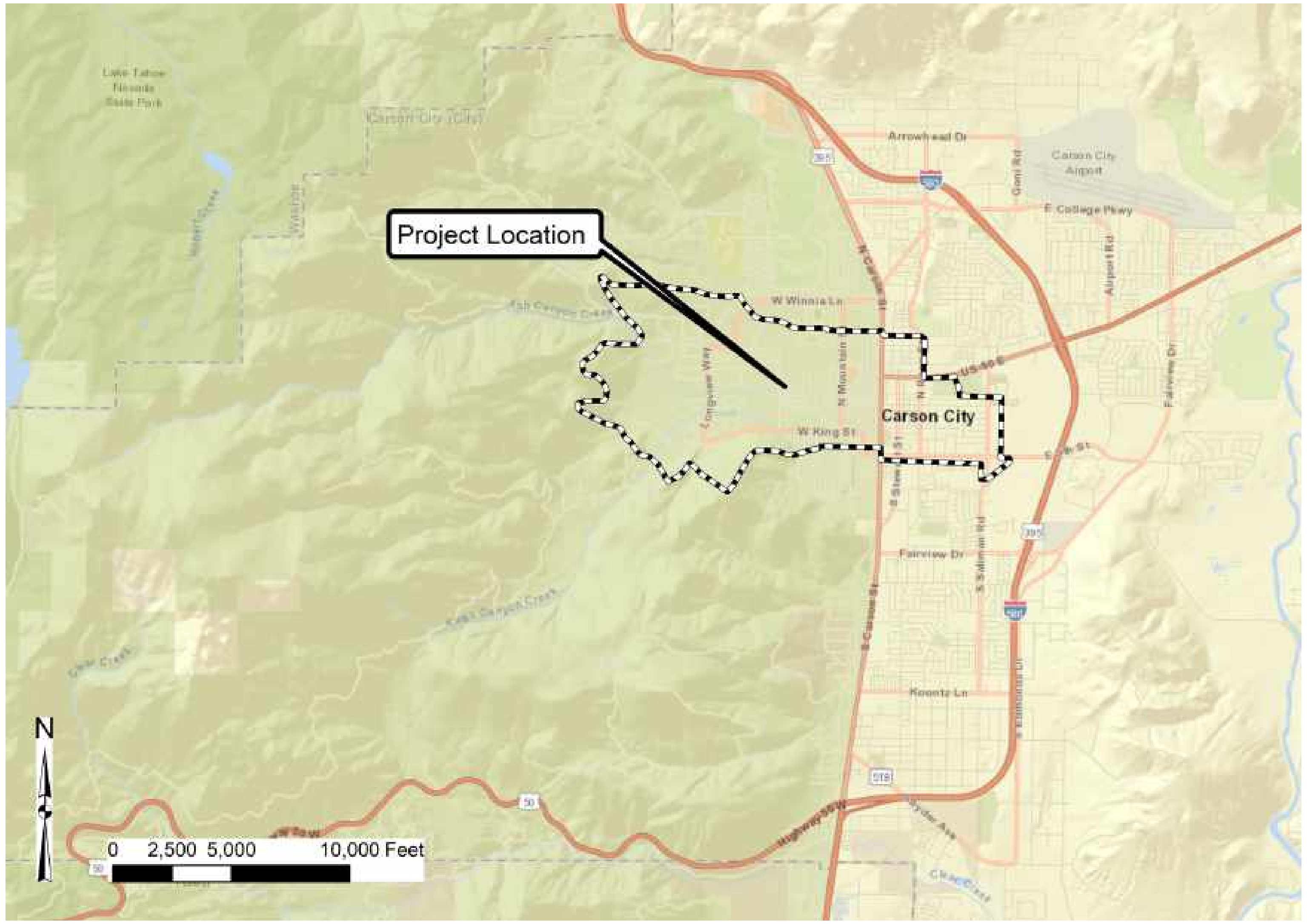
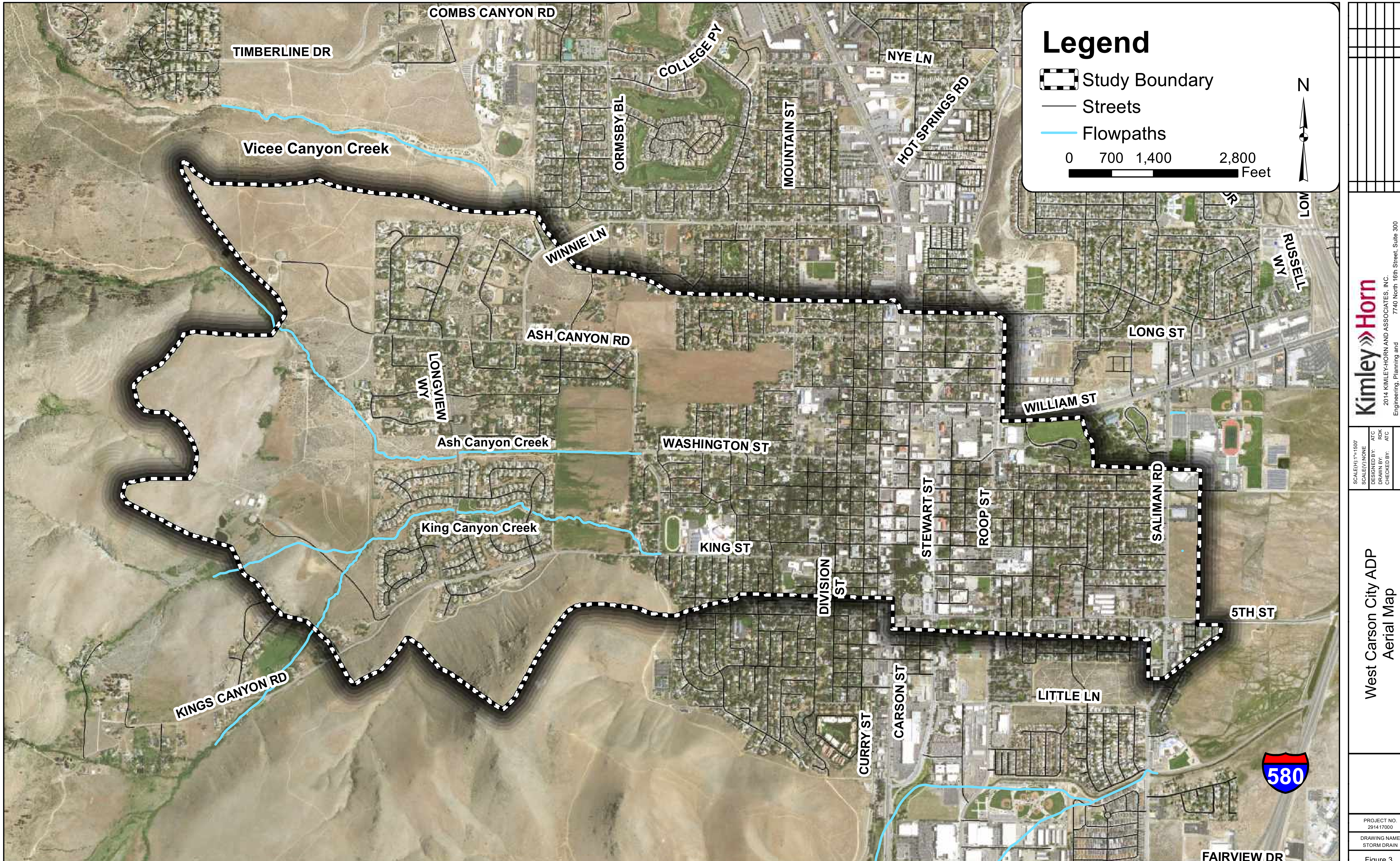


Figure 2: Location Map



Legend
Study Boundary
Streets
Flowpaths
0
700
1,400
2,800
Feet
N
COMBS CANYON RD
TIMBERLINE DR
COLLEGE PY
NYE LN
HOT SPRINGS RD
ORMSBY BL
MOUNTAIN ST
Vicee Canyon Creek
WINNIE LN
RUSSELL WY
LONG ST
ASH CANYON RD
LONGVIEW WY
WILLIAM ST
Ash Canyon Creek
WASHINGTON ST
King Canyon Creek
KING ST
STEWART ST
ROOP ST
SALIMAN RD
DIVISION ST
5TH ST
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CARSON ST
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LITTLE LN
580
FAIRVIEW DR
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DESIGNED BY: ATC
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DATE: 06/2021
West Carson City ADP
Aerial Map
PROJECT NO. 291417000
DRAWING NAME STORM DRAIN
Figure 3

1.1 Goals

The WCCADP project goals are to define the existing flood hazards for Ash Canyon and Kings Canyon Creeks using detailed two-dimensional surface modeling coupled with sub surface storm drain modeling, current hydrologic and hydraulic parameters, and current methodologies consistent with Carson City standards. Once the existing conditions were defined, a proposed mitigation project was developed to reduce flooding impacts and continue to build resiliency within the watershed. Public input was collected from two public meetings and was a major input to the existing flood hazards determination and mitigation project development. The proposed mitigation project was developed into a design concept with an engineer's estimate of probable cost for future planning purposes. The overarching goals for the WCCADP are as follows:

- Generate a detailed two-dimensional hydraulic floodplain model coupled with a one-dimensional storm drain model defining the existing conditions
- Determine flood hazard areas based on the model results and public input
- Identify proposed mitigation solution(s)

2 Project History

2.1 Previous Studies

This portion of Carson City was initially studied in the *Hydrologic Analysis US 395 Bypass Freeway Carson City, Nevada Report* (WRC, 1997), the *Southwest Carson City Regional Hydrologic Analysis Final Report* (Manhard, 2010), and the *Hydrologic Analysis for Carson City Restudy* (HDR, 2010).

The Hydrologic Analysis US 395 Bypass Freeway Carson City, Nevada, by WRC Nevada Inc (WRC) documents the detailed hydrologic analysis executed for the purpose of determining design peak flows in and around Carson City. The analysis completed by WRC was conducted for the Nevada Department of Transportation as part of an assessment for the future construction of the US 395 Freeway Bypass.

Manhard Consulting Ltd. (Manhard) completed a comprehensive regional hydrologic analysis of the Southwest Carson Watersheds in March 2010 presented in the *Southwest Carson City Regional Hydrologic Analysis Final Report* (Southwest Regional Hydrology).

The Hydrologic Analyses for Carson City Restudy Flood Insurance Study Carson City, Nevada was completed in June 2010 by HDR (Carson City Restudy Hydrology). This project developed a regional HEC-1 model that was used as input into the two-dimensional model developed for this study. The SCS Curve Number Method was used to compute rainfall excess and losses. The SCS Unit Hydrograph Method was utilized as the rainfall runoff transformation within each sub-basin. Routing of runoff from the sub-basins was accomplished using the Muskingum-Cunge Method of hydrograph routing. The 100-year, 24-hour rainfall distribution was used for the hydrologic analysis and is based on the National Oceanic and Atmospheric Administration Atlas 14 (NOAA Atlas 14) published by the National Weather Service in 2004 and revised in 2006. This restudy referenced the other two previous studies and results were compared and verified. Excerpts from this study have been provided in Appendix A.

2.2 FEMA Floodplain Delineation for King's Canyon and Ash Canyon Creeks

Ash Canyon and King Canyon Creeks are FEMA delineated floodplains. Both floodplains begin as Zone A as they exit the Carson Range on the west side of the study boundary. The Zone A floodplains transition to Zone AO in the mountain piedmont area until upstream of Longview Way. At Longview Way, the reaches have been channelized and are defined as Zone AE. The Zone AE floodplains terminates near Ormsby Blvd where the creeks outfall into the City storm drain system and are routed downstream of Saliman Road. From Ormsby Blvd to Saliman Road, there are isolated Zone AO floodplains where ponding depths exceed one foot and are out of the street section. Figure 4 shows the limits of the FEMA Special Flood Hazard Areas within the study boundary.

The Anderson Ranch Letter of Map Revision (LOMR) was submitted and approved by FEMA (FEMA Case No. 20-09-0437P) and is now effective as of February 18, 2021. The LOMR application used the Carson City Restudy Hydrology and developed a two-dimensional HEC-RAS model that was provided for this study. The LOMR modified the Zone AE on Ash Canyon Creek from upstream of Longview Way to Ormsby Blvd.

3 Survey and Terrain Data

The terrain data required for this study was downloaded from USGS National Topographic Map **(USGS, n.d.)**. USGS captured LiDAR for this portion of Carson City in 2017. The LiDAR data was download in LAZ format. A bare ground elevation terrain dataset was then generated from the LAZ file. The bare ground terrain dataset was then used for the hydraulic analyses. The USGS LiDAR data used the following coordinate systems.

USGS LiDAR Coordinate System (USGS and DAS, 2017)

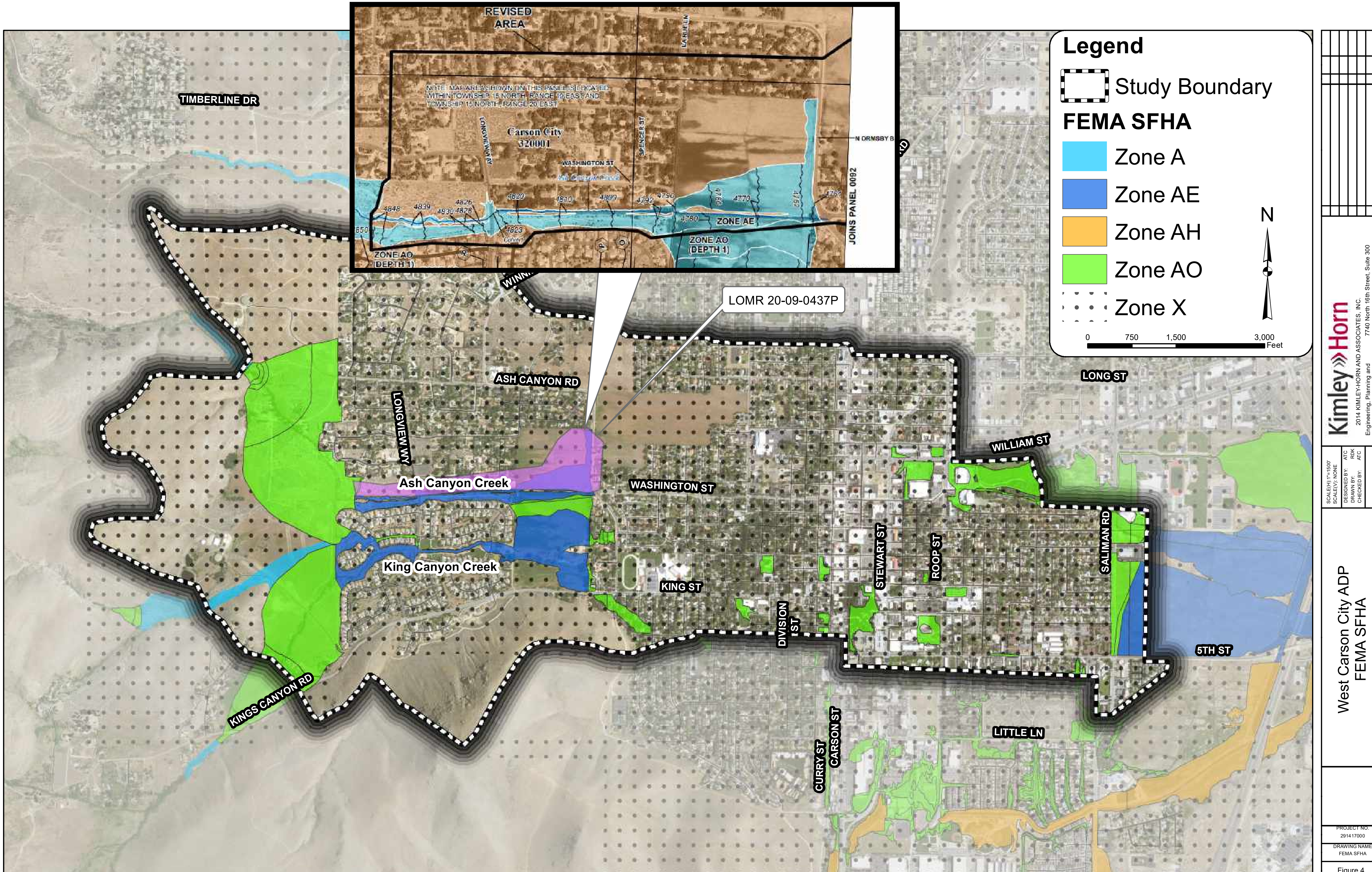
- Coordinate System: universal Transverse Mercator 11 North
- Horizontal Datum: North American Datum of 1983 of 2011
- Vertical Datum: North American Vertical Datum of 1988
- Units: Meters

The bare ground terrain dataset was then converted to match the project coordinate systems:

Project Coordinate System:

- Horizontal Datum: North American Datum of 1983 (NAD83)
- Vertical Datum: North American Vertical Datum of 1988 (NAVD88)
- Units: Feet

The USGS Survey Report excerpts have been provided in Appendix B. A topographic map is provided in Figure 5.


Legend
Study Boundary
FEMA SFHA
Zone A
Zone AE
Zone AH
Zone AO
Zone X
N
0 750 1,500 3,000 Feet
REVISED AREA
NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 15 NORTH, RANGE 19 EAST AND TOWNSHIP 15 NORTH, RANGE 20 EAST
Carson City 320001
WASHINGTON ST
ZONE AE
ZONE AO (DEPTH 1)
JOINS PANEL 0092
LOMR 20-09-0437P
TIMBERLINE DR
ASH CANYON RD
LONGVIEW WY
Ash Canyon Creek
King Canyon Creek
WASHINGTON ST
KING ST
KINGS CANYON RD
DIVISION ST
CURRY ST
CARSON ST
STEWART ST
ROOP ST
SALIMAN RD
WILLIAM ST
LONG ST
5TH ST
LITTLE LN
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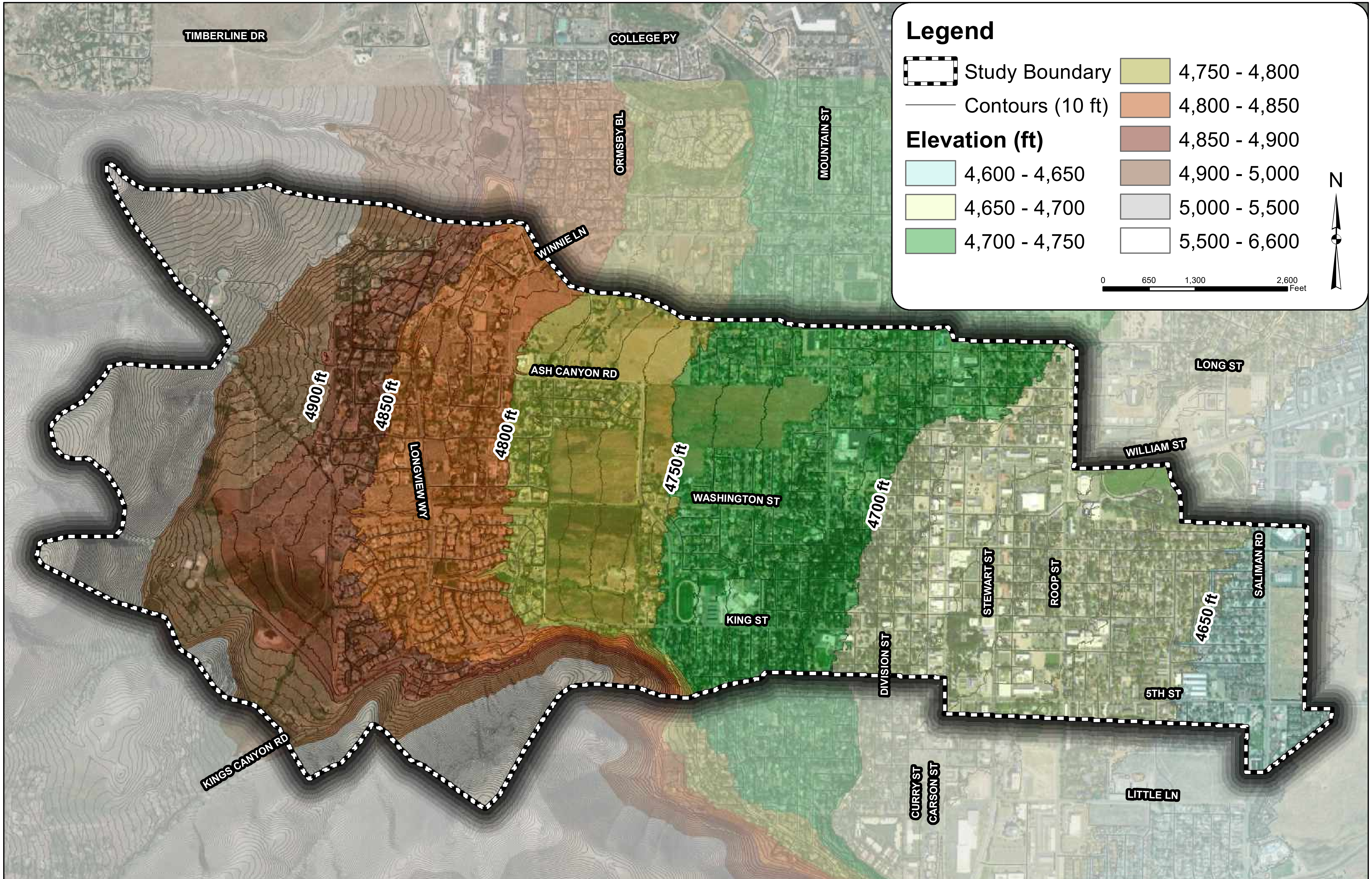
FEMA SFHA
PROJECT NO. 291417000
DRAWING NAME FEMA SFHA
Figure 4



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Phoenix, Arizona 85020 (602) 944-5500

West Carson City ADP
Topography Map

PROJECT NO. 291417000
DRAWING NAME TOPOGRAPHY MAP
Figure 5

4 Hydrology

4.1 Methodology

The Carson City Restudy Hydrology (HDR, 2010) was used as the basis for the upstream hydrology. The HEC-1 model was reviewed, and no changes or modifications were warranted to the upper watershed. The WCCADP only revised the hydrology within the study boundary in FLO-2D based on the same hydrologic methodologies as the HEC-1 model. The FLO-2D model (FLO-2D, 2020) Build No 20.07.22 was created for the urbanized portion of the watershed. Inflow hydrographs from the upper watershed (HEC-1) were routed through the FLO-2D model domain. The FLO-2D model also used rainfall on the grid to account for runoff generated in the FLO-2D model domain.

4.2 Inflow Hydrographs

There are six HEC-1 inflow hydrographs that were input into the FLO-2D model. These inflow hydrographs were derived directly from the HEC-1 model (HDR, 2010). Table 1 is a summary of the peak discharges. Figure 6 shows these inflow locations within the FLO-2D domain.

Table 1: Inflow Hydrographs

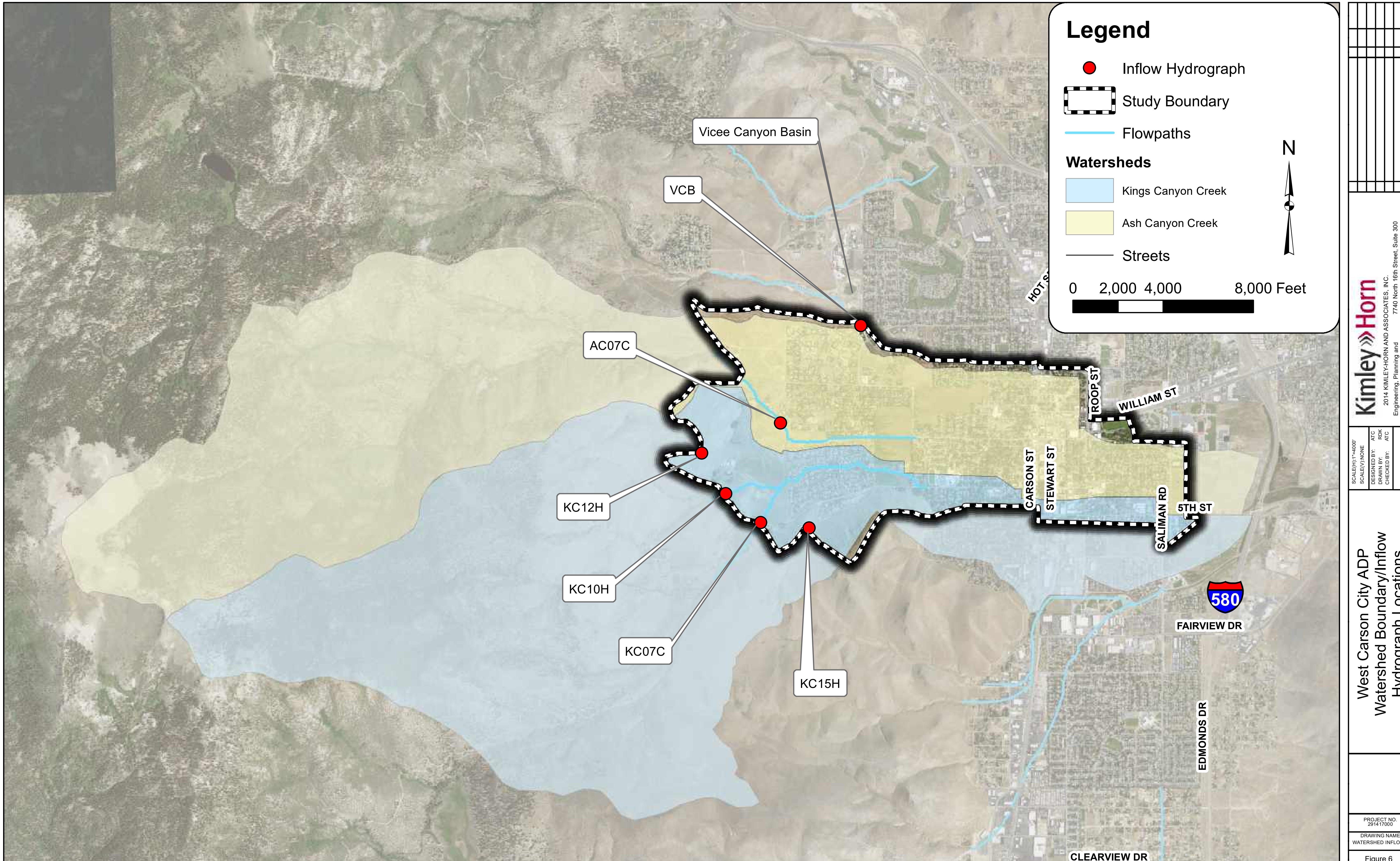
HEC-1 Card/ Inflow ID	Description	Drainage Area	10-year	25-year	50-year	100-year	500-year
AC07C	Ash Canyon Creek at the foothills	5.18	268	512	753	1049	2061
KC15H	Sub-basin inflow at King St and Kingsview Way	0.30	38	62	86	114	207
VCB	Outflow from Vicee Canyon Basin	1.83	0	0	0	0	117
KC12H	Sub-basin discharge into Meadow	0.28	30	56	80	111	213
KC10H	Sub-basin discharge into Meadow	0.44	22	50	79	115	238
KC07C	Kings Canyon Creek at Water Tank Road	5.16	225	435	643	899	1773

4.3 Rainfall and Storm Duration

NOAA14 rainfall was used and spatially varied in the FLO-2D model. The controlling storm duration is 24-hours per the Carson City Restudy Hydrology (HDR, 2010). Table 2 shows the maximum and minimum rainfall that was used in the FLO-2D model input. Figure 7 shows the rainfall spatial variation over the study boundary for the 100-year, 24-hour model. SCS Type II rainfall distribution was applied in the FLO-2D model domain.

Table 2: NOAA14 Rainfall Data

Storm Event	Rainfall Minimum (inches)	Rainfall Maximum (inches)
10-year, 24-hour	2.239	2.900
25-year, 24-hour	2.689	3.483
50-year, 24-hour	3.046	3.945
100-year, 24-hour	3.348	4.337
500-year, 24-hour	4.339	5.621


Legend
Inflow Hydrograph
Study Boundary
Flowpaths
Watersheds
Kings Canyon Creek
Ash Canyon Creek
Streets
0 2,000 4,000 8,000 Feet
N
Vicee Canyon Basin
VCB
AC07C
KC12H
KC10H
KC07C
KC15H
ROOP ST
WILLIAM ST
CARSON ST
STEWART ST
SALIMAN RD
5TH ST
580
FAIRVIEW DR
EDMONDS DR
CLEARVIEW DR
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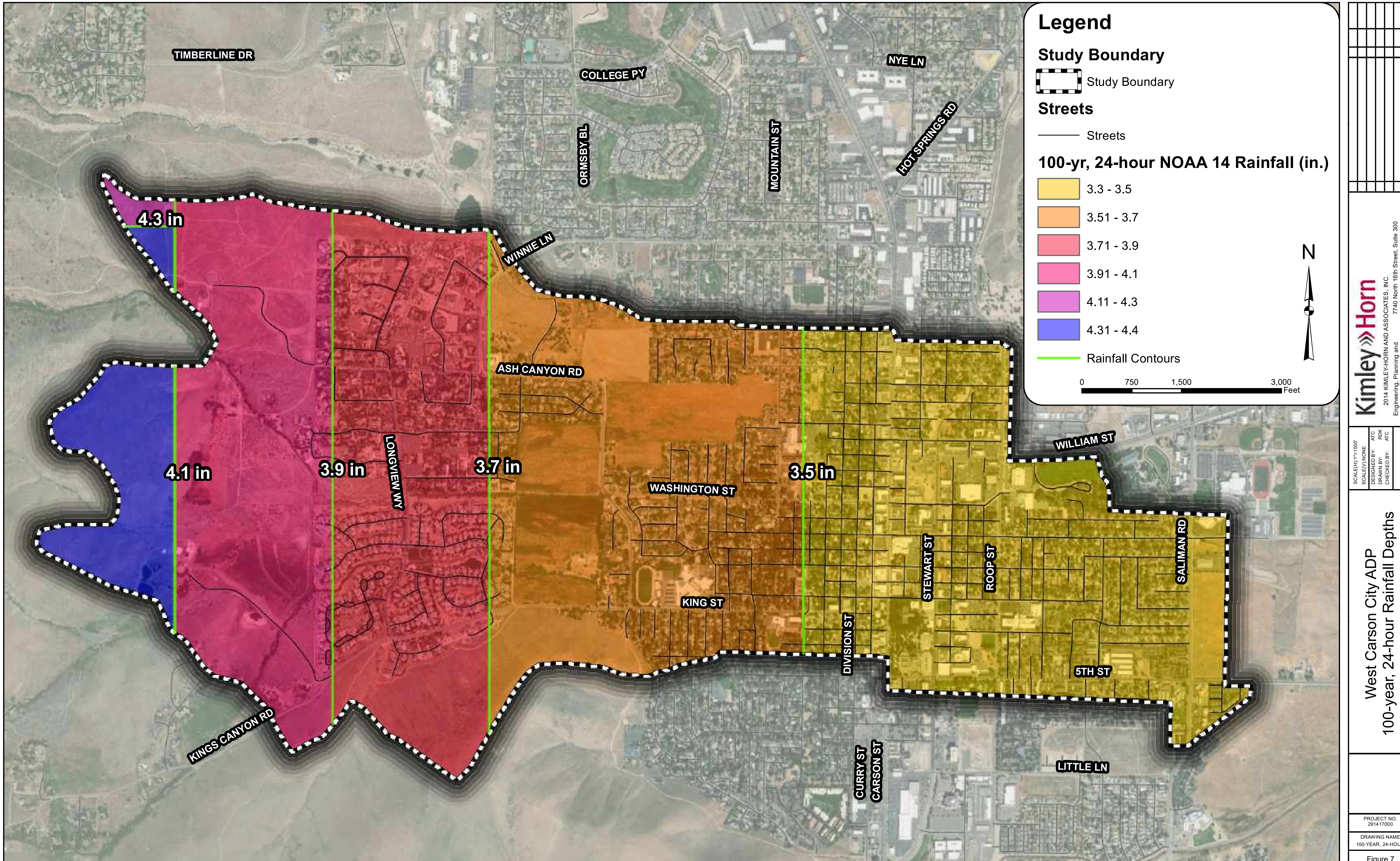
West Carson City ADP
Watershed Boundary/Inflow
Hydrograph Locations
PROJECT NO. 291417000
DRAWING NAME
WATERSHED INFLOWS
Figure 6



Legend
Study Boundary
Study Boundary
Streets
Streets
100-yr, 24-hour NOAA 14 Rainfall (in.)
3.3 - 3.5
3.51 - 3.7
3.71 - 3.9
3.91 - 4.1
4.11 - 4.3
4.31 - 4.4
Rainfall Contours
0
750
1,500
3,000
Feet
N
4.3 in
4.1 in
3.9 in
3.7 in
3.5 in
TIMBERLINE DR
COLLEGE PY
NYE LN
HOT SPRINGS RD
ORMSBY BL
MOUNTAIN ST
WINNIE LN
ASH CANYON RD
LONGVIEW WY
WASHINGTON ST
KING ST
WILLIAM ST
STEWART ST
ROOP ST
SALIMAN RD
DIVISION ST
5TH ST
CURRY ST
CARSON ST
LITTLE LN
KINGS CANYON RD
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West Carson City ADP
100-year, 24-hour Rainfall Depths
PROJECT NO.
291417000
DRAWING NAME
100-YEAR, 24-HOUR
Figure 7

4.4 Soils

Soil data was extracted from the Natural Resource Conservation Service (NRCS) Soil Survey Geographic (SSURGO) data base for Carson City Area, Nevada (NRCS, 2019). The Carson City Restudy Hydrology HEC-1 model and the FLO-2D model both use the SCS Curve Number Method to compute rainfall losses. The hydrologic soil group was assigned per the NRCS as shown in Table 3 and spatially in Figure 8 and Figure 9.

Table 3: Soil Parameters

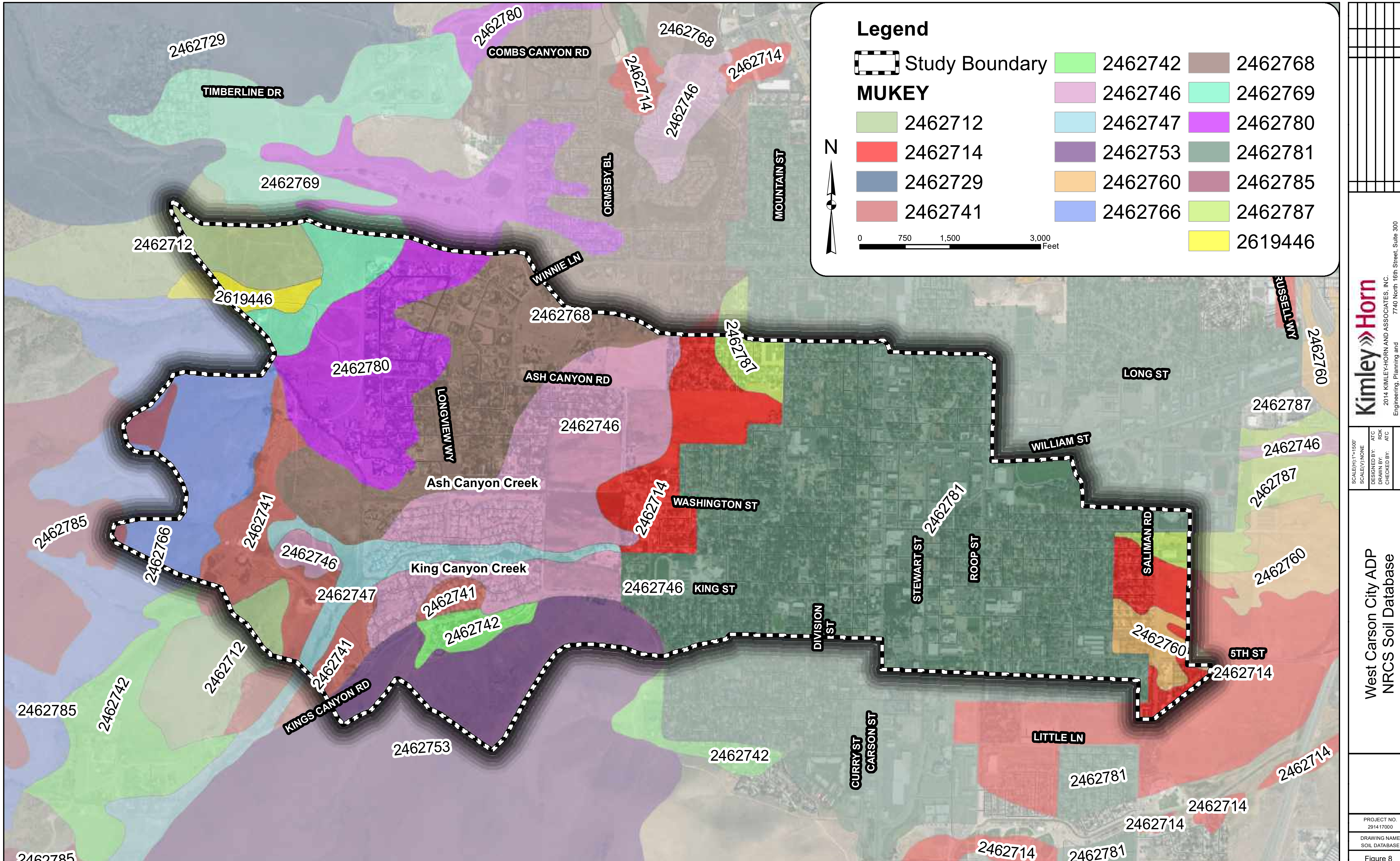
MUKEY	Map Unit Symbol	Soil Name	Hydrologic Soil Group
2462712	2	Aldax variant-Rock outcrop complex, 30 to 50 percent slopes	D
2462714	4	Bishop loam, saline	C
2462729	19	Glenbrook-Rock outcrop complex, 30 to 50 percent slopes	D
2462741	31	Holbrook gravelly fine sandy loam, 4 to 8 percent slopes	A
2462742	32	Holbrook very stony fine sandy loam, 4 to 15 percent slopes	A
2462746	36	Jubilee coarse sandy loam, 0 to 2 percent slopes	A
2462747	37	Jubilee sandy loam, 2 to 4 percent slopes	A
2462753	43	Koontz-Sutro association, steep	D
2462760	50	Orizaba loam, saline-alkali	C
2462766	56	Rock outcrop-Aldax variant complex, 50 to 75 percent slopes	D
2462768	58	Surpass coarse sandy loam, 2 to 4 percent slopes MLRA 26	C
2462769	59	Surpass coarse sandy loam, 4 to 8 percent slopes	A
2462780	70	Toll gravelly loamy sand, 0 to 15 percent slopes	A
2462781	71	Urban land	C
2462785	75	Vicee-Aldax variant complex, 30 to 50 percent slopes	B
2462787	77	Voltaire silty clay loam, saline	C
2619446	6721	Surpass sandy loam, 8 to 15 percent slopes	A

4.5 Land Use

Land use coverages was obtained from Carson City Open GIS Portal. Shapefiles were downloaded and verified with recent aerial imagery. The curve numbers were assigned in FLO-2D based on the land use type and the hydrologic soil group from the NRCS SSURGO database. Table 4 shows the curve number associated with the land use type and the hydrologic soil group per *NRCS Urban Hydrology for Small Watersheds Manual* (USDA NRCS, 1986). The land use map is provided in Figure 10, and the curve number values used in the FLO-2D model are shown spatially in Figure 11.

Table 4: Land Use Curve Numbers

Land Use	Curve Number			
	Hydrologic Soil Group A	Hydrologic Soil Group B	Hydrologic Soil Group C	Hydrologic Soil Group D
Commercial	89	92	94	95
High Density Residential (8-36 du/ac)	81	88	91	93
Industrial	89	92	94	95
Low Density Residential (0.2-3 du/ac or 5-0.33 ac/du)	61	75	83	87
Medium Density Residential (3-8 du/ac)	77	85	90	92
Office	89	92	94	95
Parks & Recreation	41	62	75	81
Rangeland	39	61	73	82
Roadway	95	95	95	95


Legend
Study Boundary
MUKEY
2462712
2462714
2462729
2462741
2462742
2462746
2462747
2462753
2462760
2462766
2462768
2462769
2462780
2462781
2462785
2462787
2619446
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0 750 1,500 3,000 Feet
COMBS CANYON RD
TIMBERLINE DR
ORMSBY BL
MOUNTAIN ST
WINNIE LN
ASH CANYON RD
LONGVIEW WY
Ash Canyon Creek
King Canyon Creek
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5TH ST
LITTLE LN
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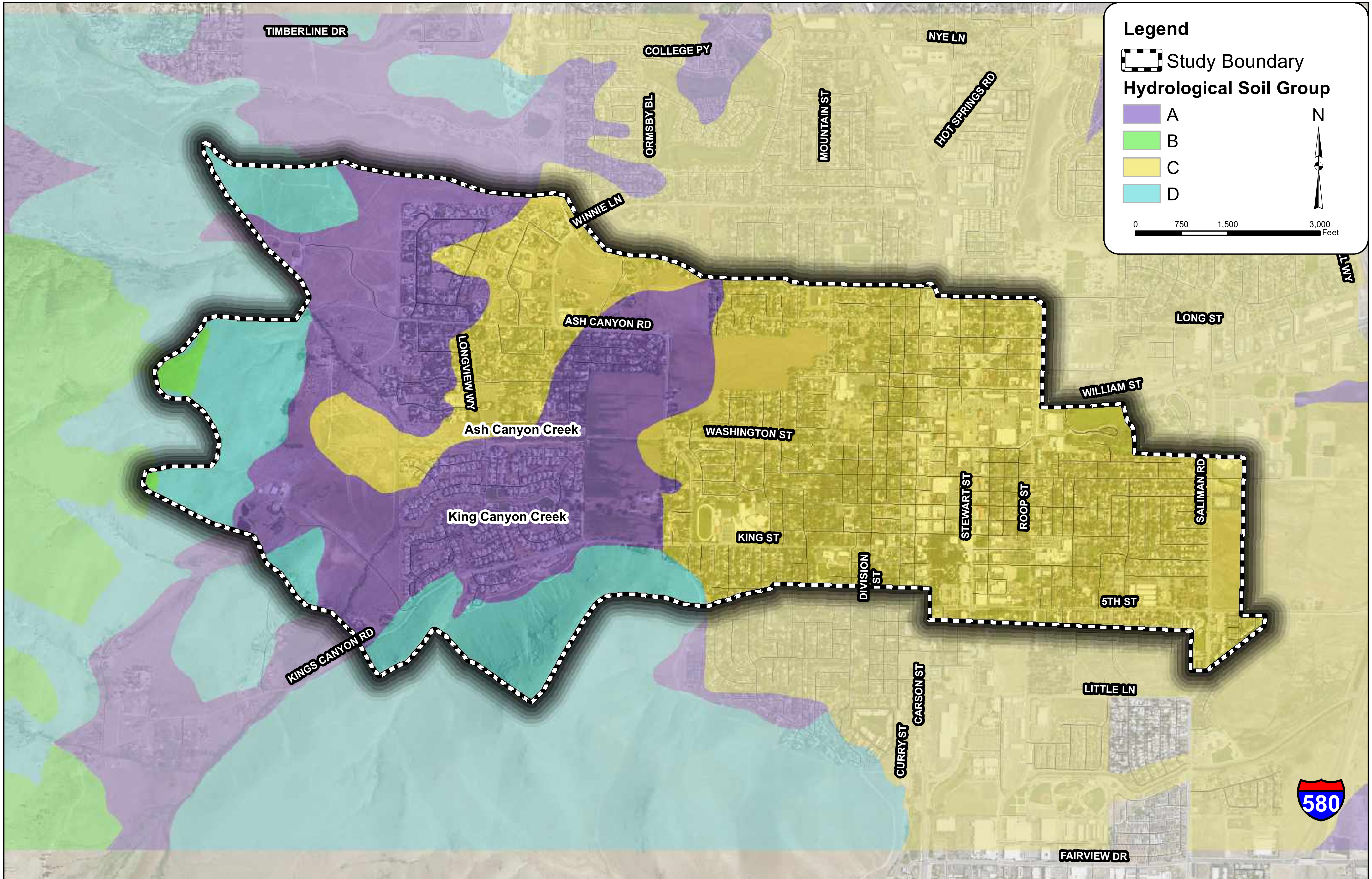
NRCS Soil Database
PROJECT NO. 291417000
DRAWING NAME SOIL DATABASE
Figure 8



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West Carson City ADP
Hydrologic Soil Group

PROJECT NO.
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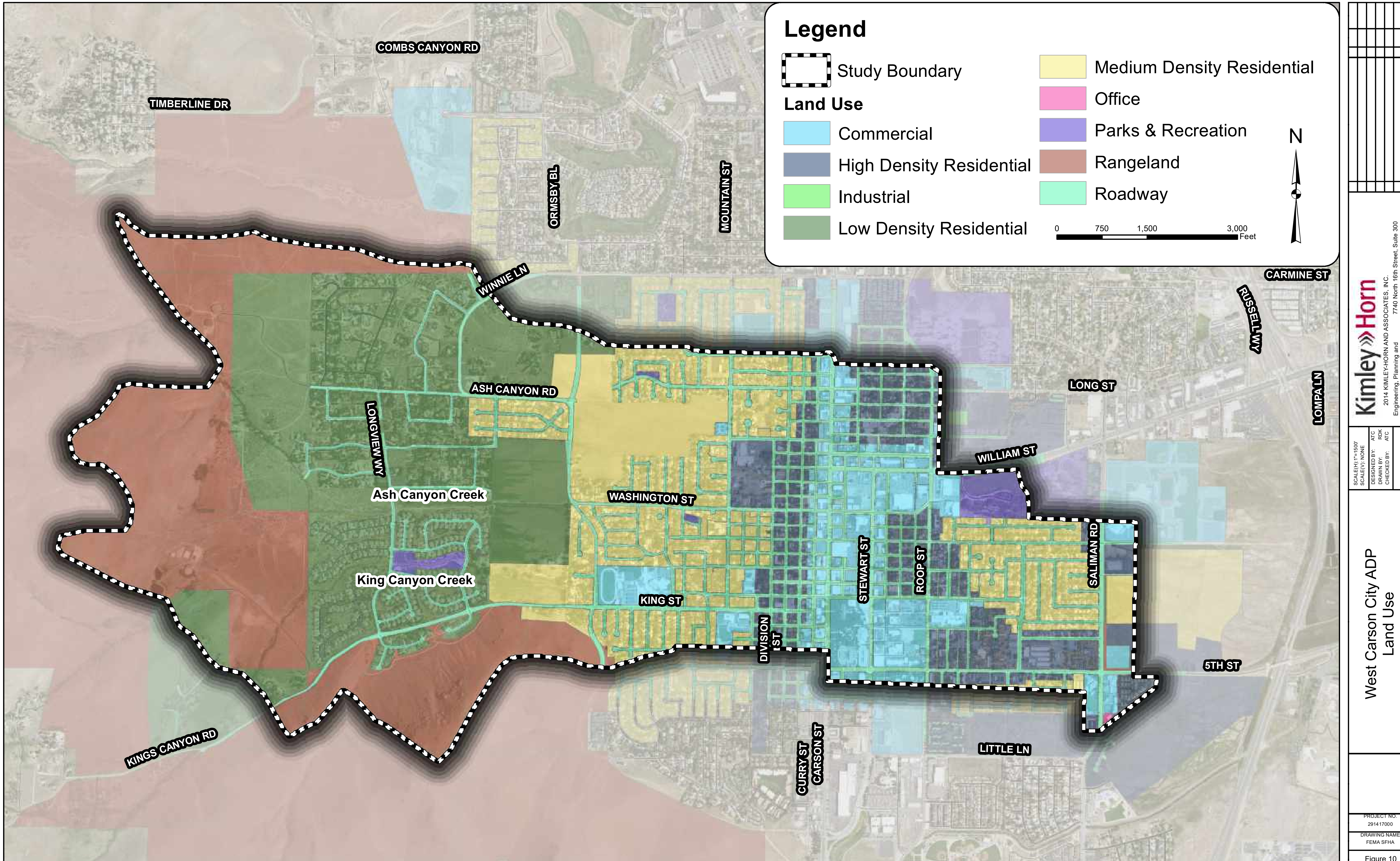
HYDRO SOIL GROUP

Figure 9


Legend
Study Boundary
Land Use
Commercial
High Density Residential
Industrial
Low Density Residential
Medium Density Residential
Office
Parks & Recreation
Rangeland
Roadway
0 750 1,500 3,000 Feet
N
COMBS CANYON RD
TIMBERLINE DR
ORMSBY BL
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CARMINE ST
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West Carson City ADP
Land Use
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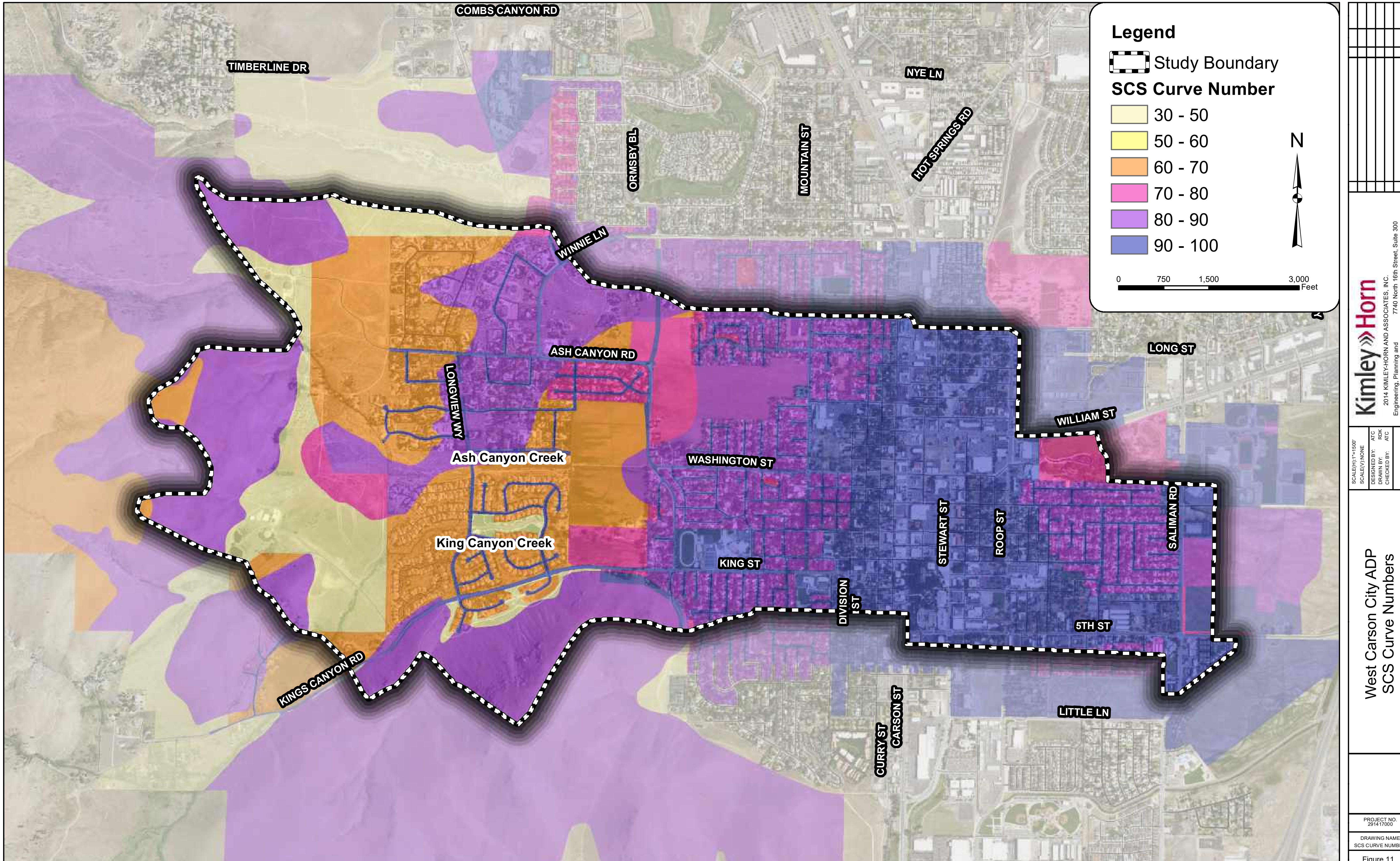
DRAWING NAME
FEMA SFHA
Figure 10



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ASH CANYON RD
LONGVIEW WY
LONG ST
WILLIAM ST
Ash Canyon Creek
WASHINGTON ST
King Canyon Creek
KING ST
DIVISION ST
STEWART ST
ROOP ST
SALIMAN RD
5TH ST
KINGS CANYON RD
CURRY ST
CARSON ST
LITTLE LN
Legend
Study Boundary
SCS Curve Number
30 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
N
0
750
1,500
3,000
Feet
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West Carson City ADP
SCS Curve Numbers
PROJECT NO.
291417000
DRAWING NAME
SCS CURVE NUMBER
Figure 11

4.6 Hydrology Verification

There are no stream gages within the FLO-2D model domain, but the rainfall loss percentages were reviewed for the FLO-2D model domain and are in line with what would be expected for this urban portion of the watershed. The FLO-2D model hydrology is only for the urban portion of the watershed, while the Carson City Restudy Hydrology is being utilized for the upper watershed. The Carson City Restudy Hydrology was verified and compared against the other previous studies (HDR, 2010). The verification and comparison of the Carson City Restudy Hydrology is provided in Appendix A.

The FLO-2D model results show that the HEC-1 sub-basins delineations do not align with the FLO-2D results. The FLO-2D model discretizes the urban watershed and shows that runoff is splitting and combining differently than the HEC-1 model sub-basins and concentration points making it difficult to compare flows at specific points between models. Instead of verifying runoff at certain points in the watershed, rainfall excess percentages were reviewed for the FLO-2D model verification. Table 5 shows the total rainfall volume, rainfall loss, and rainfall excess percentages. The rainfall loss and rainfall excess are within the anticipated ranges for urban watersheds.

Table 5: FLO-2D Rainfall Loss and Excess Percentages

Storm Event	Total Rainfall Volume (AC-ft)	Total Rainfall Loss Volume (AC-ft)	Rainfall Excess Percentage (%)	Rainfall Loss Percentage (%)
10-year, 24-hour	444	244	45	55
25-year, 24-hour	533	270	49	51
50-year, 24-hour	603	289	52	48
100-year, 24-hour	663	303	54	46
500-year, 24-hour	860	343	60	40

5 Hydraulics

5.1 Methodology

FLO-2D and SWMM were used for the hydraulic modeling. The culverts and storm drain were modeled within the FLO-2D study domain. The storm drain components were modeled using the FLO-2D/SWMM integration. Culvert sizes and storm drain data were collected from the Carson City GIS databases. The storm drain system is very complex and GIS shapefiles were provided that had documented the storm drain size, material, and location.

5.2 FLO-2D Model Controls

The model simulation time for the 24-hour storm duration was set to 30 hours. The timestep is 0.1 hours. The courant number is 0.6 and a TOLER value of 0.004 ft. The limiting Froude number was set to 0.95. The shallow n-value is 0.20.

5.3 Grid Size

The FLO-2D model used 15’ x 15’ grids for the study area. This grid size was determined based on wash and street widths.

5.4 Manning’s n-Values

Manning’s n-values were derived from the land use file and were assigned spatially in the FLO-2D model. The n-values were assigned based on typical values for two-dimensional models in and around Carson City. A shallow n-value of 0.2 was assigned globally. Figure 14 shows the Manning’s n-values assigned in the FLO-2D model.

Table 6: FLO-2D Floodplain n-Values

Land Use Type	FLO-2D Floodplain n-Values
Commercial	0.035
High Density Residential (8-36 du/ac)	0.05
Industrial	0.035
Low Density Residential (0.2-3 du/ac or 5-0.33 ac/du)	0.065
Medium Density Residential (3-8 du/ac)	0.06
Office	0.035
Parks & Recreation	0.040
Rangeland	0.09
Roadway	0.03

5.5 Culverts and Hydraulic Structures

Eight culverts were modeled in the FLO-2D model using the general culvert equations. FLO-2D general culvert routines only have the capabilities for single barrel pipe or box culverts. Four of the eight culverts are multiple barrel pipe culverts. Multiple barrel pipe culverts were modeled as a single barrel box culvert by equating the box culvert rise to the pipe diameter and the span to have the equivalent pipe opening area. Table 7 shows the culvert information within the watershed. Figure 15 shows these culverts spatially in the watershed.

Table 7: Culvert Data

Culvert Name	Type	Length (ft)	Number of Barrels	Diameter (ft)	Span (ft)	n-Value	Inlet Loss Coefficient	Exit Loss Coefficient
ORMSBY02	Pipe	490	1	1.5	-	0.024	0.50	1
THAMES	Pipe	97	2	4	6.28	0.013	0.50	1
LONGVIEW01	Pipe	90	2	4	6.28	0.013	0.50	1
LONGVIEW02	Pipe	92	2	4	6.28	0.013	0.50	1
ASHCANRD	Pipe	89	3	4	9.42	0.024	0.50	1
CHELSEA	Pipe	273	1	2.5	-	0.013	0.50	1
CULV01	Pipe	216	1	2.5	3.93	0.013	0.50	1
WATERTANK	Pipe	64	1	3	-	0.013	0.50	1

The equivalent area methodology used for the multiple pipe culverts are shown in Table 8.

Table 8: Multiple Barrel Pipe Culverts

Culvert Name	Type	Number of Barrels	Diameter (ft)	Modeled As	Rise (ft)	Span (ft)	Equivalent Area (sf)
THAMES	Pipe	2	4	Box	4	6.28	25.12
LONGVIEW01	Pipe	2	4	Box	4	6.28	25.12
LONGVIEW02	Pipe	2	4	Box	4	6.28	25.12
ASHCANRD	Pipe	3	4	Box	4	9.42	37.68
CULV01	Pipe	2	2.5	Box	2.5	3.93	9.825

Figure 12 is an illustration of the multiple pipe barrel to equivalent box culvert approach used in FLO-2D.

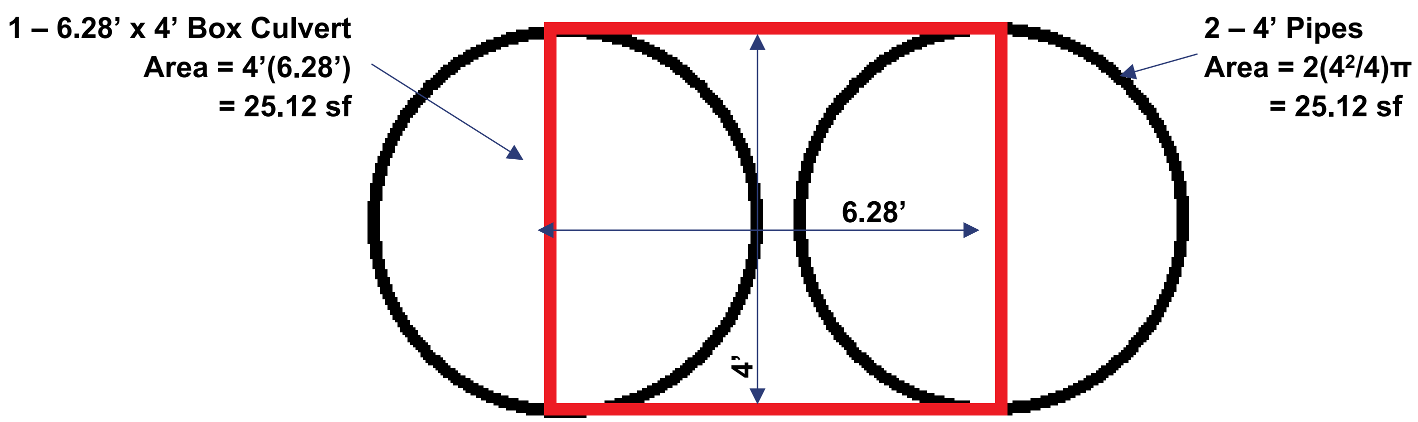


Figure 12: Equivalent Area Methodology

5.6 Boundary Conditions

Outflow nodes were place along the downstream boundary of the FLO-2D model. Outflow nodes remove the flow off the grid using normal depth calculations.

5.7 Storm Drain Model Components

A SWMM storm drain model was generated and integrated into the FLO-2D model. The storm drain data was received from Carson City in GIS format. The GIS files listed the storm drain size, material, and some invert elevation data. The invert elevations of the storm drain system were not consistent in the provided GIS files and assumptions based on pipe size and minimum cover were made to compile the SWMM model. Entrance and exit loss coefficient were applied to the storm drain system. The storm drain network and profiles were reviewed and verified with City staff prior to FLO-2D integration. Figure 15 shows the storm drain systems modeled.

Over 500 storm drain inlets were included in the FLO-2D model. A combination inlet Catch Basin Type 4-R was used in the FLO-2D model based on typical catch basins found in the watershed. Rating tables were used to model these combination inlets in FLO-2D. Rating tables were also computed for the Ash Canyon and Kings Canyon Creek inlets upstream of Ormsby Blvd. The rating tables are provided in Appendix E.

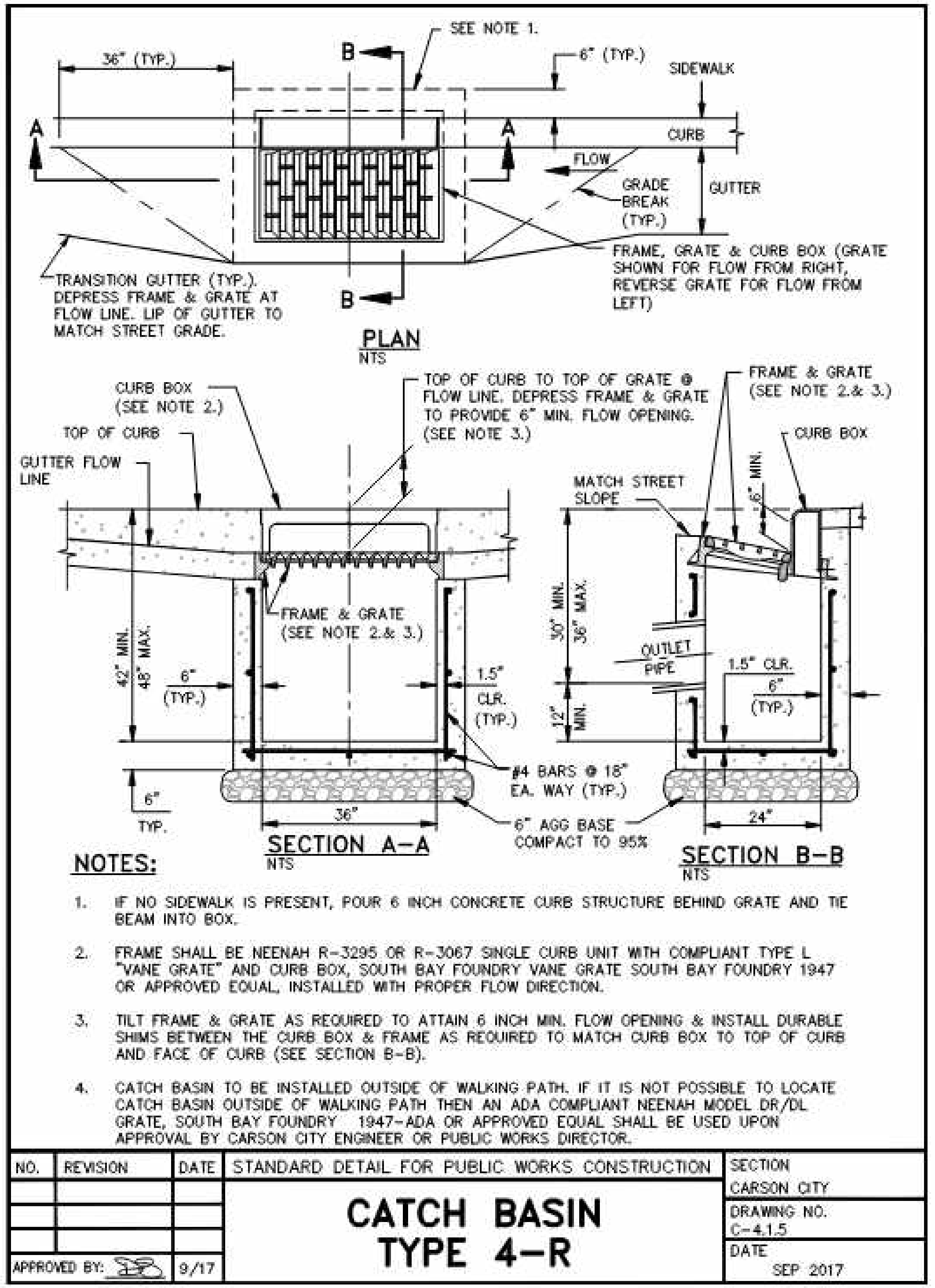
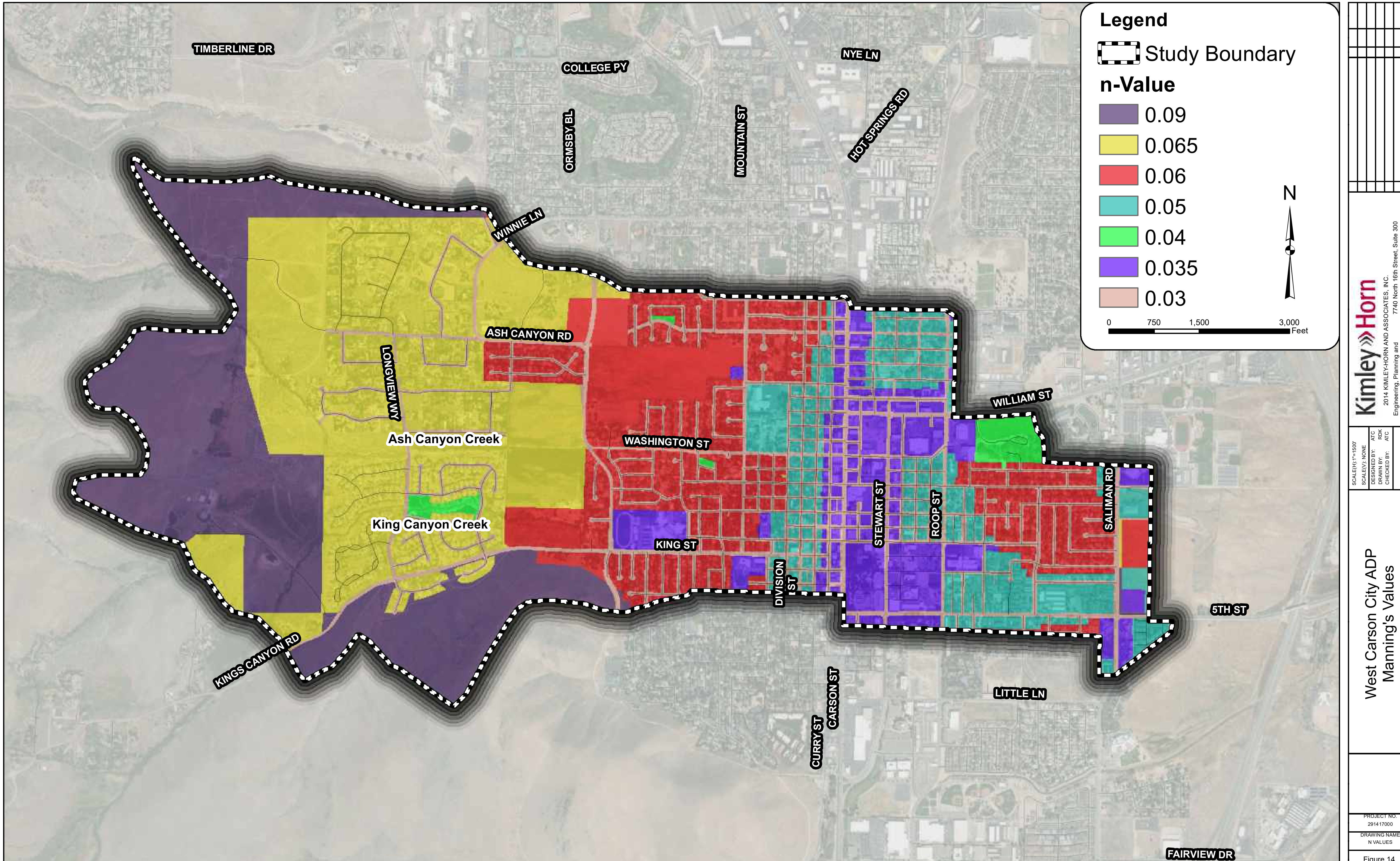


Figure 13: Typical Catch Basin Inlets



Legend
Study Boundary
n-Value
0.09
0.065
0.06
0.05
0.04
0.035
0.03
N
0
750
1,500
3,000
Feet
TIMBERLINE DR
COLLEGE PY
NYE LN
ORMSBY BL
MOUNTAIN ST
HOT SPRINGS RD
WINNIE LN
ASH CANYON RD
LONGVIEW WY
Ash Canyon Creek
King Canyon Creek
WASHINGTON ST
KING ST
WILLIAM ST
STEWART ST
ROOP ST
SALIMAN RD
DIVISION ST
5TH ST
CARSON ST
CURRY ST
LITTLE LN
KINGS CANYON RD
FAIRVIEW DR
West Carson City ADP
Manning's Values
SCALE(H):1"=1500'
SCALE(V): NONE
DESIGNED BY: ATC
DRAWN BY: RDK
CHECKED BY: ATC
DATE: 06/2021
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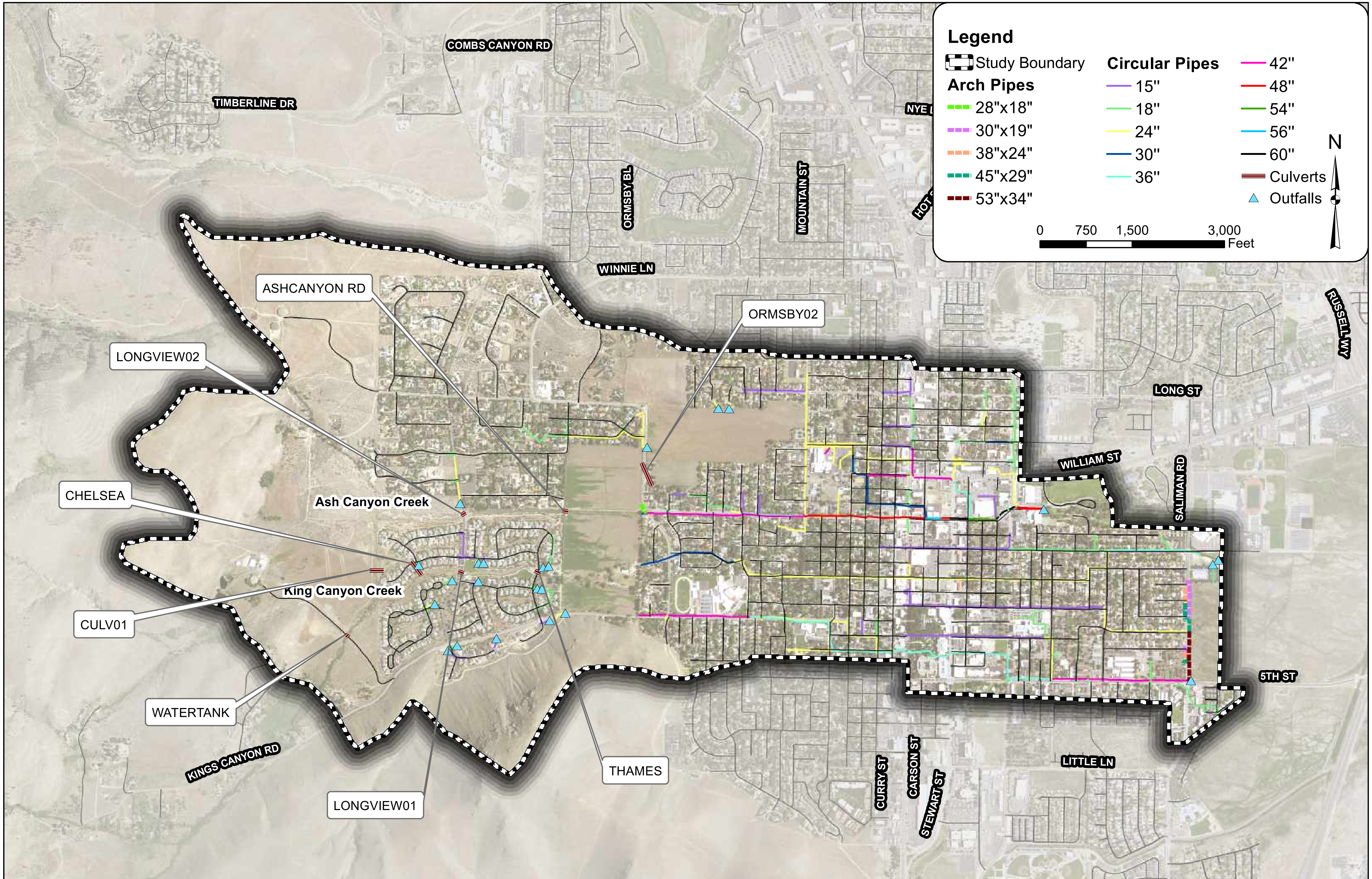
PROJECT NO.
291417000
DRAWING NAME
N VALUES
Figure 14



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West Carson City ADP
Storm Drain & Culverts

PROJECT NO. 291417000
DRAWING NAME STORM DRAIN & CULVERTS
Figure 15

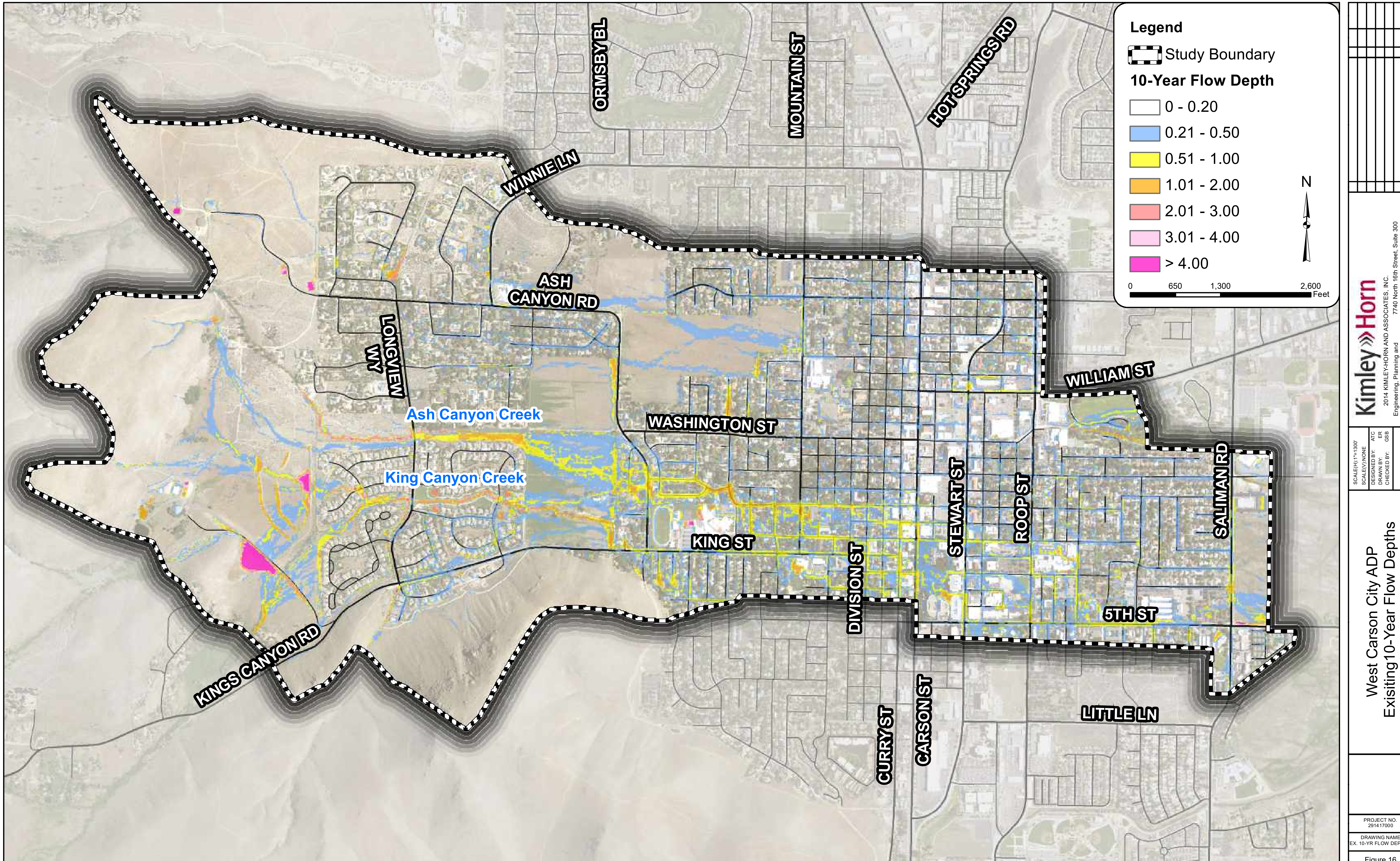
5.8 Results

The FLO-2D model results are provided in the following figures. These results show the max flow depths and velocities for each storm event (10-, 25-, 50-, 100-, and 500-year). The existing condition results show that the storm drain systems at the intersections of Ormsby Blvd/Washington Street and Ormsby Blvd/King Street have limited capacity and are overwhelmed in the 100-year condition. Once the stormwater exceeds the capacity of the storm drain, runoff continues downstream into Washington Street and Kings Street and then flows through the street network in a southeasterly direction. The storm drain capacity is approximately 100 cfs for both Ash Canyon and Kings Canyon Creek storm drain systems. Table 9 shows the total runoff volume per storm event for each creek and the minimum required storage volume to limit the discharge to the storm drain capacity of 100 cfs for each storm drain system.

Table 9: Stormwater Runoff Volumes

	Stormwater Runoff Volumes (AC-ft)			Minimum Required Storage Volume (AC-ft)[1]		
Storm Event	Kings Canyon Creek	Ash Canyon Creek	Total	Kings Canyon Creek	Ash Canyon Creek	Total
10-year	178	188	366	58	72	130
25-year	294	297	591	167	175	342
50-year	396	394	790	265	265	530
100-year	508	501	1,009	374	366	740
500-year	816	795	1,611	672	640	1,312

[1] Volume required to attenuate the flow to 100 cfs for both Ash Canyon and King Canyon Creeks. 100 cfs is the approximate capacity of the existing storm drain systems for both Ash Canyon and King Canyon Creeks


Legend
Study Boundary
10-Year Flow Depth
0 - 0.20
0.21 - 0.50
0.51 - 1.00
1.01 - 2.00
2.01 - 3.00
3.01 - 4.00
> 4.00
N
0
650
1,300
2,600
Feet
ORMSBY BL
MOUNTAIN ST
HOT SPRINGS RD
WINNIE LN
ASH CANYON RD
LONGVIEW WY
WILLIAM ST
Ash Canyon Creek
WASHINGTON ST
King Canyon Creek
STEWART ST
ROOP ST
SALIMAN RD
KING ST
DIVISION ST
5TH ST
KINGS CANYON RD
CURRY ST
CARSON ST
LITTLE LN
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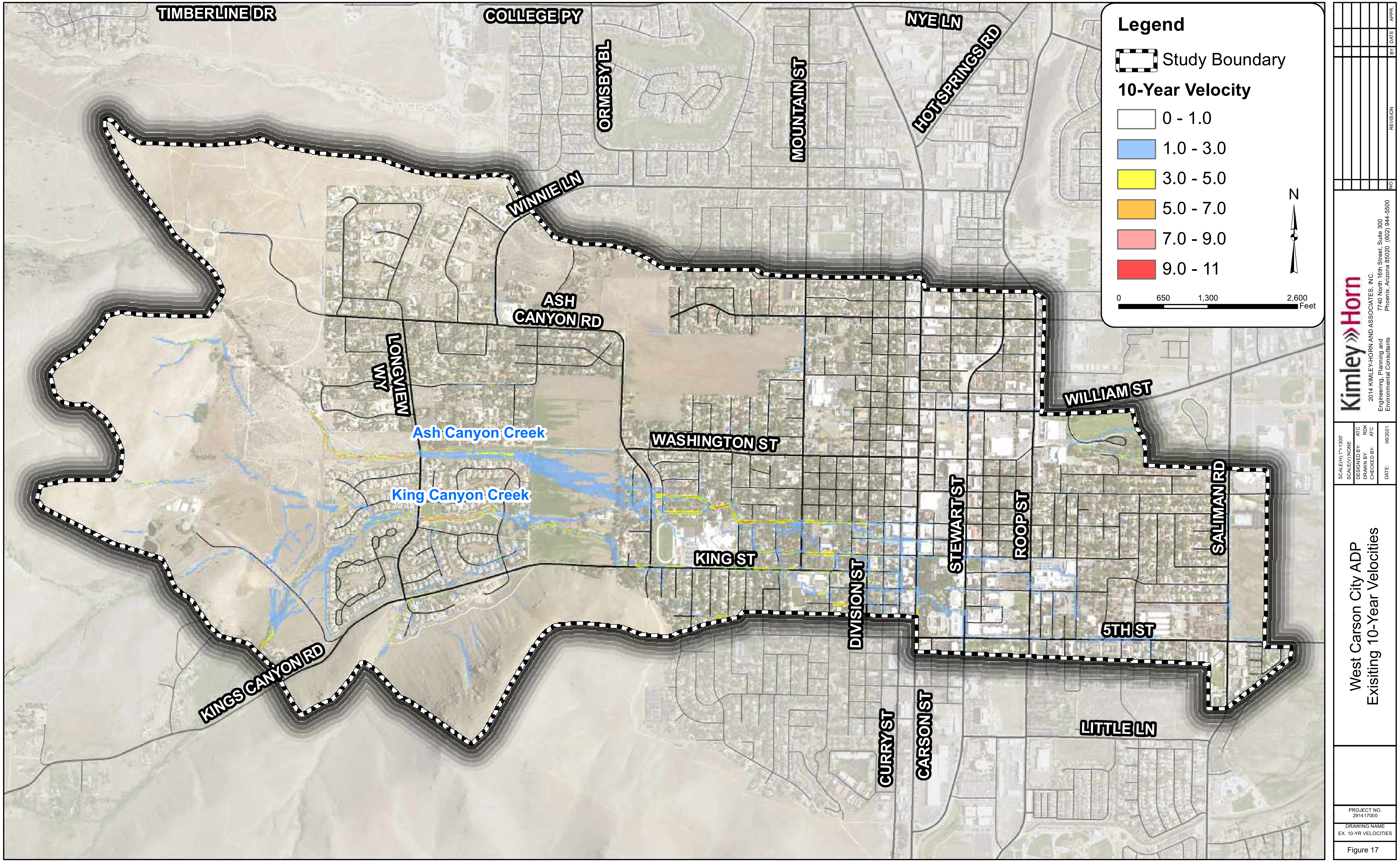
SCALE(V):NONE
DESIGNED BY: ATC
DRAWN BY: ER
CHECKED BY: GSB
DATE: 05/2021
West Carson City ADP
Exisiting10-Year Flow Depths
PROJECT NO. 291417000
DRAWING NAME EX. 10-YR FLOW DEPTHS
Figure 16


Legend
Study Boundary
10-Year Velocity
0 - 1.0
1.0 - 3.0
3.0 - 5.0
5.0 - 7.0
7.0 - 9.0
9.0 - 11
N
0 650 1,300 2,600 Feet
TIMBERLINE DR
COLLEGE PY
NYE LN
HOT SPRINGS RD
ORMSBY BL
MOUNTAIN ST
WINNIE LN
ASH CANYON RD
LONGVIEW WY
WILLIAM ST
Ash Canyon Creek
WASHINGTON ST
King Canyon Creek
KING ST
STEWART ST
ROOP ST
SALIMAN RD
DIVISION ST
5TH ST
KINGS CANYON RD
CURRY ST
CARSON ST
LITTLE LN
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CHECKED BY: ATC
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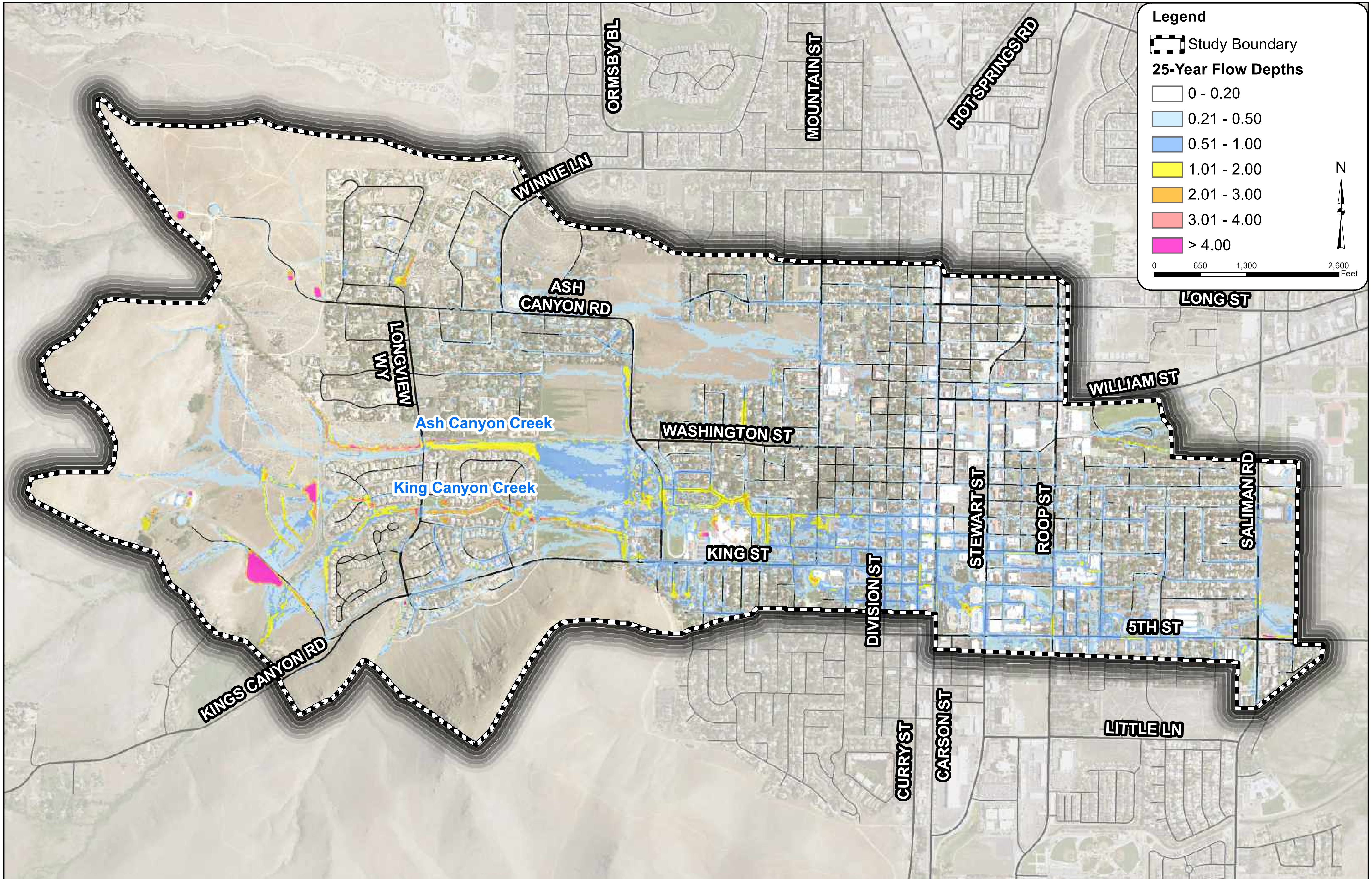
West Carson City ADP
Exisiting 10-Year Velocities
PROJECT NO.
291417000
DRAWING NAME
EX. 10-YR VELOCITIES
Figure 17



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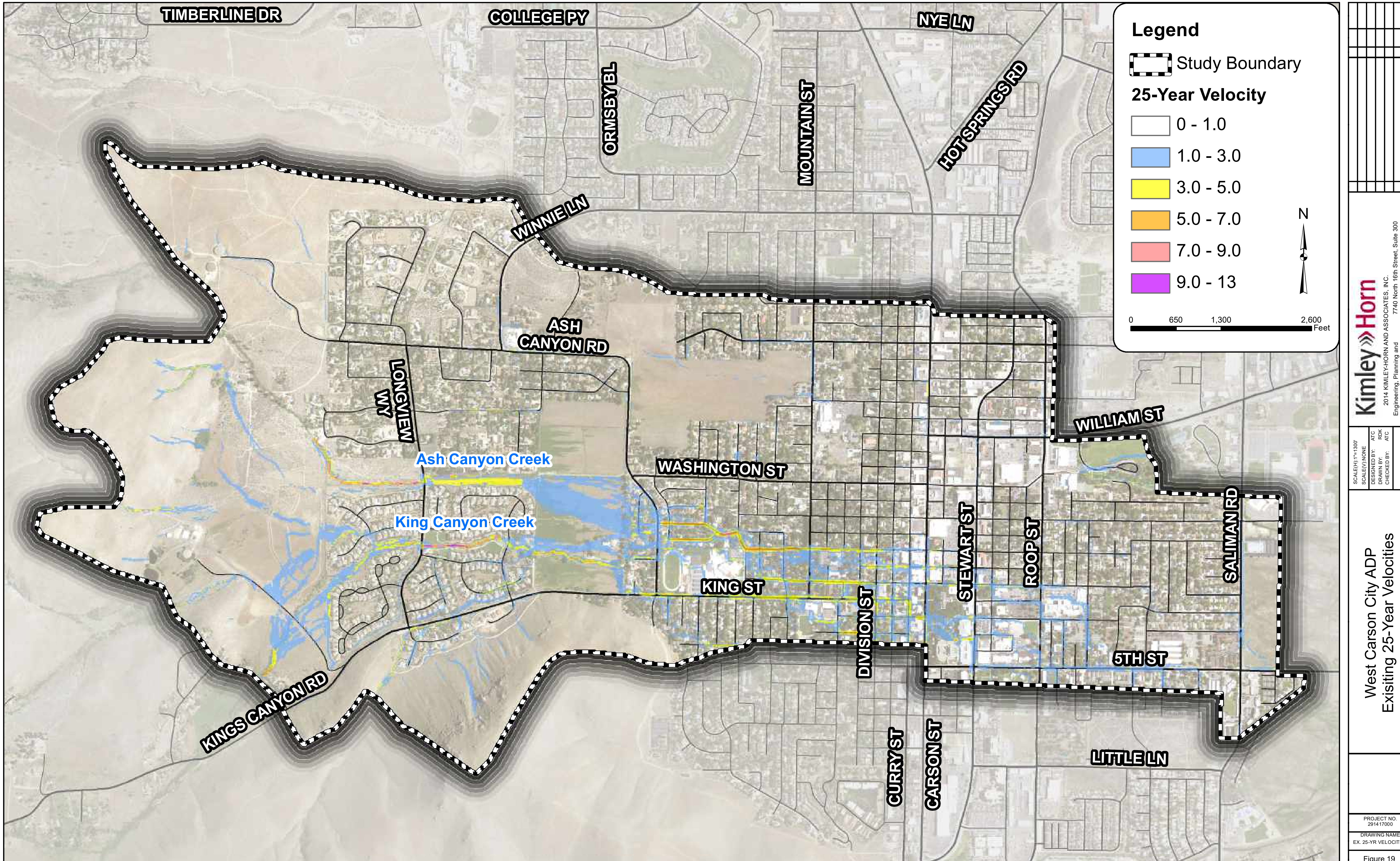
West Carson City ADP
Existing 25-Year Flow Depths

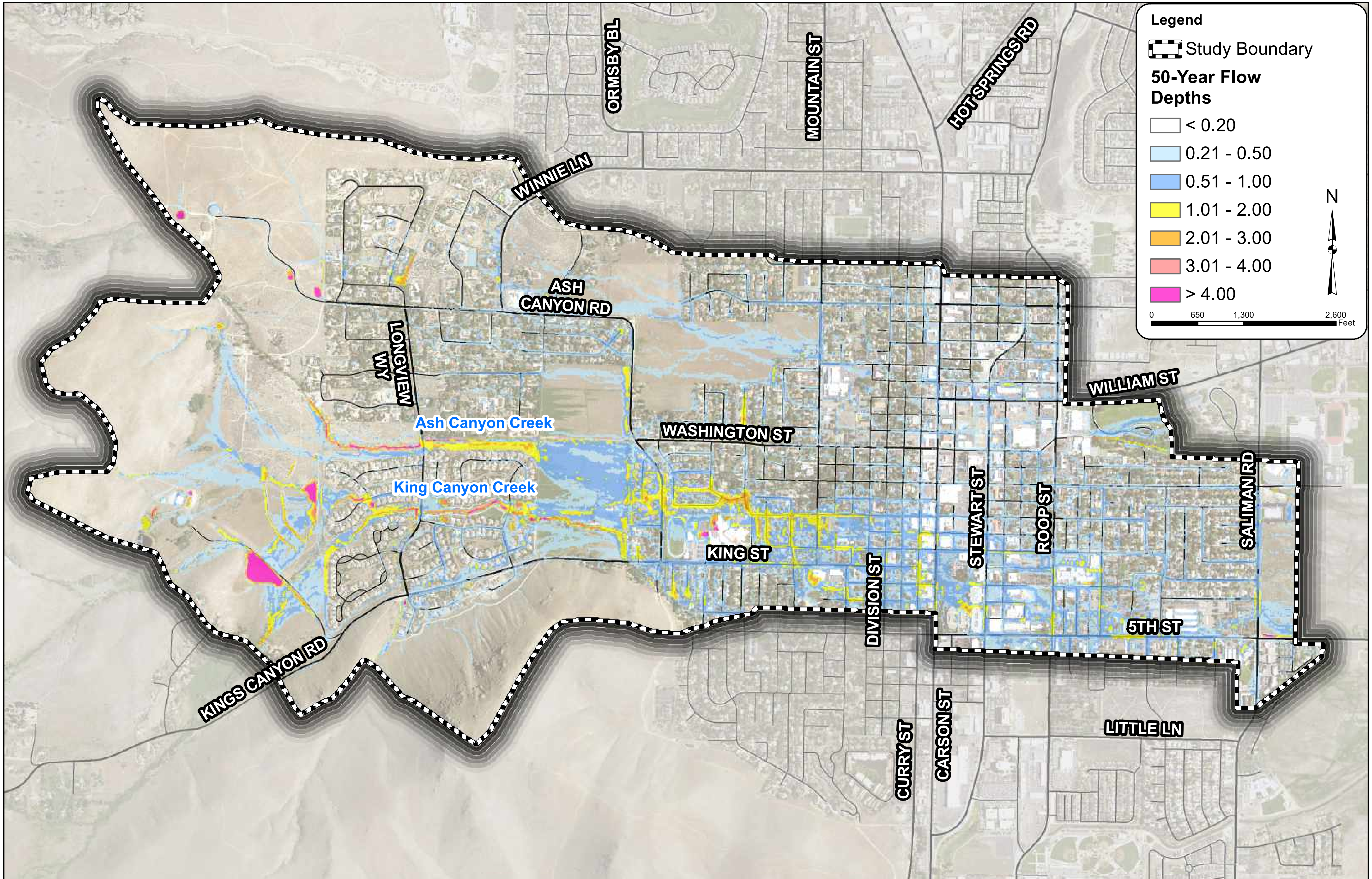
PROJECT NO.
291417000

DRAWING NAME
EX 25-YR FLOW DEPTHS

Figure 18



TIMBERLINE DR
COLLEGE PY
NYE LN
ORMSBY BL
MOUNTAIN ST
HOT SPRINGS RD
WINNIE LN
ASH CANYON RD
LONGVIEW WY
WILLIAM ST
Ash Canyon Creek
WASHINGTON ST
King Canyon Creek
STEWART ST
ROOP ST
SALIMAN RD
KING ST
DIVISION ST
5TH ST
KINGS CANYON RD
CURRY ST
CARSON ST
LITTLE LN
Legend
Study Boundary
25-Year Velocity
0 - 1.0
1.0 - 3.0
3.0 - 5.0
5.0 - 7.0
7.0 - 9.0
9.0 - 13
N
0
650
1,300
2,600
Feet
Kimley»Horn
West Carson City ADP
Exisiting 25-Year Velocities
PROJECT NO.
291417000
DRAWING NAME
EX. 25-YR VELOCITIES
Figure 19



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West Carson City ADP
Exisiting 50-Year Flow Depths

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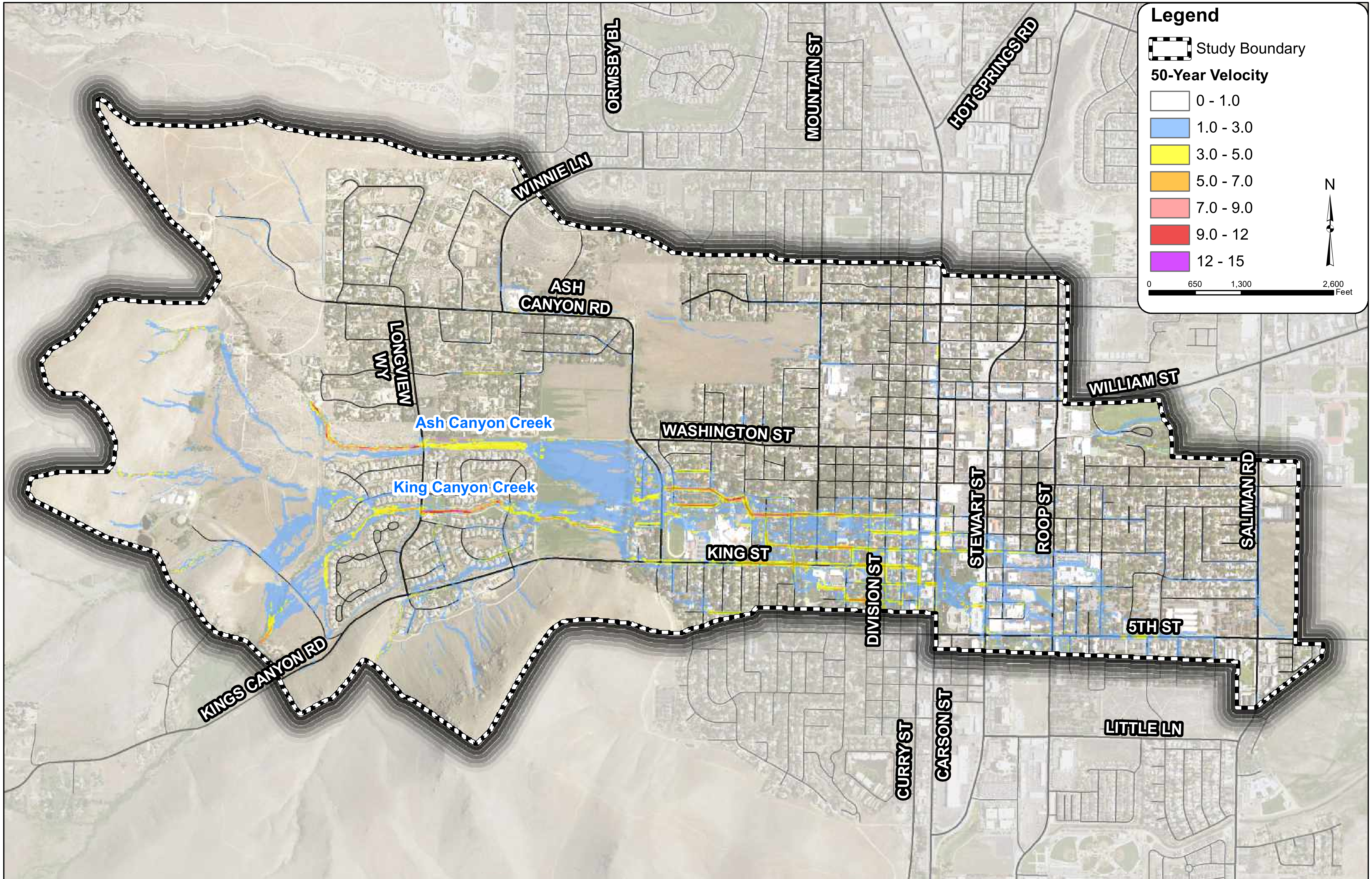
291417000
DRAWING NAME
EX. 50-YR FLOW DEPTHS
Figure 20



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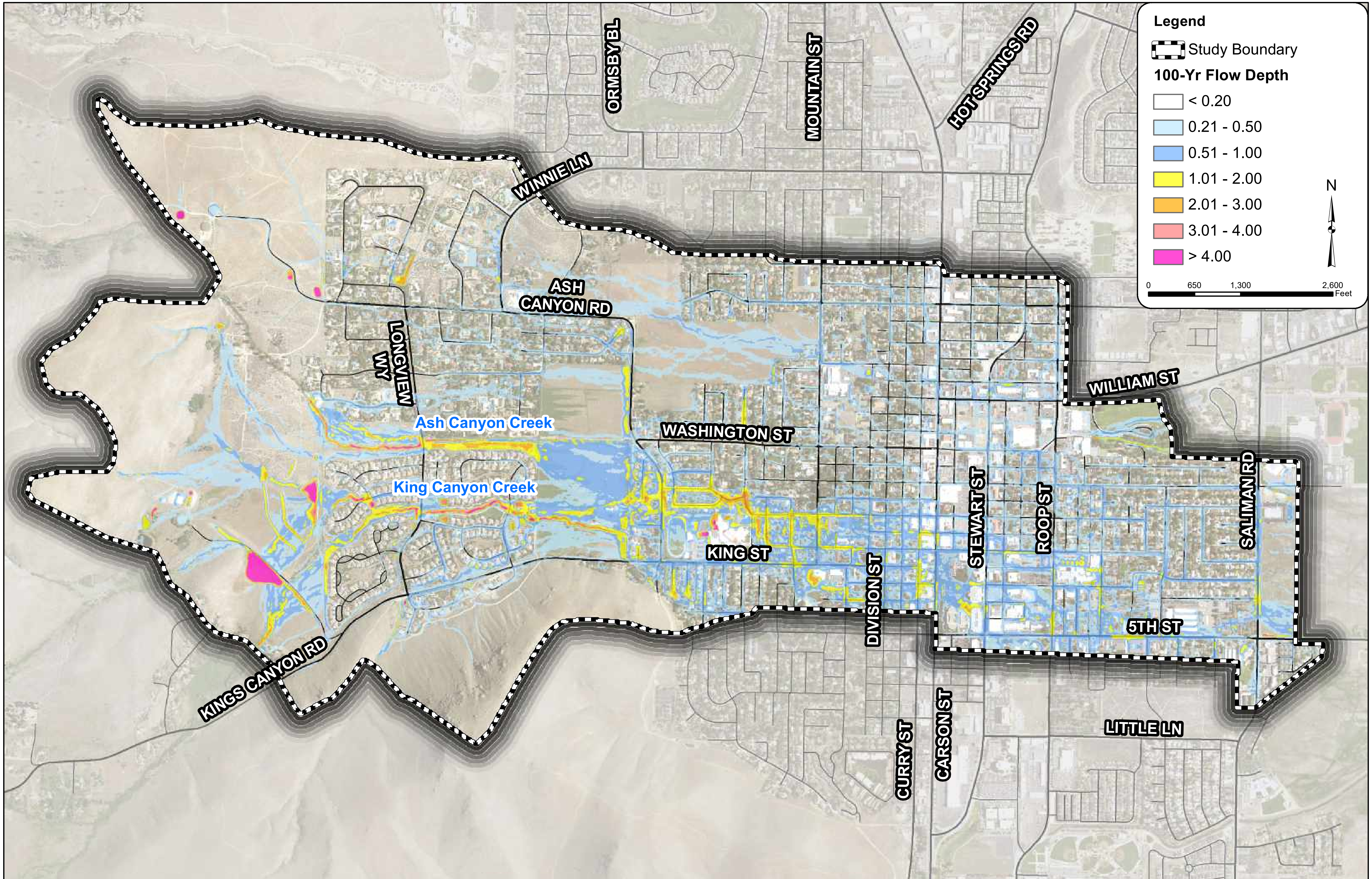
Exisiting 50-Year Velocities

PROJECT NO.
291417000

DRAWING NAME
EX. 50-YR VELOCITIES

Figure 21



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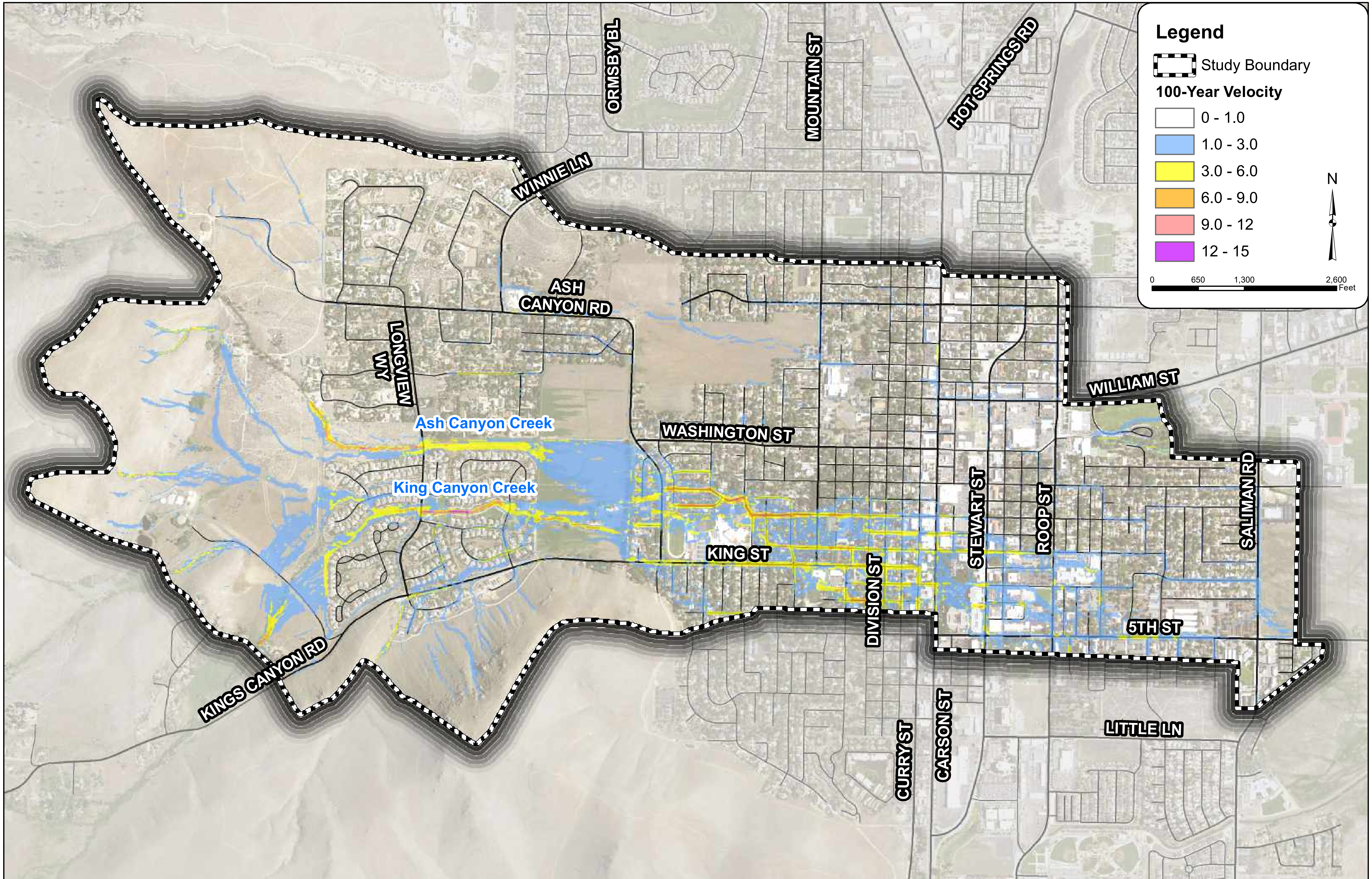
West Carson City ADP
Existing 100-Year Flow Depths

PROJECT NO. 291417000
DRAWING NAME EX 100-YR FLOW DEPTHS
Figure 22



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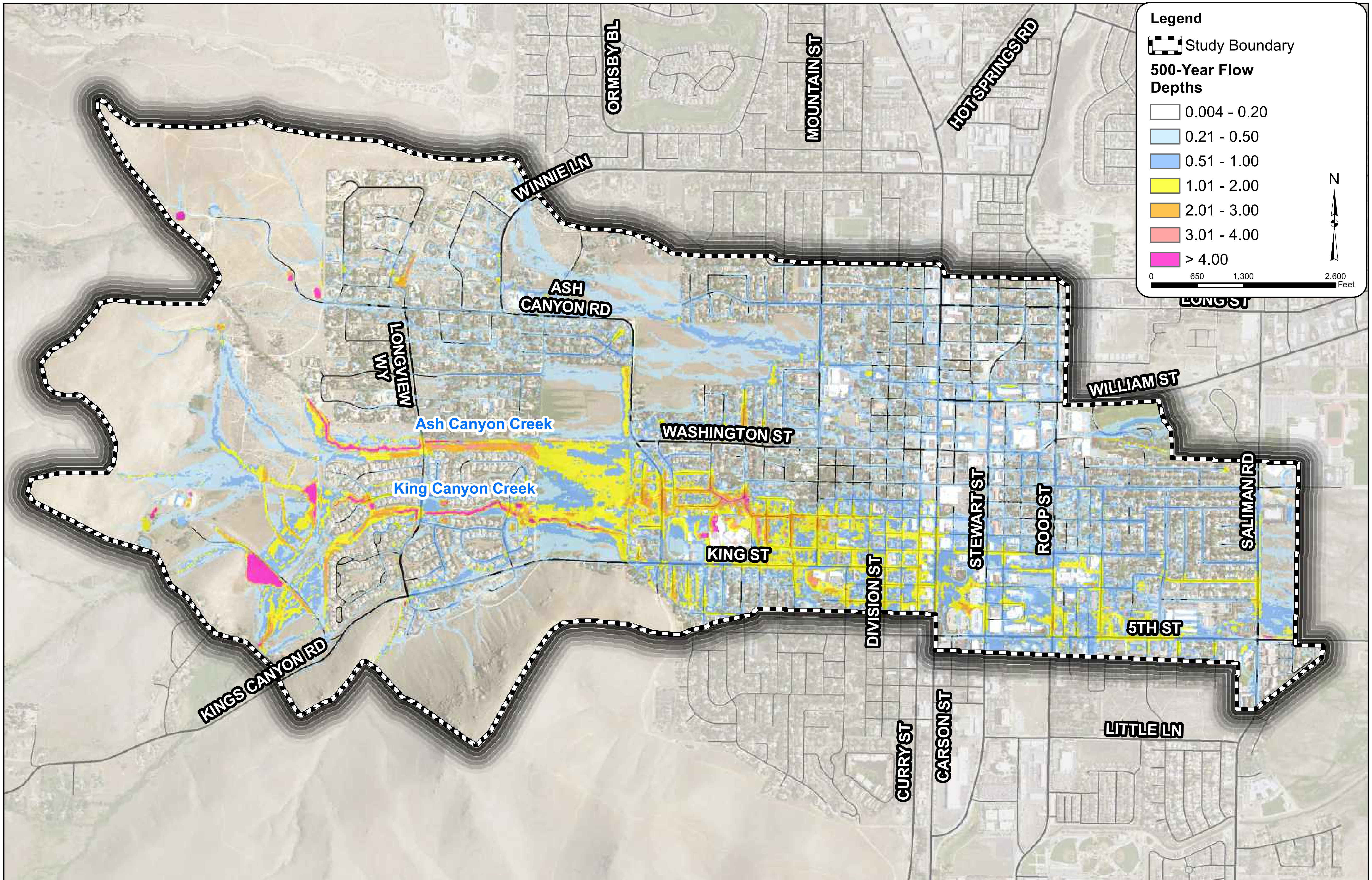
Exisiting100-Year Velocities

PROJECT NO.
291417000

DRAWING NAME
EX. 100-YR VELOCITIES

Figure 23



West Carson City ADP
Existing 500-Year Flow Depths

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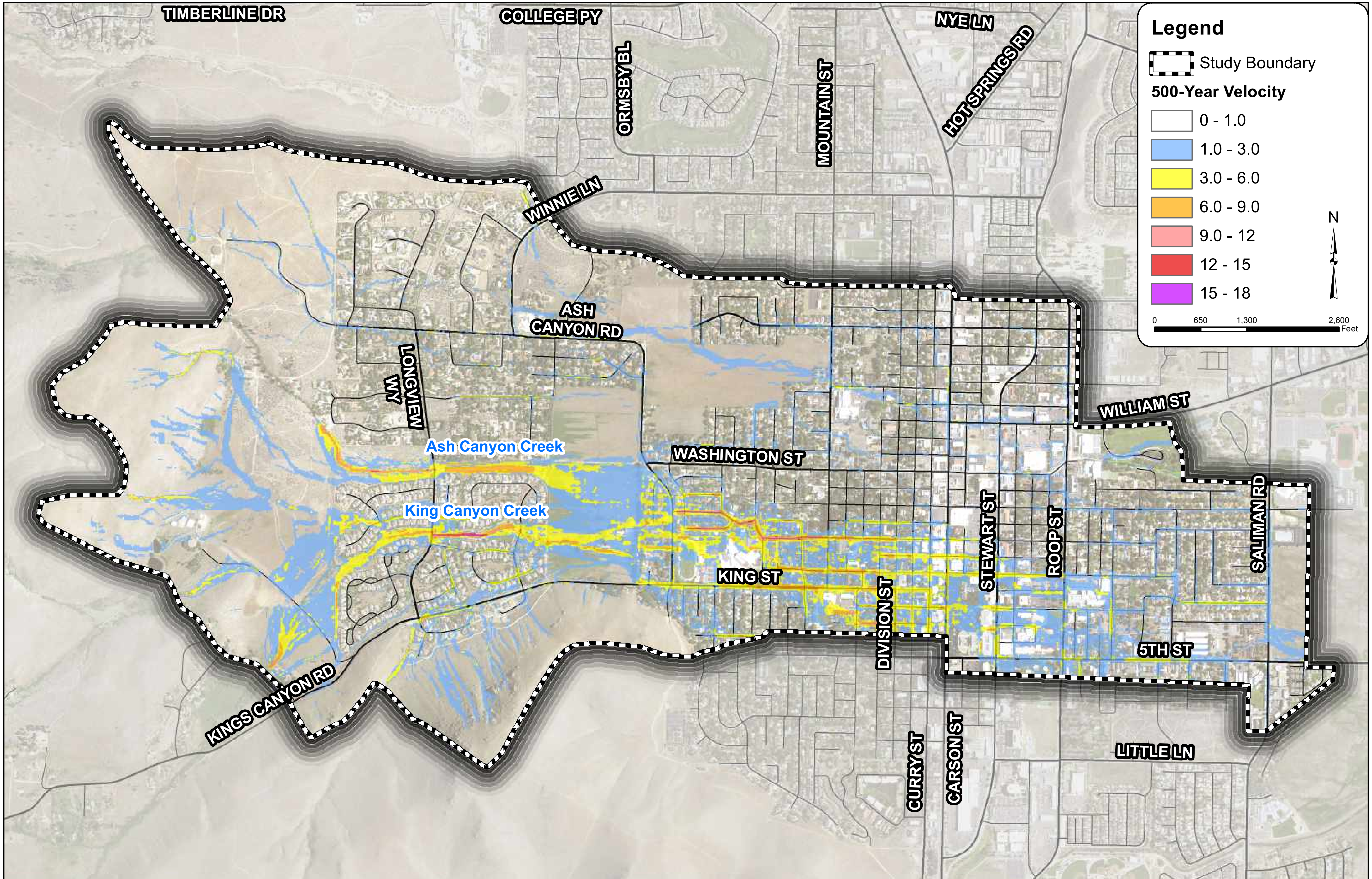
DATE: 06/2021

PROJECT NO.
291417000

DRAWING NAME
EX. 500-YR FLOW DEPTHS

Figure 24



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DATE: 06/2021

West Carson City ADP
Exisiting 500-Year Velocities

PROJECT NO.
291417000
DRAWING NAME
EX. 500-YR VELOCITIES
Figure 25

6 Area Drainage Plan

6.1 Overview

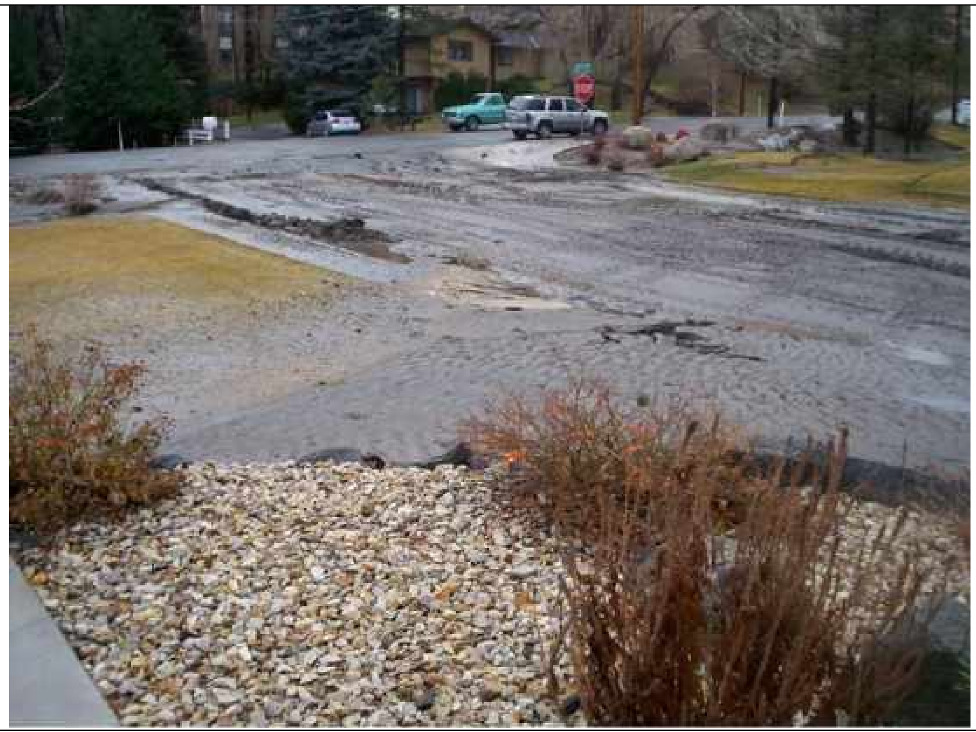
The area drainage plan focused on evaluating potential mitigation solutions to reduce the risk of flooding within the study boundary. Ash Canyon and Kings Canyon Creeks are the two main sources of flooding and are the main contributors to the flood prone areas. Carson City has developed sandbag plans for Washington Street and Kings Street to convey flows through the city due to these two creeks overtopping and running down the street and outside the public right-of-way. The City would like to evaluate a more permanent solution to alleviate flooding in this portion of the City. This area drainage plan details the existing flood prone areas, watershed constraints, opportunities, and a design concept with a construction cost estimate for a proposed drainage mitigation project.

6.2 Flood Prone Areas

Flood prone areas were developed based on the existing flow depths and velocities from the FLO-2D modeling effort and verified based on data collected from the City and residents. The following figures show recent flooding that has occurred and typical sandbag placement in some flood prone areas.

Sandbags	Sandbags
	

Sandbags	December 2005 Storm
	
December 2005 Storm	**December 2005 Storm**
	

December 2005 Storm	December 2005 Storm
	
December 2005 Storm	**December 2005 Storm**
	

December 2005 Storm	December 2005 Storm
	
December 2005 Storm	**December 2005 Storm**
	

Burger King Flooding	Specer Road Backyard Ponding
	
2017 Flooding	**Fermi Road Flooding and Debris**
	

2016 Flooding	Roadside Damage Due to Flooding in 2017
	

6.2.1 Public Meeting #1

A virtual public meeting was held on December 9, 2020 that discussed the existing drainage conditions and patterns. Prior to the meeting, a project website was established to provide meeting and project information to residents. The website also provided the means for members of the public to submit questions and flood data. Residents were able to submit anecdotal flood evidence to the project team to be reviewed and documented as part of this study. Several residents submitted descriptions of flooding and/or photos of flooding. A summary of these flooding issues is provided in Figure 27. The detailed information provided by the public has been included in Appendix C.

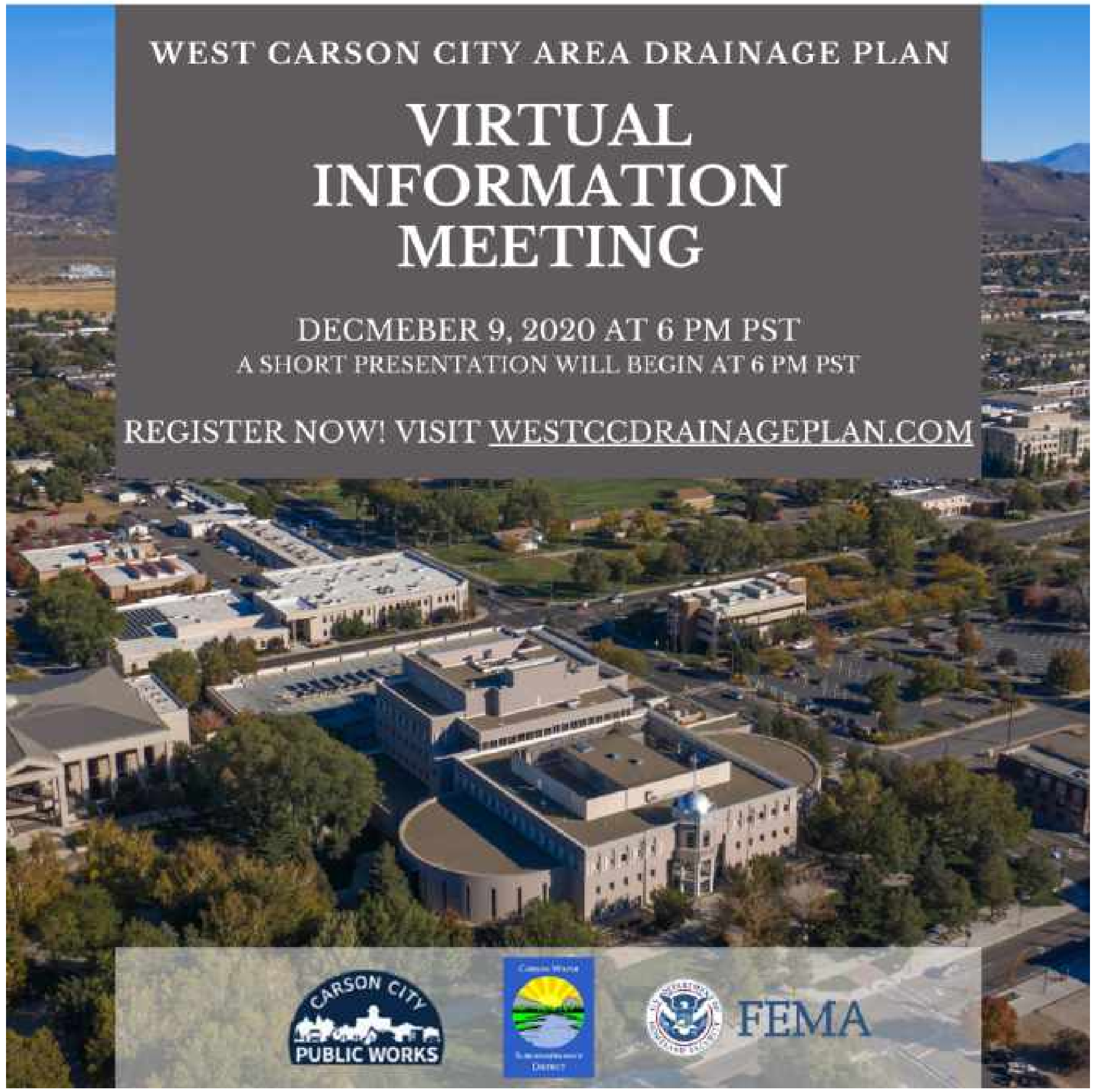


Figure 26: Public Meeting #1

6.2.2 Flood Risk

In addition to the public responses about flooding issues within the study area, flooding risk zones were defined by the following methodologies from the US Department of the Interior Bureau of Reclamation (USBR) for flood hazard classification. USBR published flood danger levels for pedestrians and passenger cars (USBR, 1988). The flood danger was developed based on a flow depth and velocity criteria. The flood danger levels were classified in three categories: low, moderate, and high risk. These risk levels are defined as the following:

Low Risk *– A region that would have little to no flooding. Stormwater flow depths and velocities would be minimal.*

Moderate Risk *– A region that could be in some danger of flood waters. Stormwater flow depths and velocities could have negative impacts.*

High Risk *– A region that is in danger from flood waters. Stormwater flow depths and velocities that would have negative impacts*

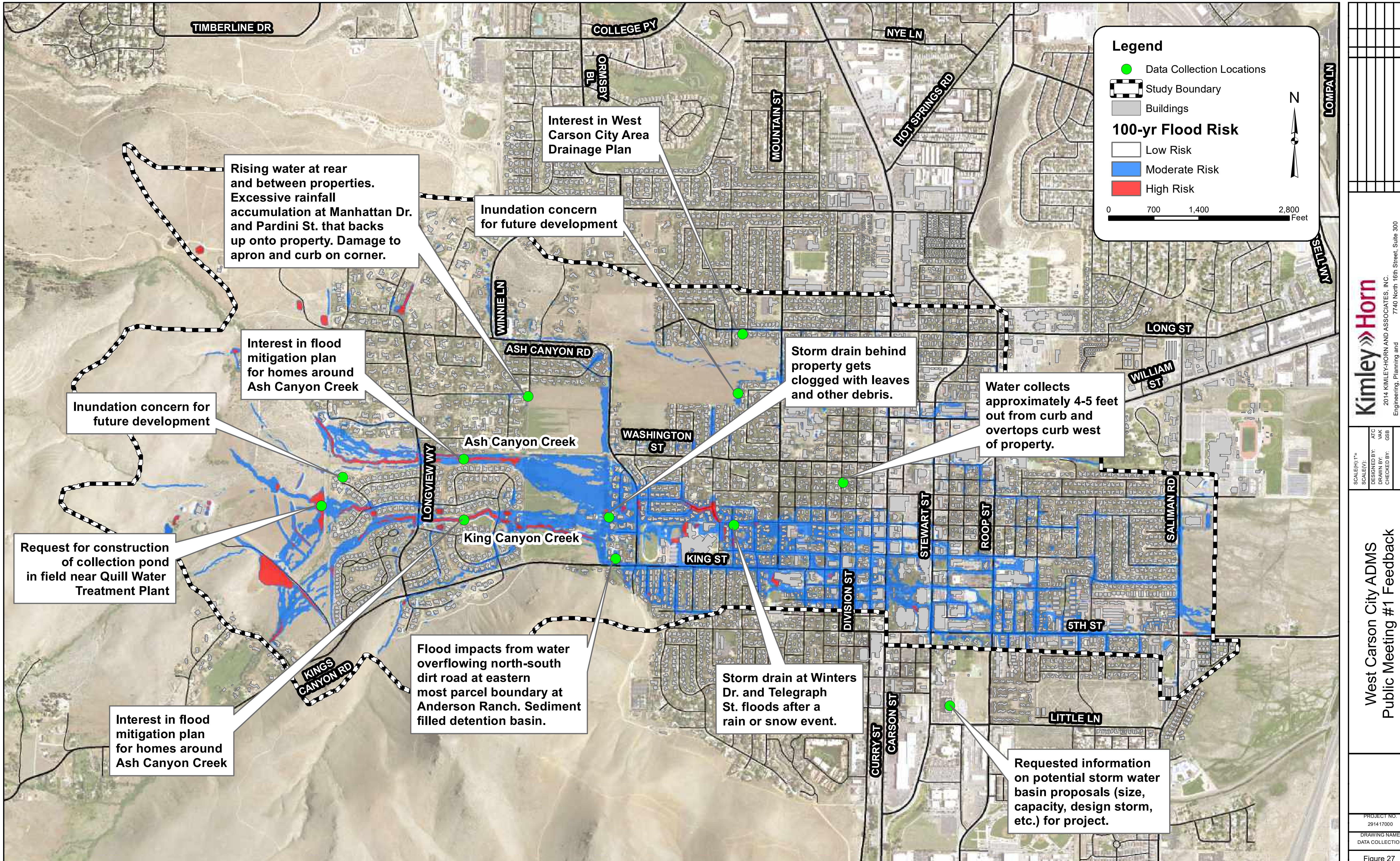
These different risk categories are shown spatially for pedestrians (Figure 28) and passenger cars (Figure 29) for the 100-year storm event.

6.2.3 Constraints

The biggest constraint is the lack of downstream conveyance east of Ormsby Blvd. The conveyance is limited to existing storm drain and the street network. There is no main channel conveyance from Ormsby Blvd to Saliman Road. When the storm drain system is overwhelmed in a flood flow condition, stormwater is then conveyed through the street network and flows in a southeasterly direction through the City. The storm drain systems work for low flow conditions but are quickly overwhelmed in flood flow conditions. In addition to the lack of conveyance, another constraint is the lack of open space or right-of-way east of Ormsby Blvd to allow for feasible construction of additional drainage infrastructure. This portion of Carson City is fully developed, and it would be difficult to increase conveyance in an overland or subsurface condition due to the lack of available space.

6.3 Opportunities

West of Ormsby Blvd (upstream of the storm drain systems), there is more open space and city owned property that is adjacent to Ash Canyon and Kings Canyon Creeks. The creeks also have natural drainage ways and channels that are available to convey flows downstream. There are less utilities in this area as well, potential creating less utility conflicts for any sub surface improvements.


Legend
Data Collection Locations
Study Boundary
Buildings
100-yr Flood Risk
Low Risk
Moderate Risk
High Risk
N
0 700 1,400 2,800 Feet
TIMBERLINE DR
COLLEGE PY
NYE LN
ORMSBY BL
MOUNTAIN ST
HOT SPRINGS RD
LOMPA LN
SELLWAY
LONG ST
WILLIAM ST
WINNIE LN
ASH CANYON RD
WASHINGTON ST
LONGVIEW WY
KING ST
STEWART ST
ROOP ST
SALIMAN RD
DIVISION ST
5TH ST
KINGS CANYON RD
CURRY ST
CARSON ST
LITTLE LN
Ash Canyon Creek
King Canyon Creek
Interest in West Carson City Area Drainage Plan
Rising water at rear and between properties. Excessive rainfall accumulation at Manhattan Dr. and Pardini St. that backs up onto property. Damage to apron and curb on corner.
Inundation concern for future development
Interest in flood mitigation plan for homes around Ash Canyon Creek
Storm drain behind property gets clogged with leaves and other debris.
Water collects approximately 4-5 feet out from curb and overtops curb west of property.
Inundation concern for future development
Request for construction of collection pond in field near Quill Water Treatment Plant
Flood impacts from water overflowing north-south dirt road at eastern most parcel boundary at Anderson Ranch. Sediment filled detention basin.
Storm drain at Winters Dr. and Telegraph St. floods after a rain or snow event.
Interest in flood mitigation plan for homes around Ash Canyon Creek
Requested information on potential storm water basin proposals (size, capacity, design storm, etc.) for project.
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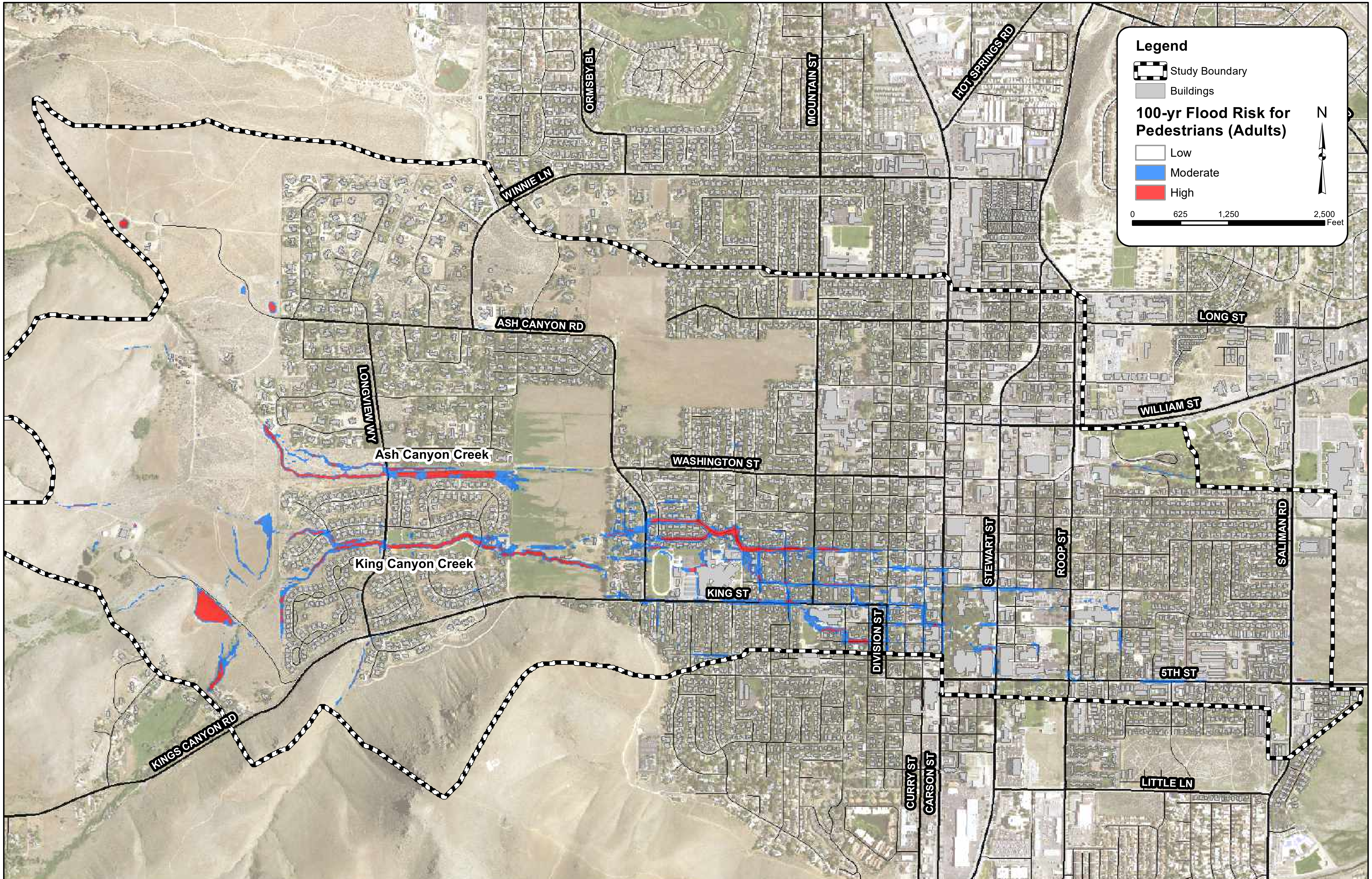
West Carson City ADMS
Public Meeting #1 Feedback
PROJECT NO. 291417000
DRAWING NAME DATA COLLECTION
Figure 27



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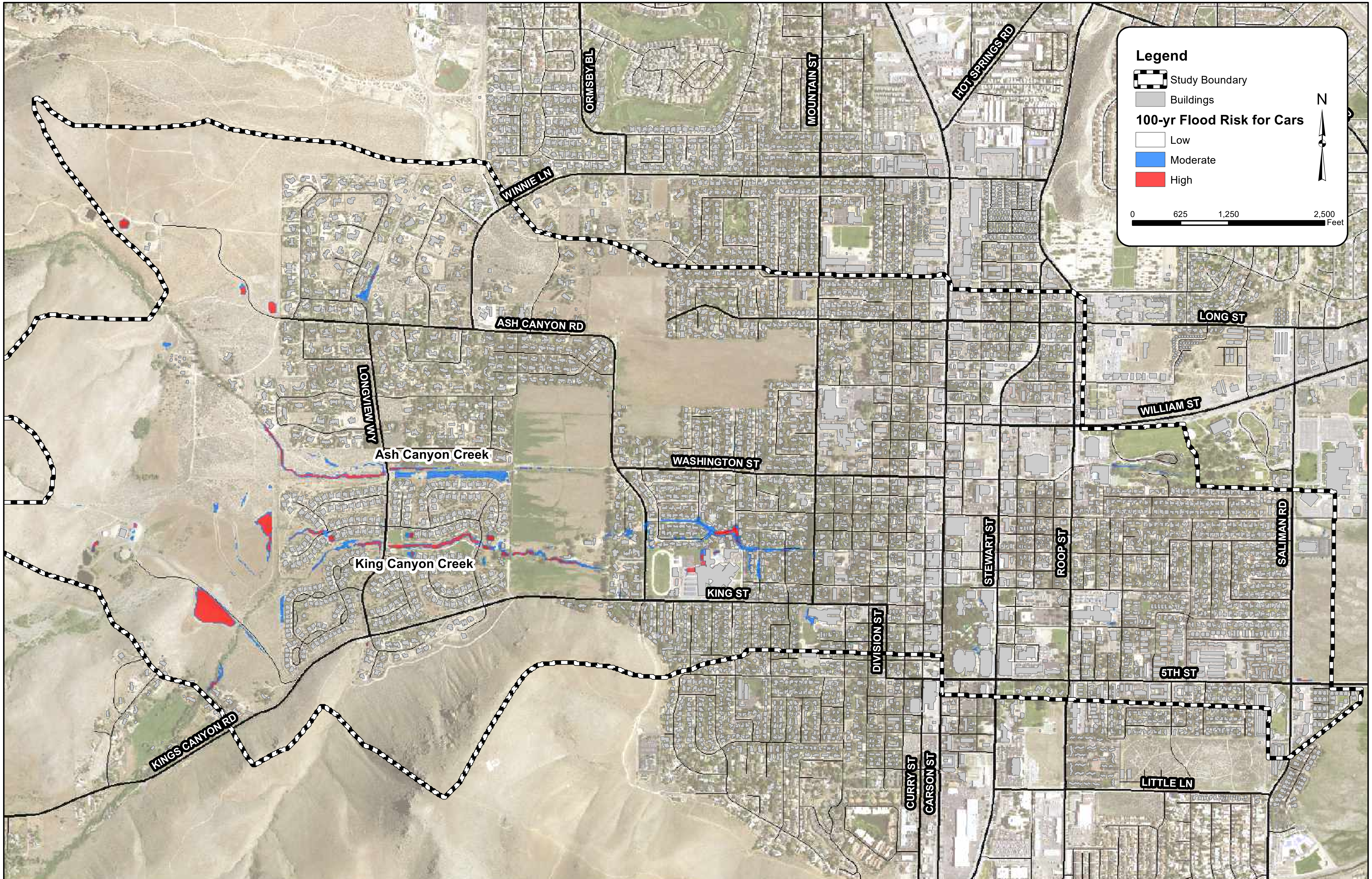
DATE: 11/2020

West Carson City ADMS
100-Year Flood Risk for Pedestrians (Adults)

PROJECT NO. 291417000
DRAWING NAME PEDESTRIAN RISK
Figure 28



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West Carson City ADMS
100-Year Flood Risk for Cars

PROJECT NO. 291417000
DRAWING NAME VEHICULAR RISK

Figure 29

6.4 Design Analysis

6.4.1 Preliminary Analysis

In discussion with the City and due to the constraints downstream of Ormsby Blvd., retention/detention basins were evaluated upstream of Ormbsy Blvd to attenuate the flow reaching the existing storm drain systems at Washington Street and Kings Street. The proposed basin locations were evaluated based on existing flood prone areas, open space, and city owned property. The existing storm drain systems were evaluated to determine capacity prior to flows overtopping in Washington and Kings Street. This condition was used as the starting point to find out the total volume required for the basins upstream.

The volume required for the Ash Canyon Creek basin(s) was calculated to be 366 ac-ft for 100-year flood attenuation. With Ash Canyon Creek channel improvements from the Pardini Street alignment to Washington Street and inlet improvement to the storm drain inlet at Washington Street, 100 cfs could be conveyed in the storm drain system without overtopping into Washington Street. The total volume for Kings Canyon Creek basin(s) was calculated to be 374 ac-ft to reduce the 100-year peak discharge to 100 cfs at Kings Street. With inlet improvements, 100 cfs could be conveyed by the storm drain system without overtopping into Kings Street. The storm drain system in Kings Street near Richmond Avenue splits into two separate systems. The 42'' pipe in Kings Street splits into a 24'' pipe and a 36'' pipe and then recombines into a single 36'' pipe downstream near Curry and 4th Street. At this location, the model indicates that flows surcharge into the street due to the reduction in storm drain capacity, but flows are shallow and contained in the street.

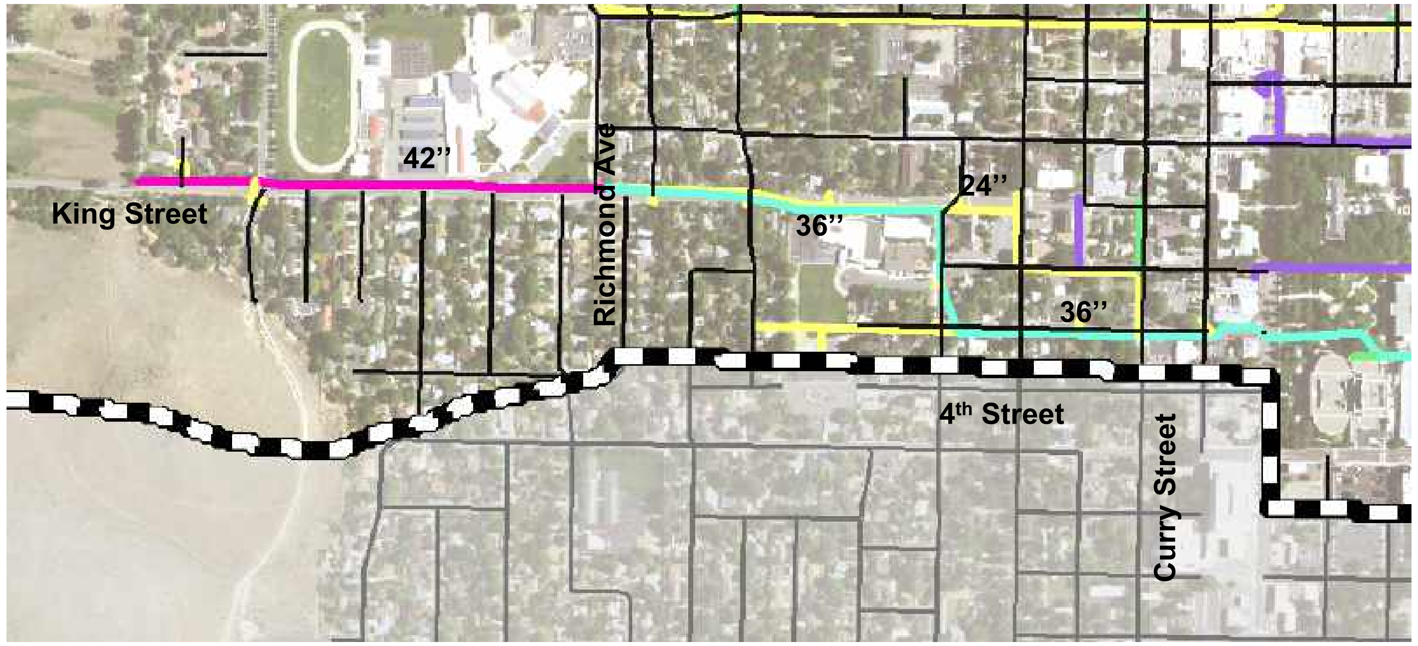


Figure 30: Kings Street Storm Drain System

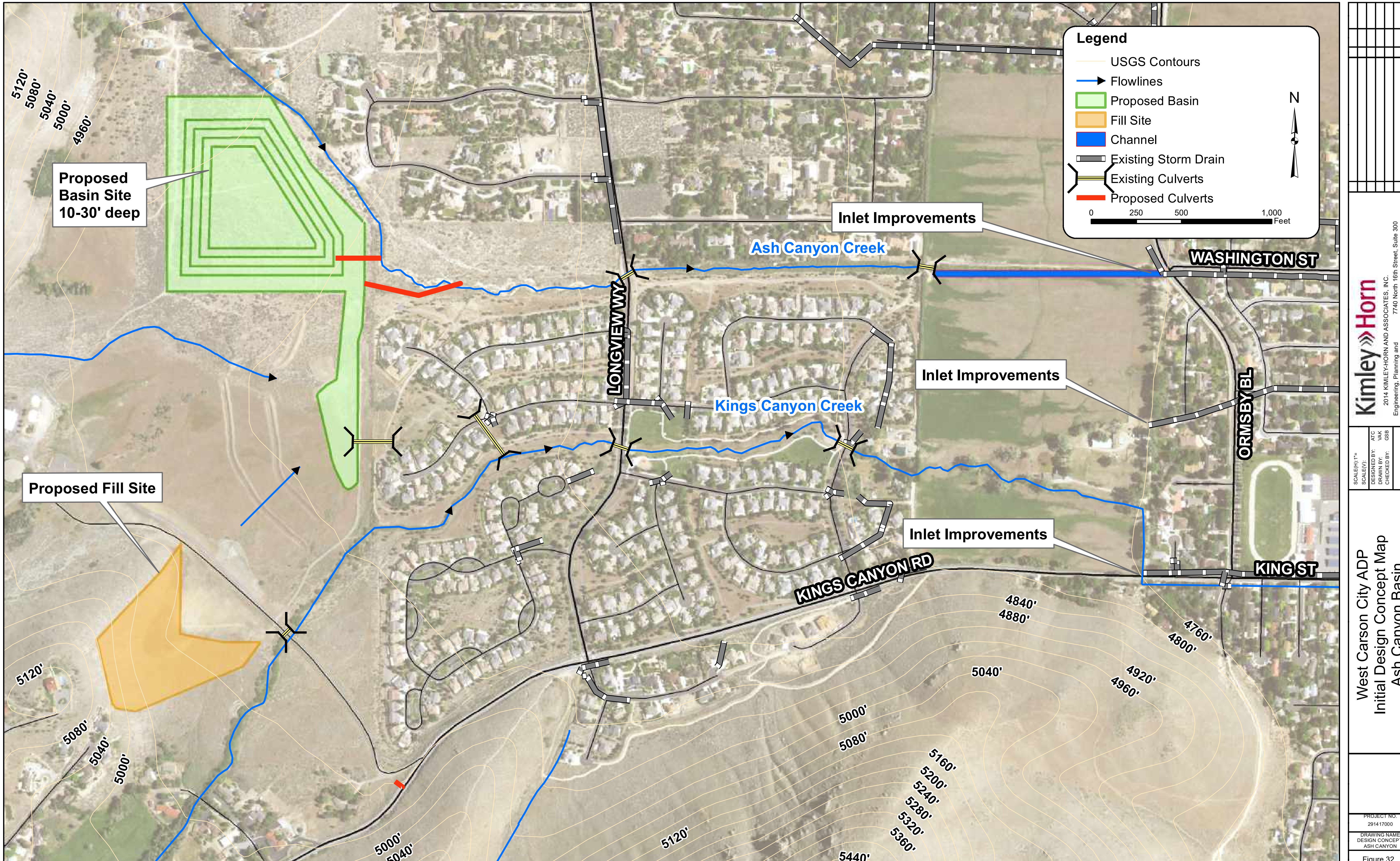
The total required volume upstream of Ormsby Blvd for both Ash Canyon and Kings Canyon Creek is 740 ac-ft (366 ac-ft + 374 ac-ft) to limit flows to 100 cfs at the storm drain systems at Washington Street and Kings Street for the 100-year storm event. These improvements would restrict the Ash Canyon and Kings Canyon 100-year runoff from being conveyed through the downstream street network and impacting adjacent properties and buildings. The following figures illustrate the Ash Canyon Creek improvements, the Kings Canyon Creek improvements, and the combined improvements with the potential positive and negative impacts. Each scenario has a net positive impact over the entire study area. There are a few isolated locations where there are negative impacts. These negative impacts are isolated to the storm drain inlet locations (near Washington Street and Kings Street) where inlet improvements and future design refinements would be required to mitigate the impacts to adjacent properties.

Existing topography was evaluated to see how the 740 ac-ft of volume required could be configured in upstream open space. 740 ac-ft is feasible but would require most of the available open space and basin depths of nearly 30 feet in some locations. Excavation costs may total approximately $15 million depending on unit hall costs.

6.4.2 Public Meeting #2

A second public meeting was held on Tuesday May 11, 2021 to present these basin concepts to the public. The intent was to obtain public feedback about the proposed improvements, basin locations, aesthetics, and what they would like to see in this area. Overall, the responses were favorable towards any potential flood mitigation projects. A recap of the meeting is provided in Appendix D.

Figure 31: Public Meeting #2 Postcard Invitation



Legend
USGS Contours
Flowlines
Proposed Basin
Fill Site
Channel
Existing Storm Drain
Existing Culverts
Proposed Culverts
0
250
500
1,000
Feet
N
Proposed Basin Site 10-30' deep
Proposed Fill Site
Inlet Improvements
Inlet Improvements
Inlet Improvements
Ash Canyon Creek
Kings Canyon Creek
LONGVIEW WY
WASHINGTON ST
ORMSBY BL
KING ST
KINGS CANYON RD
5120'
5080'
5040'
5000'
4960'
4840'
4880'
4760'
4800'
4920'
4960'
5040'
5000'
5080'
5160'
5200'
5240'
5280'
5320'
5360'
5440'
5120'
5000'
5040'
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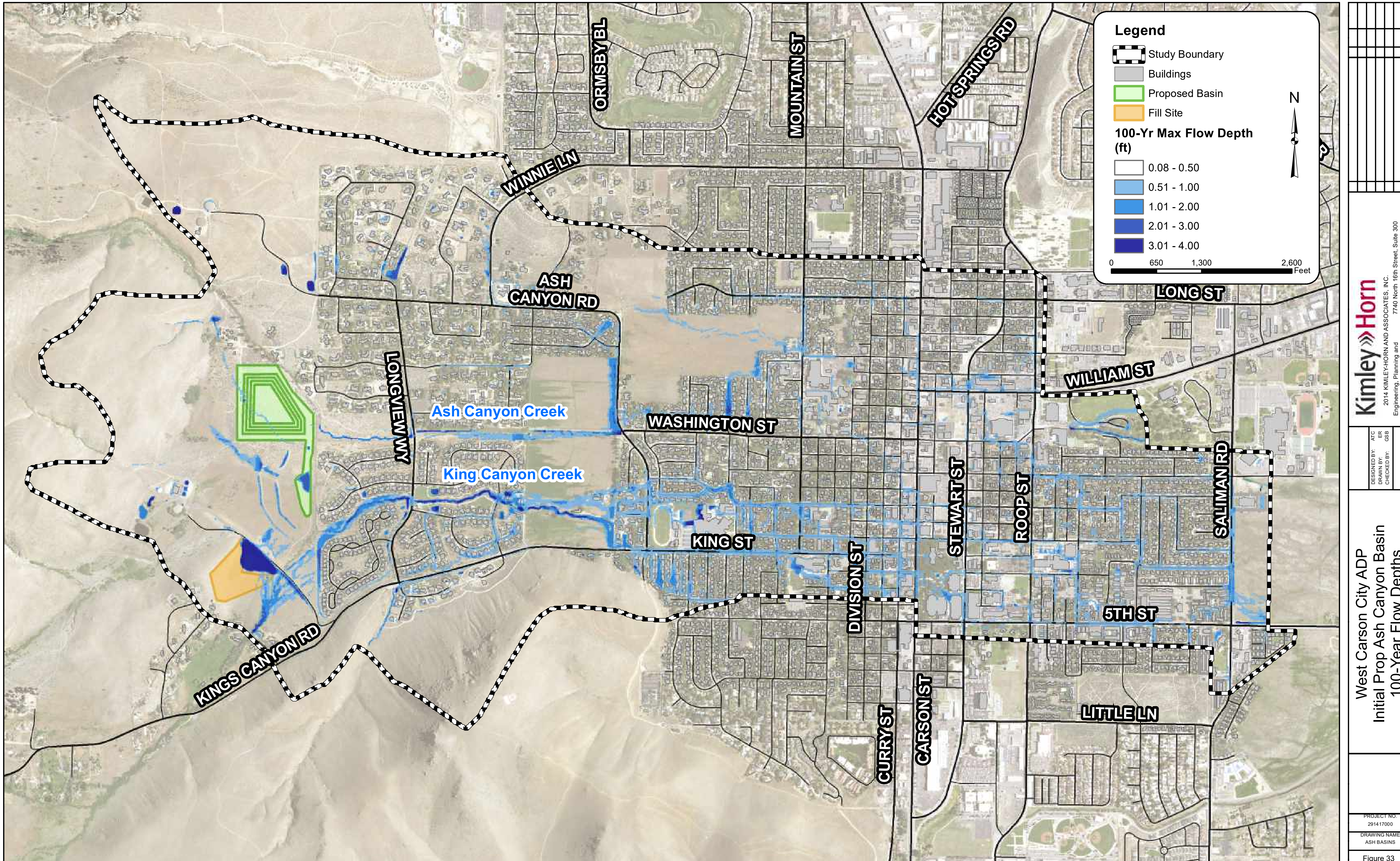
West Carson City ADP
Initial Design Concept Map
Ash Canyon Basin
PROJECT NO.
291417000
DRAWING NAME
DESIGN CONCEPT
ASH CANYON
Figure 32



Legend
Study Boundary
Buildings
Proposed Basin
Fill Site
100-Yr Max Flow Depth (ft)
0.08 - 0.50
0.51 - 1.00
1.01 - 2.00
2.01 - 3.00
3.01 - 4.00
0 650 1,300 2,600 Feet
N
ORMSBY BL
MOUNTAIN ST
HOT SPRINGS RD
WINNIE LN
ASH CANYON RD
LONG ST
WILLIAM ST
LONGVIEW WY
Ash Canyon Creek
WASHINGTON ST
King Canyon Creek
KING ST
STEWART ST
ROOP ST
SALIMAN RD
DIVISION ST
5TH ST
KINGS CANYON RD
LITTLE LN
CURRY ST
CARSON ST
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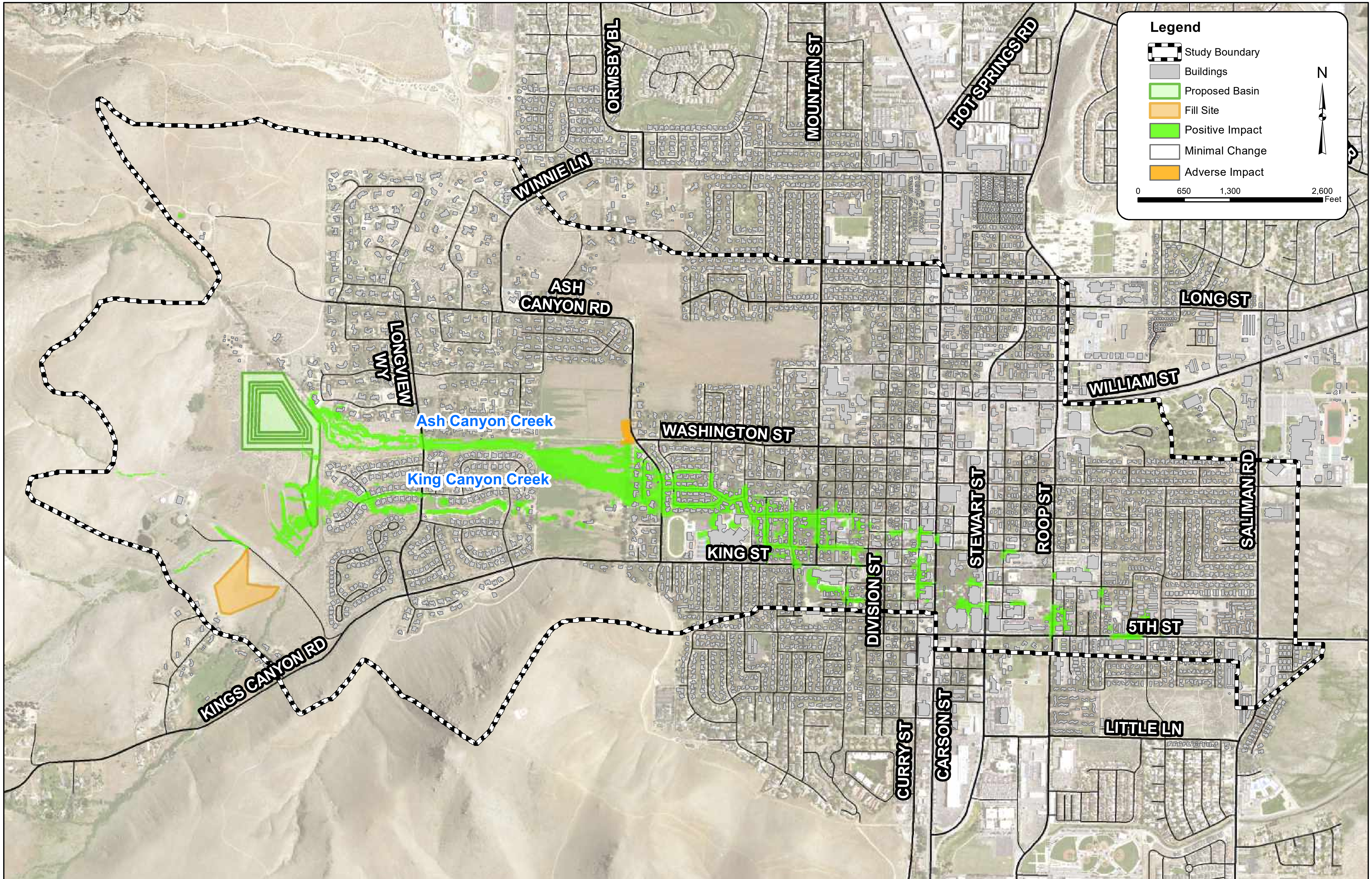
West Carson City ADP
Initial Prop Ash Canyon Basin
100-Year Flow Depths
PROJECT NO.
291417000
DRAWING NAME
ASH BASINS
Figure 33



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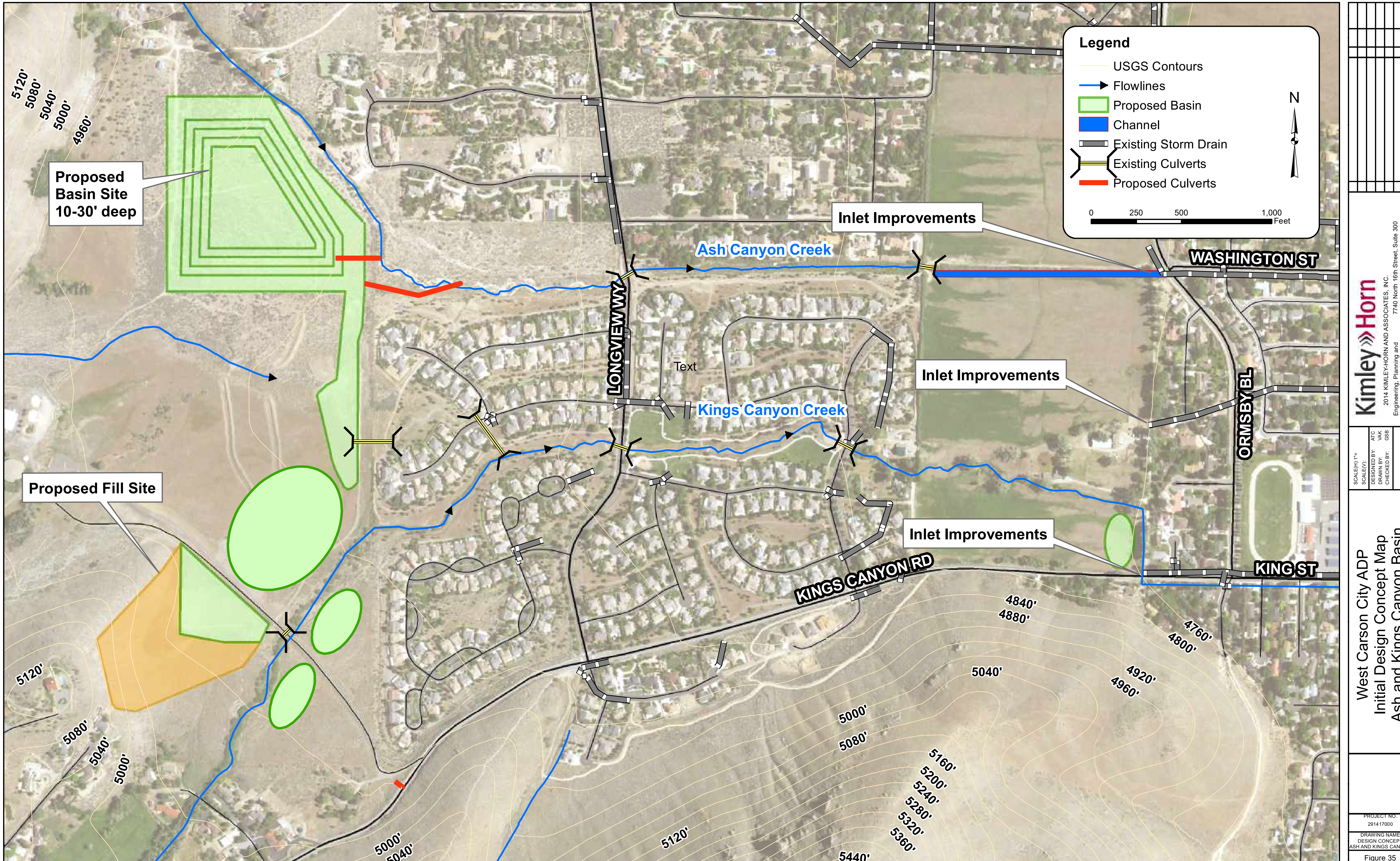
West Carson City ADP
Initial Ash Canyon Basin
Impact Map

PROJECT NO. 291417000

DRAWING NAME ASH BASIN IMPACTS

Figure 34


Legend
USGS Contours
Flowlines
Proposed Basin
Channel
Existing Storm Drain
Existing Culverts
Proposed Culverts
N
0 250 500 1,000 Feet
Proposed Basin Site 10-30' deep
Proposed Fill Site
Inlet Improvements
Inlet Improvements
Inlet Improvements
Ash Canyon Creek
Kings Canyon Creek
LONGVIEW WY
WASHINGTON ST
ORMSBY BL
KING ST
KINGS CANYON RD
Text
5120'
5080'
5040'
5000'
4960'
4840'
4880'
4760'
4800'
4920'
4960'
5040'
5000'
5080'
5160'
5200'
5240'
5280'
5320'
5360'
5120'
5440'
5000'
5040'
5120'
5080'
5040'
5000'
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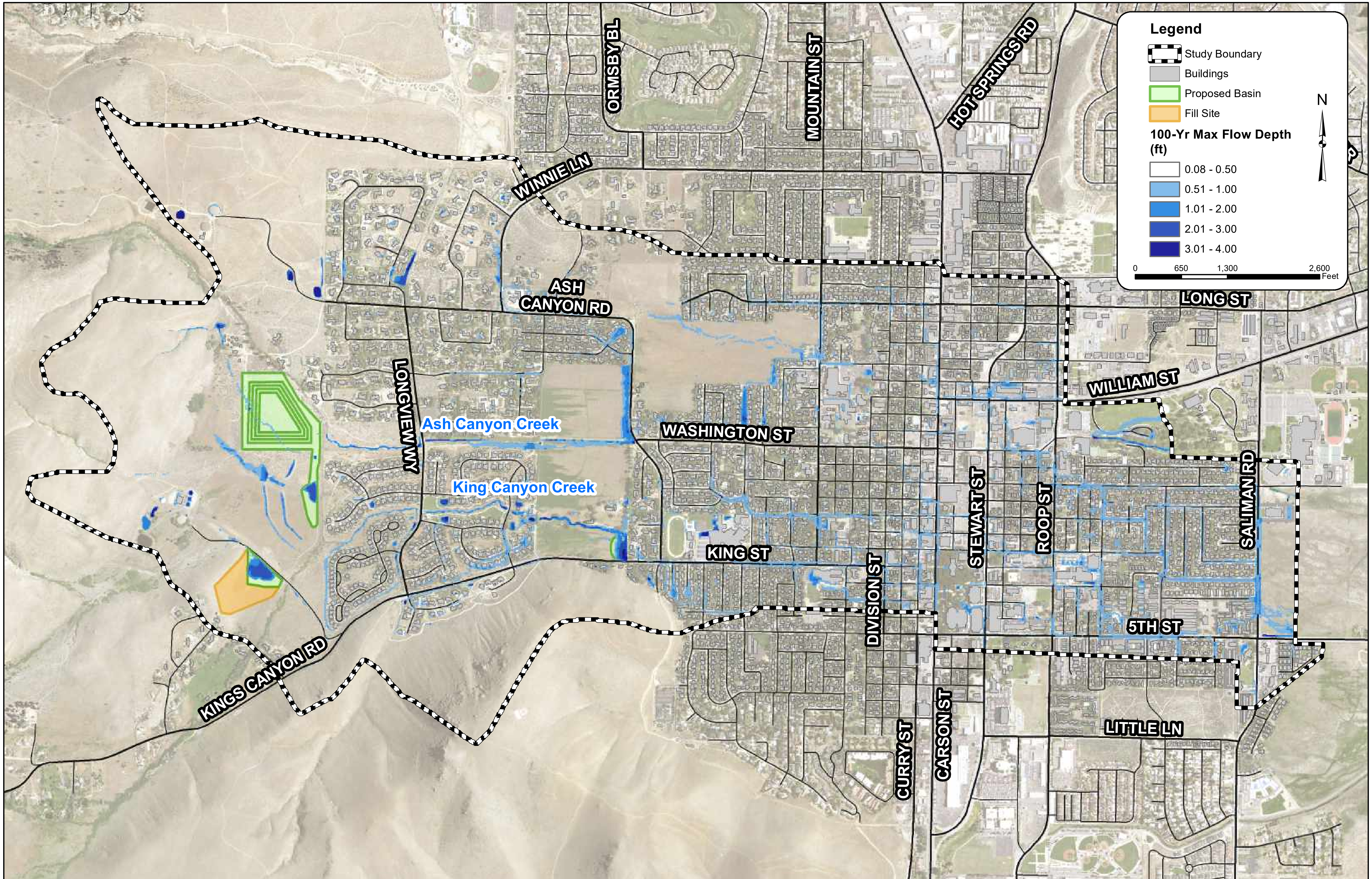
Initial Design Concept Map
Ash and Kings Canyon Basin
PROJECT NO. 291417000
DRAWING NAME DESIGN CONCEPT ASH AND KINGS CANYON
Figure 35



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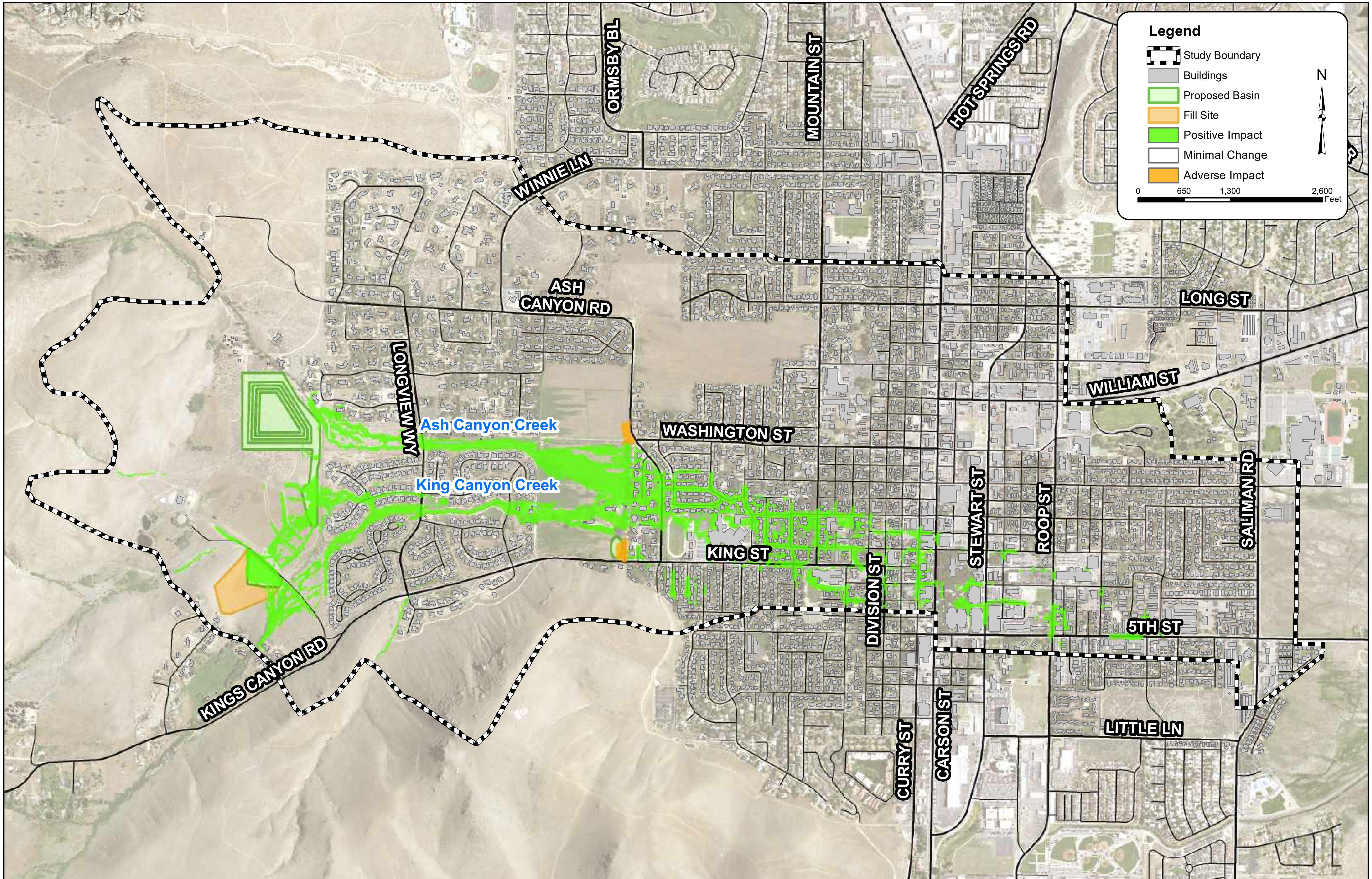
West Carson City ADP
Initial Prop Ash & Kings Canyon Basins
100-Year Flow Depths

PROJECT NO. 291417000
DRAWING NAME ASH/KINGS BASINS
Figure 36



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West Carson City ADP
Initial Ash & Kings Canyon Basins
Impact Map

PROJECT NO.
291417000

DRAWING NAME
ASH & KINGS IMPACTS

Figure 37

6.4.3 Recommended Alternative

In discussions with the City and an evaluation of the preliminary cost estimate, it was determined that the 100-year, 740 ac-ft required storage volume to match the storm drain capacity downstream would be an initial target for this area, but the study would also evaluate storage adjacent to Ash Canyon Creek for smaller storm events. Physical constraints in the area sited for the basin made constructing 740 ac-ft of storage not feasible from a cost standpoint. A smaller basin volume configuration will store more frequent flooding while improving the 100-year condition. The overall project focus was shifted to sizing the maximum basin volume feasible given the physical constraints presented by the potentially available open space. A 10-year basin solution was developed based on these constraints.

A proposed offline retention/detention basin design alternative was developed upstream of Longview Way that would capture runoff from Ash Canyon and Kings Canyon Creeks and meter flows out downstream for a 10-year solution. The proposed offline basin would divert flood flows into the basin, while allowing low flows to continue downstream in the existing channels and other conveyances. The proposed basin would meter flows downstream in three outfall conditions. The primary basin outfall would discharge to Ash Canyon Creek in 2-18'' pipes. The primary outfall would be set at an elevation above the basin bottom to retain a certain portion of runoff and to allow for sediment deposition. The secondary basin outfall would also discharge to Ash Canyon Creek in 5-48'' pipes. These pipes would release flow in a 100-year flood event. The third outfall, the emergency outfall for the basin would discharge both to Ash Canyon and Kings Canyon Creeks. The emergency spillways to each creek are set at the same elevation and flows would discharge to historical outfall locations. The spillway elevations are set at least 1-foot above the 100-year water surface in the basin.

The basin is proposed to be located on mostly City owned property near Kensington Place and Kensington Court near the water tank and the meadow infiltration basins at the foothills of the Carson Range and adjacent to Ash Canyon Creek. A portion of the basin footprint is located on private property and would require the City to work with the property owner to acquire the necessary land. There is an existing water line and fiber optic conduit that was recently constructed that would remain in place. The existing irrigation line adjacent to Ash Canyon Creek would also be protected in place. Utility coordination with the water line and irrigation lines need to be further evaluated and refined in the next phase of the project.

An overview of the proposed improvements is shown in Figure 38. The design concept for the Ash Canyon Creek Basin is shown in Figure 39. Minor grading of the channel downstream of the proposed basin would allow 100 cfs to be conveyed to the existing storm drain downstream, while flow more than 100 cfs would spill over the south bank and continue to the historical outfall. The material excavated from the Ash Canyon Creek basin is proposed to be disposed of south of the water tank access road north of Kings Canyon Creek. Figure 38 shows this proposed fill disposal location.

The estimated cost for this project including design, permitting, and construction is estimated to be approximately $19.2 million. Table 10 is summary of the costs. A detailed cost breakdown is provided in Table 11.

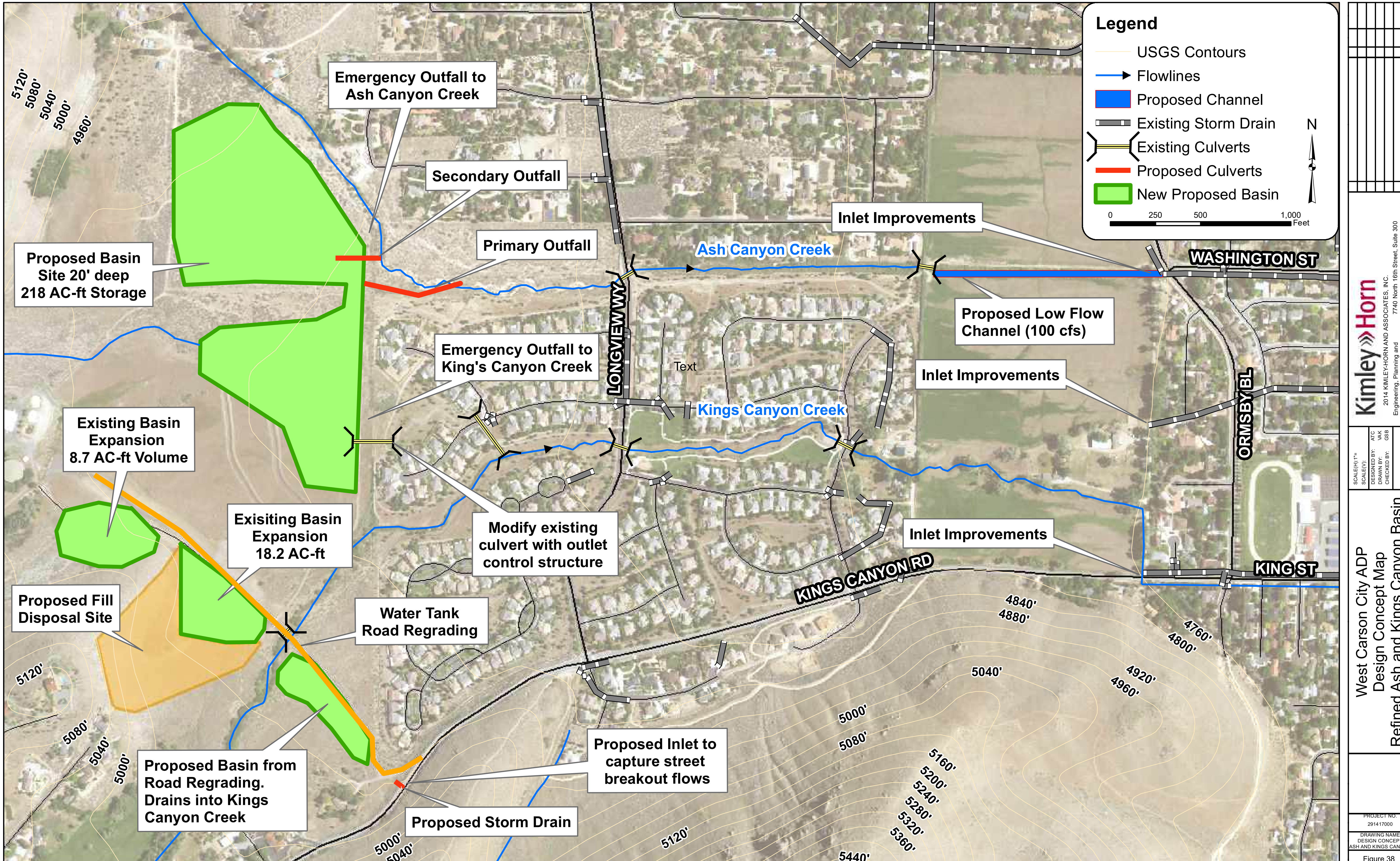
Table 10: Preliminary Cost Estimate

Item	Cost
Design and Permitting	$ 1.1 million
Construction	$ 18.1 million
Land	To be determined
Total	$ 19.2 million

Table 11: Detailed Cost Breakout

Item Description	Unit	Unit Price	Qty	Cost
DESIGN				
Design Concept Report	LS	$ 150,000	1	$ 150,000
Final Design	LS	$ 600,000	1	$ 600,000
Design Sub-Total				$ 750,000
Contingency (20%)				$ 150,000
Design Total				**$ 900,000**
PERMITTING				
FEMA	LS	$ 80,000	1	$ 80,000
Environmental	LS	$ 80,000	1	$ 80,000
Permitting Sub-Total				$ 160,000
Contingency (20%)				$ 32,000
Permitting Total				**$ 192,000**
CONSTRUCTION				
Miscellaneous Removals	LS	$ 150,000	1	$ 150,000
Clear and Grub	AC	$ 17,000	38	$ 649,000
Basin Earthwork (Export < 1 mile away)	CY	$ 7.5	1,080,200	$ 8,102,000
Riprap	SF	$ 5	89,000	$ 445,000
Ash Canyon Spillway	LS	$ 400,000	1	$ 400,000
2-36'' RCP Culverts	LF	$ 400	80	$ 32,000
2-18'' RCP Primary Basin Outfall	LF	$ 260	780	$ 203,000
5-48'' RCP Secondary Outfall	LF	$ 1,500	140	$ 210,000
1-60'' RCP Equilizer Pipe	LF	$ 400	330	$ 132,000
Concrete Emergency Wier	SF	$ 12	15,500	$ 186,000
ABC Maintenance Road and Grading	SF	$ 2	16,800	$ 34,000
Landscape Seeding and Revegitation	SF	$ 1	1,660,725	$ 1,329,000
Irrigation Relocation	LS	$ 150,000	1	$ 150,000
Utility Coordination	LS	$ 75,000	1	$ 75,000
Construction Sub-Total				$ 12,097,000
Miscellaneous Construction Costs (30%)[1]				$ 3,629,000
Contingency (20%)				$ 2,419,000
Construction Total				**$ 18,145,000**
LAND				
To be determined by appraisal				
TOTAL PROJECT COST				**19,237,000**

(1) Includes Mobilization, Traffic Control, Construction Staking, Quality Control, SWPPP, and Construction Management


Legend
USGS Contours
Flowlines
Proposed Channel
Existing Storm Drain
Existing Culverts
Proposed Culverts
New Proposed Basin
N
0 250 500 1,000 Feet
Emergency Outfall to Ash Canyon Creek
Secondary Outfall
Primary Outfall
Proposed Basin Site 20' deep 218 AC-ft Storage
Emergency Outfall to King's Canyon Creek
Existing Basin Expansion 8.7 AC-ft Volume
Exisiting Basin Expansion 18.2 AC-ft
Proposed Fill Disposal Site
Water Tank Road Regrading
Modify existing culvert with outlet control structure
Proposed Basin from Road Regrading. Drains into Kings Canyon Creek
Proposed Inlet to capture street breakout flows
Proposed Storm Drain
Inlet Improvements
Ash Canyon Creek
Kings Canyon Creek
Proposed Low Flow Channel (100 cfs)
Inlet Improvements
Inlet Improvements
Text
LONGVIEW WY
WASHINGTON ST
ORMSBY BL
KING ST
KINGS CANYON RD
5120'
5080'
5040'
5000'
4960'
4840'
4880'
4760'
4800'
4920'
4960'
5040'
5000'
5080'
5160'
5200'
5240'
5280'
5320'
5360'
5120'
5440'
5000'
5040'
5120'
5080'
5040'
5000'
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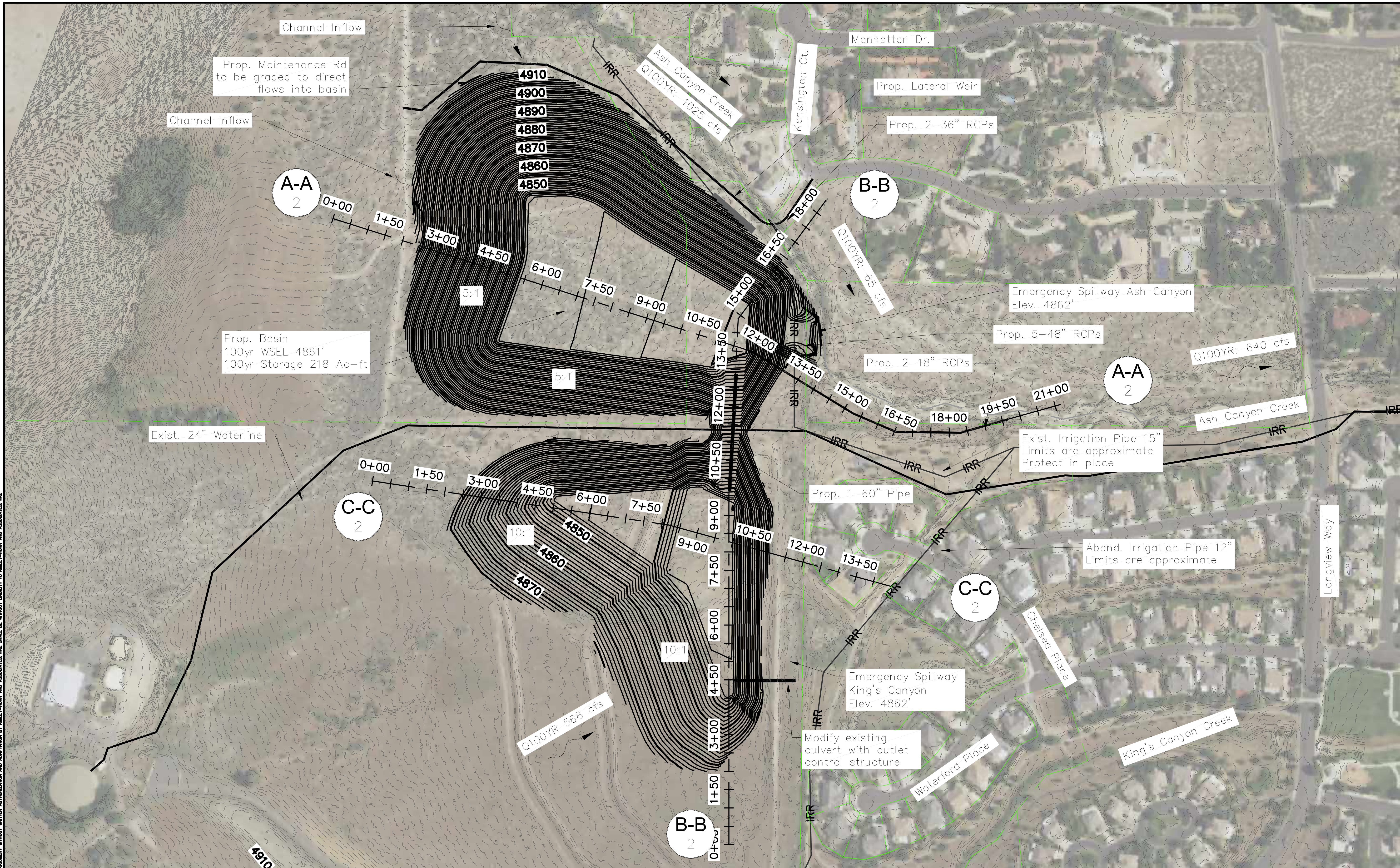
West Carson City ADP
Design Concept Map
Refined Ash and Kings Canyon Basin
PROJECT NO.
291417000
DRAWING NAME
DESIGN CONCEPT
ASH AND KINGS CANYON
Figure 38



GRAPHIC SCALE IN FEET
0 125 250

Approximate Earthwork Quantities:

Bank Cut Vol = 982,000 CY
Bank Fill Vol = 150 CY
Export Vol = 1,080,200 CY

Section A-A
Sheet No. 2

NORTH

NO.	REVISION	DATE

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CHECKED BY: ATC
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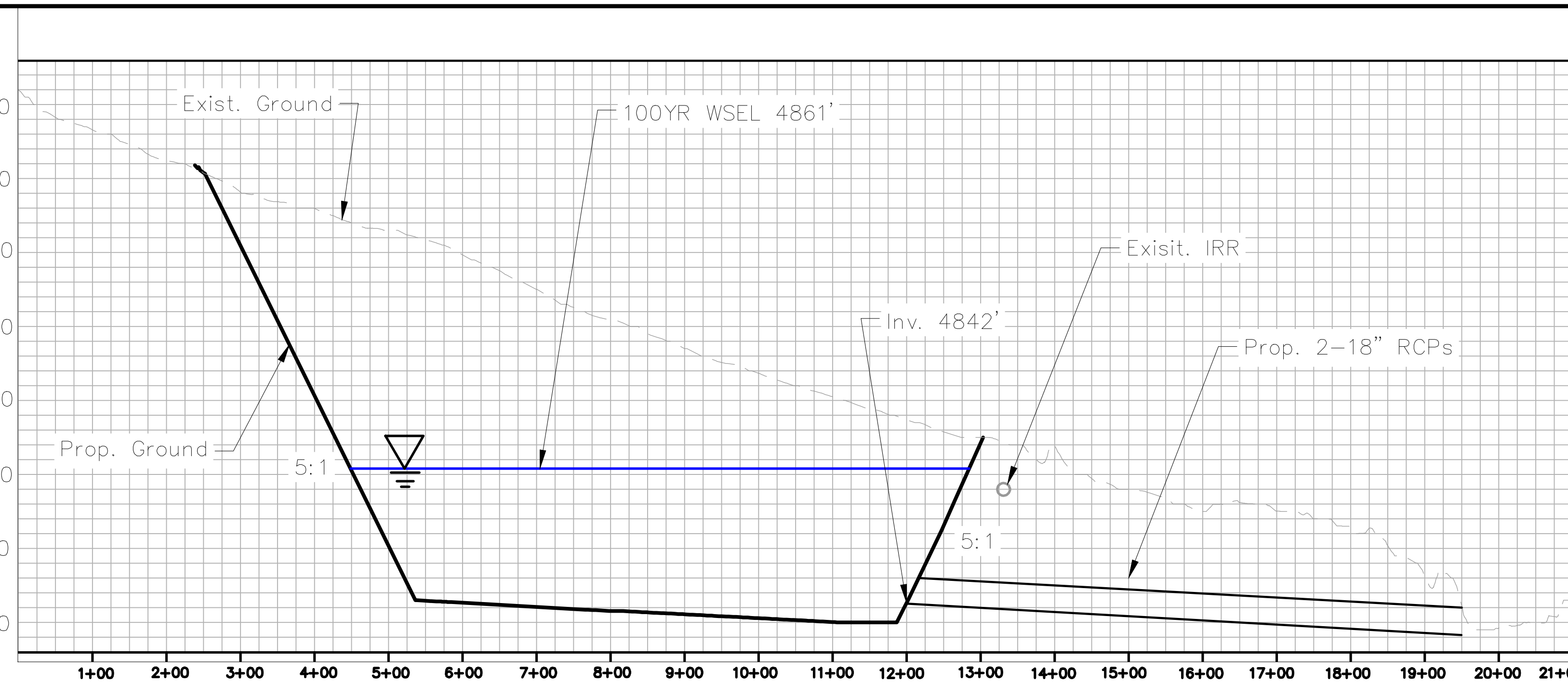
West Carson ADP
Proposed Offline Detention Basin Concept Plans

PROJECT NO. 291417000
DRAWING NAME West Carson Basin

1 OF 2

Section A–A



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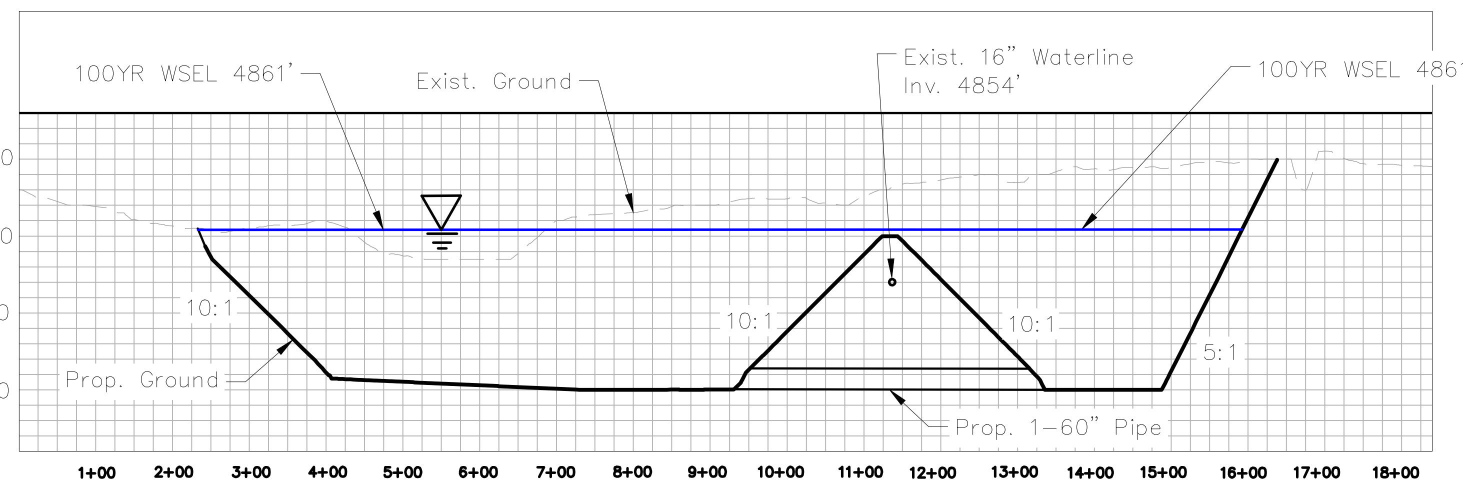
Section B–B



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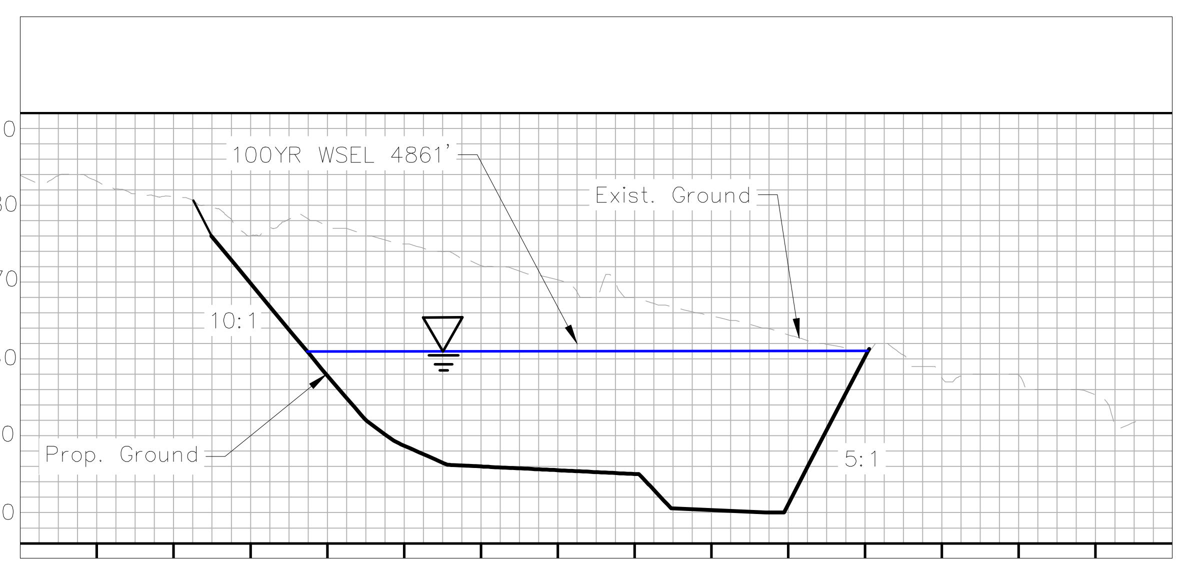
Section C–C



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K:\PHX_WaterResources\291417000_West_Carson_ADMS\CADD\Exhibits\Drainage\291417000_BasinExhibit.dwg Jun 25, 2021 Rebecca.King

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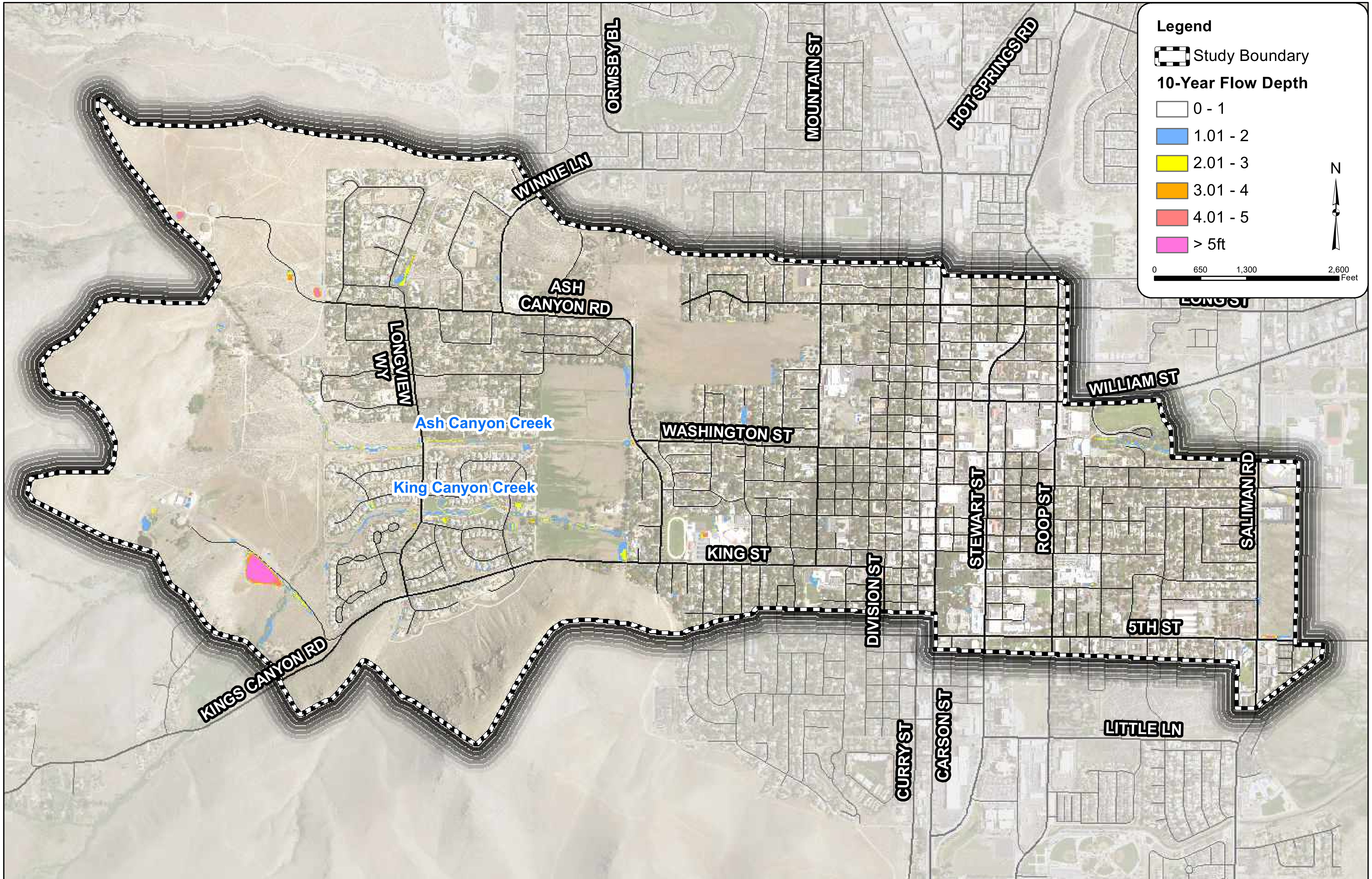
West Carson ADP
Proposed Offline Detention Basin Cross Sections

PROJECT NO.
291417000

DRAWING NAME
West Carson Basin

2 OF 2



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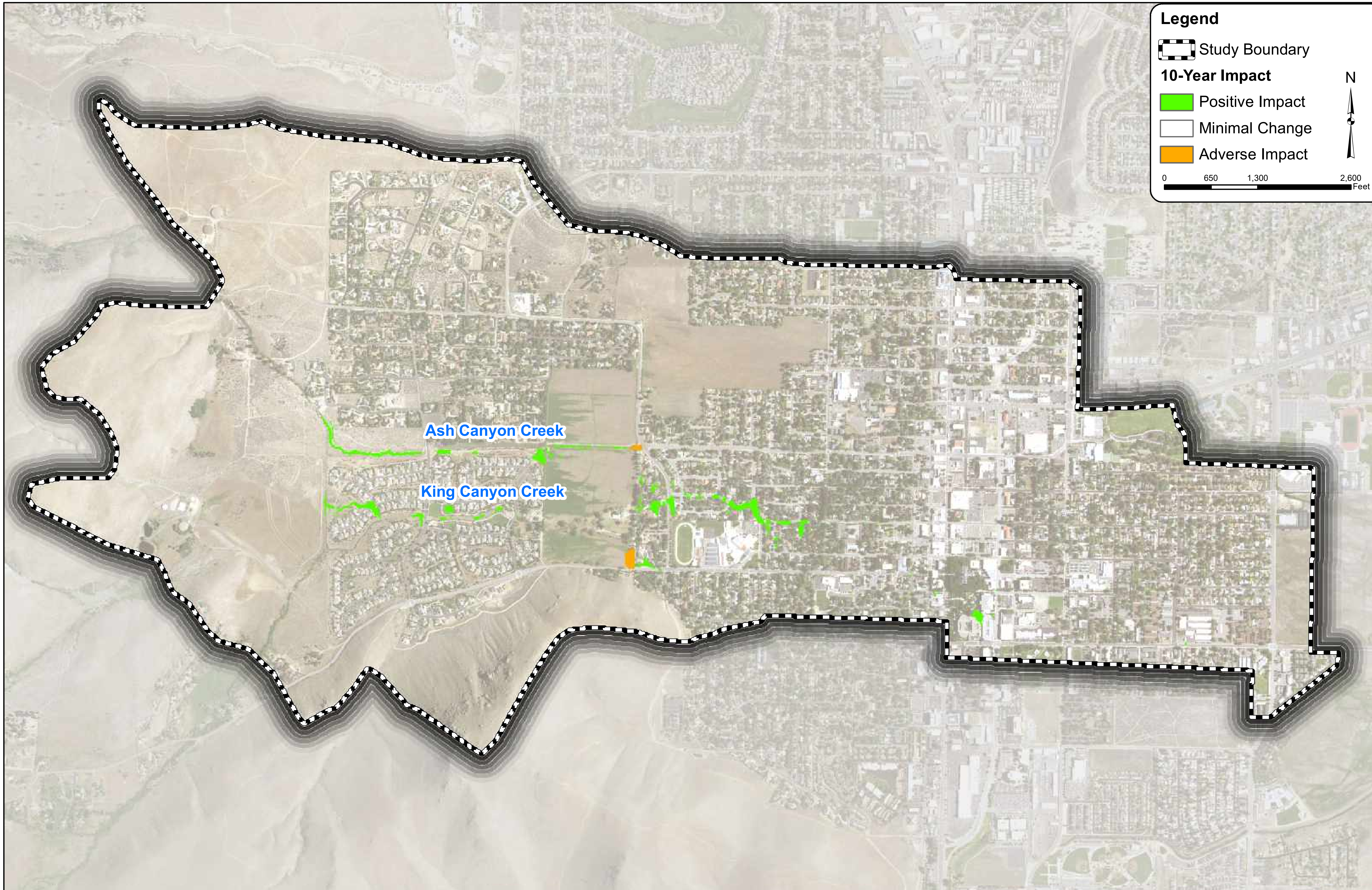
West Carson City ADP
Proposed 10-Year Flow Depths

PROJECT NO. 291417000

DRAWING NAME PROP. 10-YR FLOW DEPTHS

Figure 40



West Carson City ADP
Ash & Kings Canyon Basins
Proposed Conditions 10-Year Impact Map

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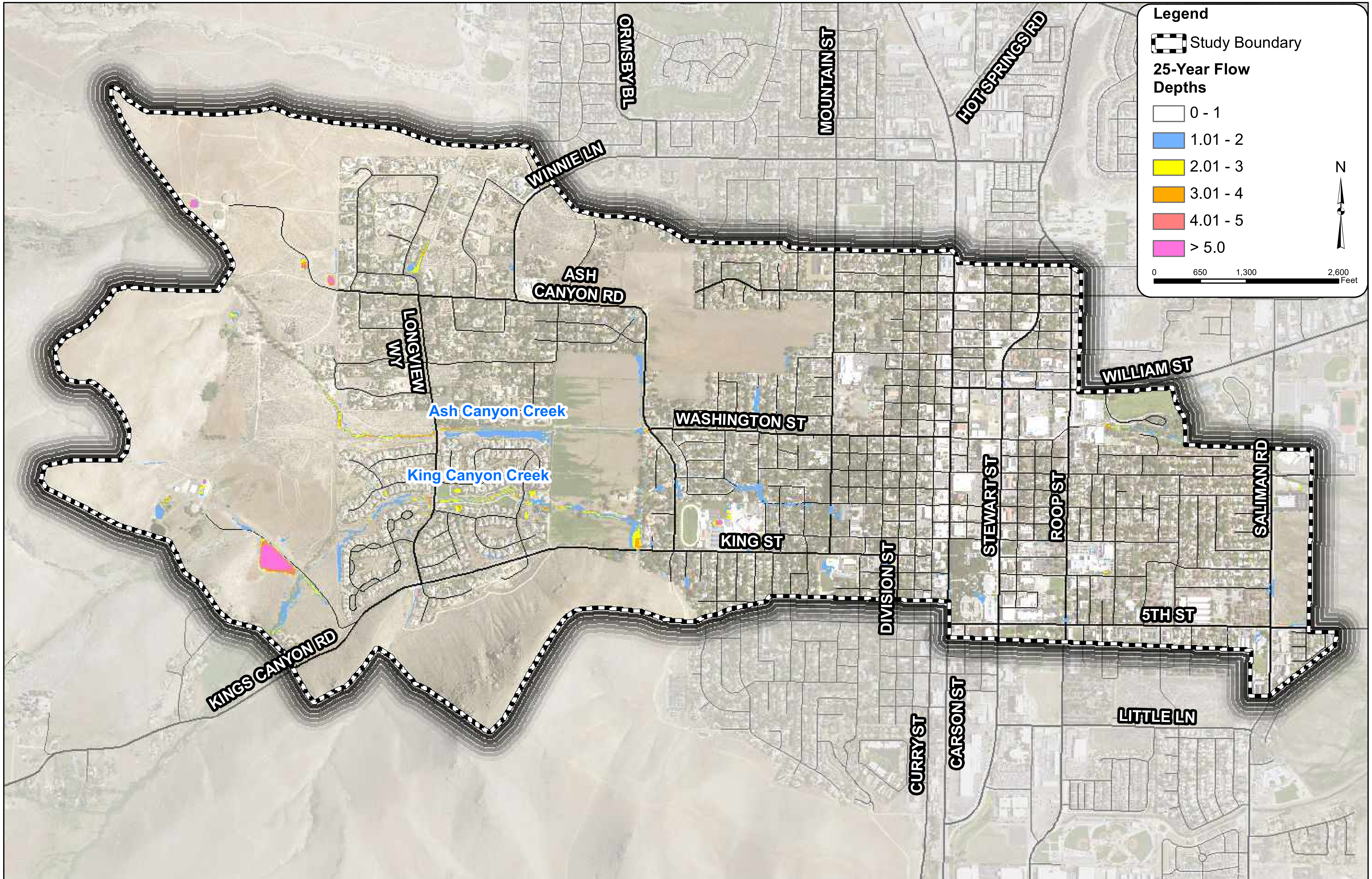
PROJECT NO. 291417000
DRAWING NAME ASH & KINGS 10-YR IMPACTS

Figure 41



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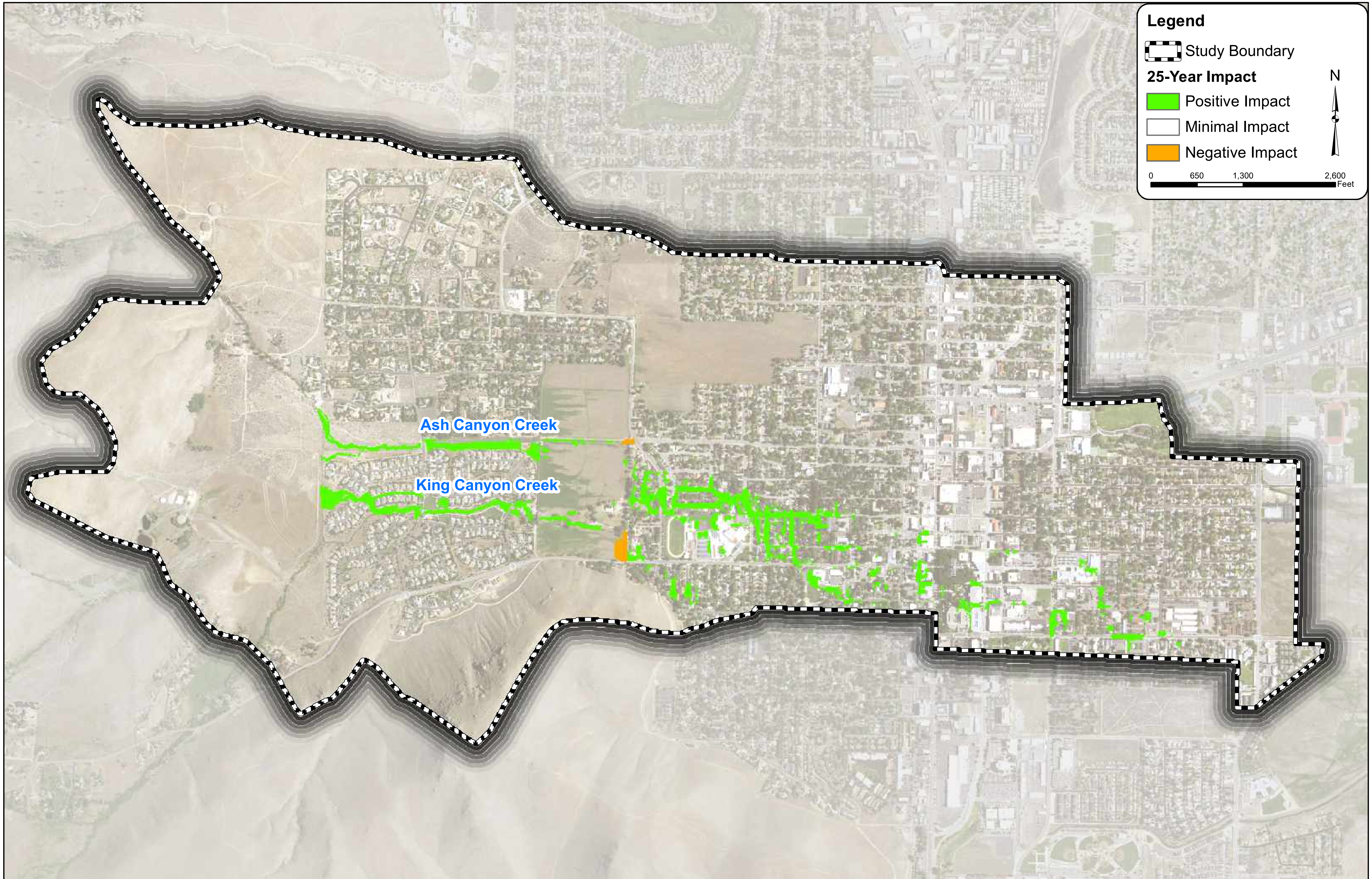
West Carson City ADP
Proposed 25-Year Flow Depths

PROJECT NO.
291417000

DRAWING NAME
PROP. 25-YR FLOW DEPTHS

Figure 42



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Ash & Kings Canyon Basins
Proposed Conditions 25-Year Impact Map

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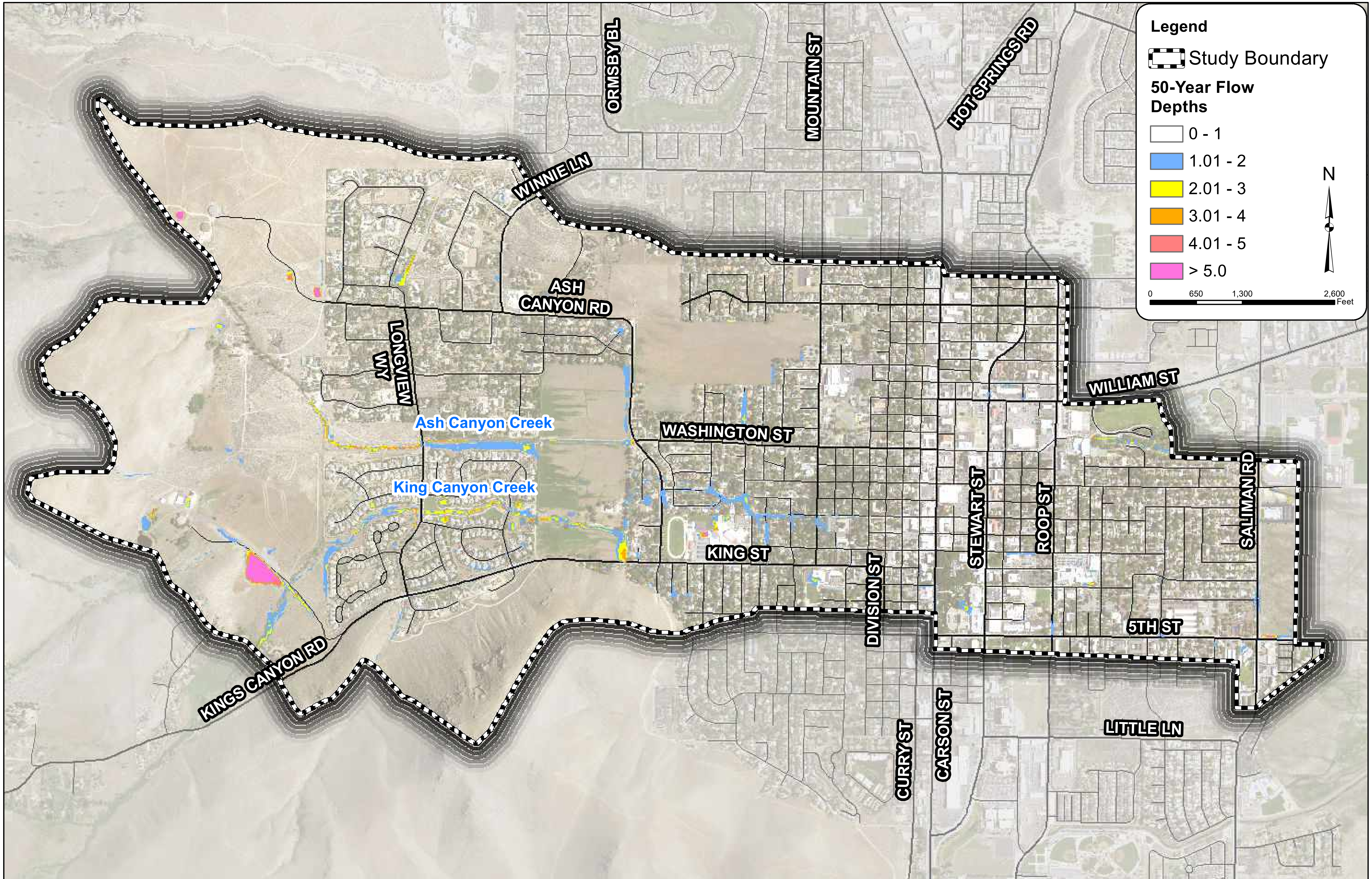
PROJECT NO.
291417000

DRAWING NAME
ASH & KINGS
25-YR IMPACTS

Figure 43



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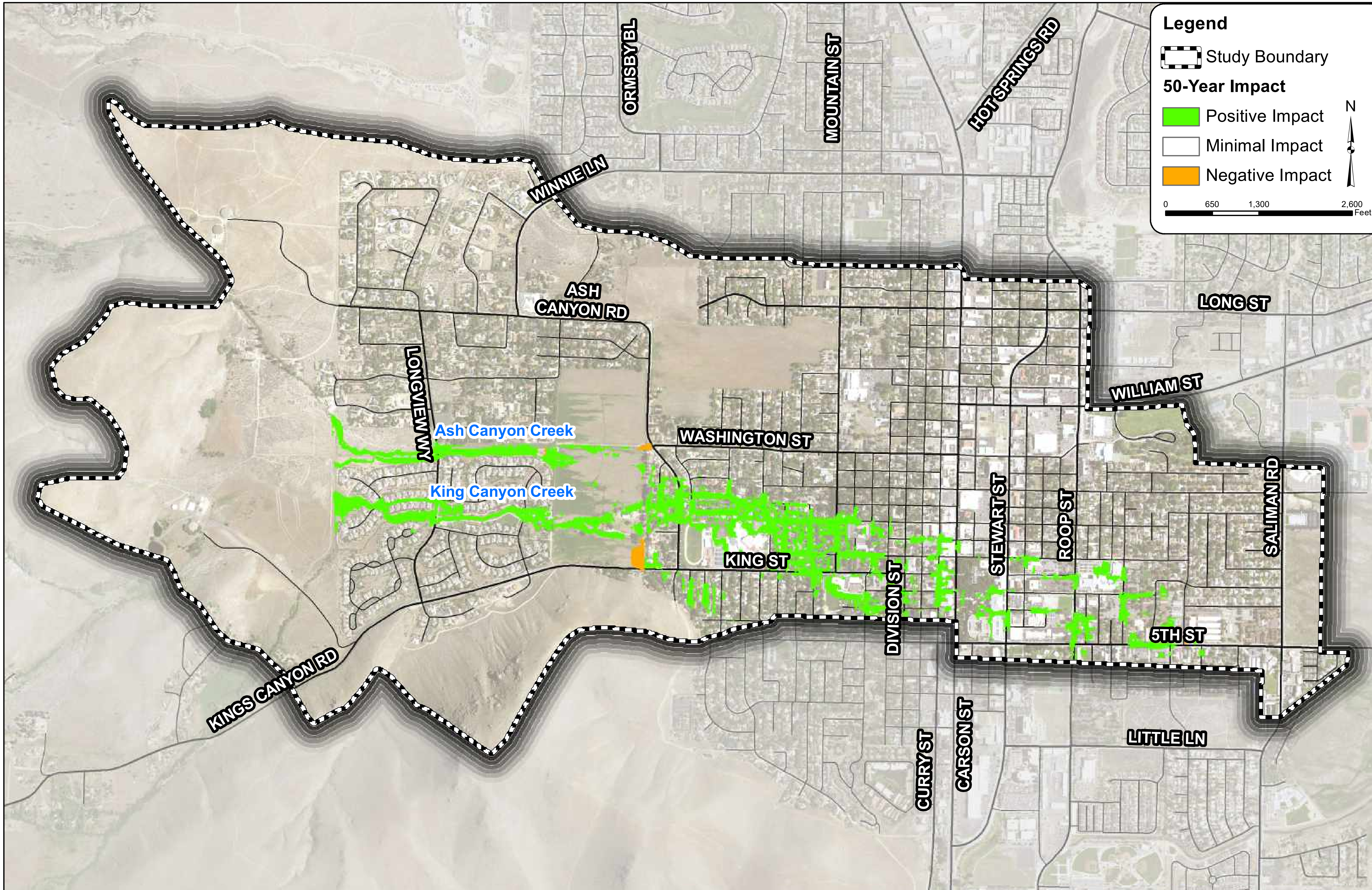
Proposed 50-Year Flow Depths

PROJECT NO.
291417000

DRAWING NAME
PROP. 50-YR
FLOW DEPTHS

Figure 44



West Carson City ADP
Ash & Kings Canyon Basins
Proposed Conditions 50-Year Impact Map

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SCALE(V):NONE
DESIGNED BY: ATC
DRAWN BY: RDK
CHECKED BY: ATC
DATE: 06/2021

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Engineering, Planning and Environmental Consultants
7740 North 16th Street, Suite 300
Phoenix, Arizona 85020 (602) 944-5500

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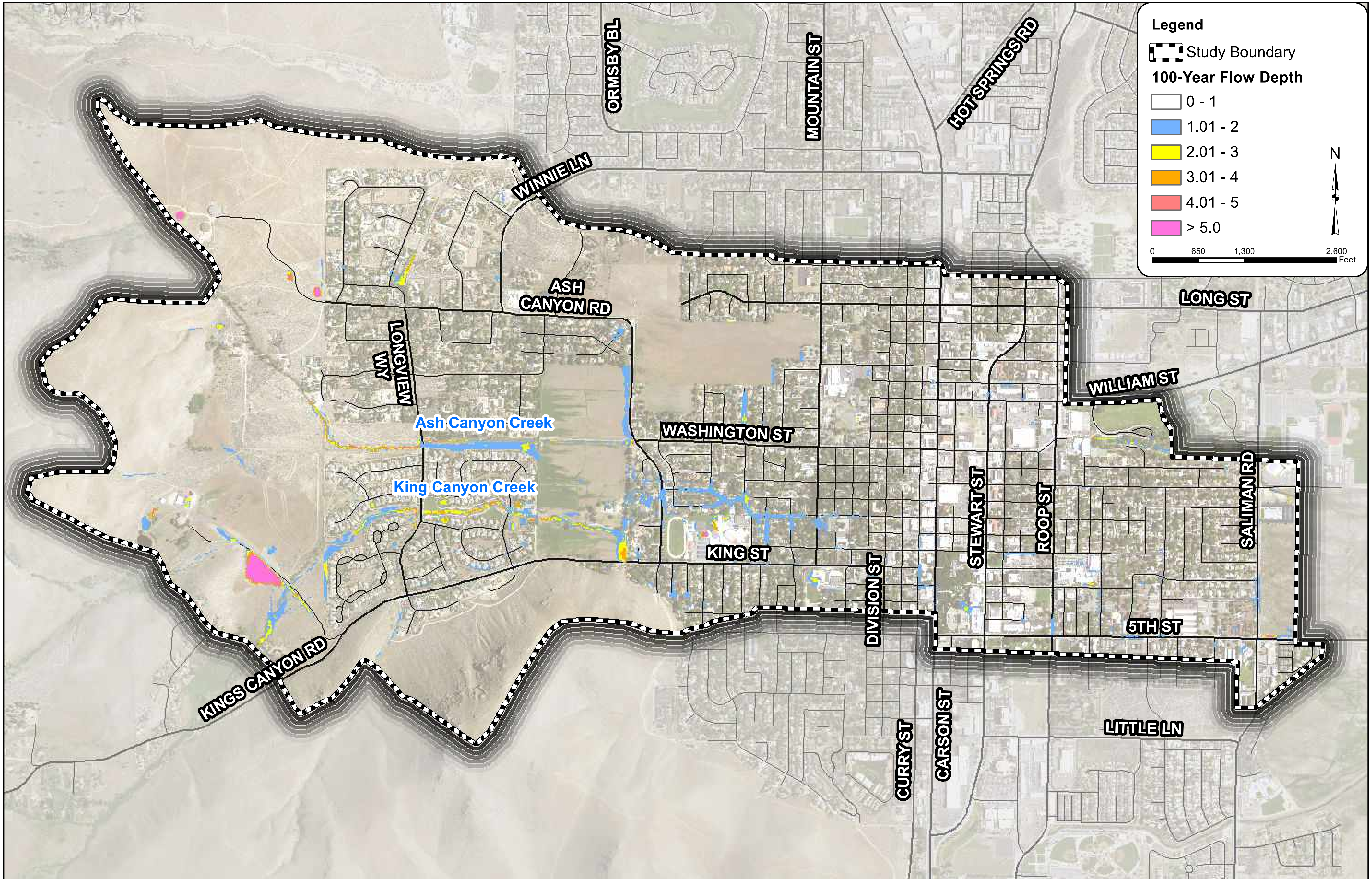
PROJECT NO. 291417000
DRAWING NAME ASH & KINGS 50-YR IMPACTS
Figure 45



West Carson City ADP
Proposed 100-Year Flow Depths

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Phoenix, Arizona 85020 (602) 944-5500

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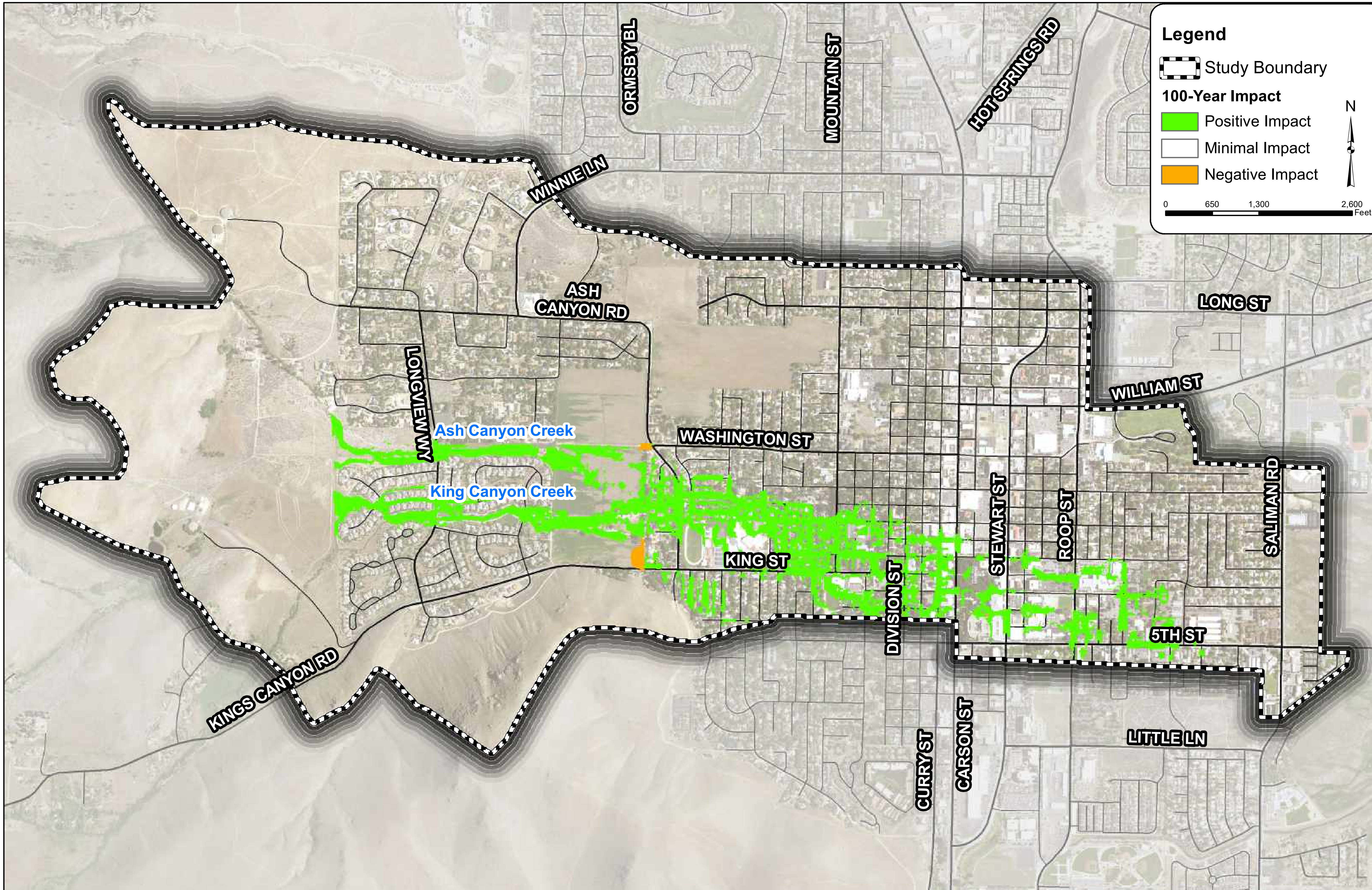
DESIGNED BY: ATC
DRAWN BY: ER
CHECKED BY: GSB
DATE: 05/2021

PROJECT NO. 291417000
DRAWING NAME PROP. 100-YR FLOW DEPTHS
Figure 46



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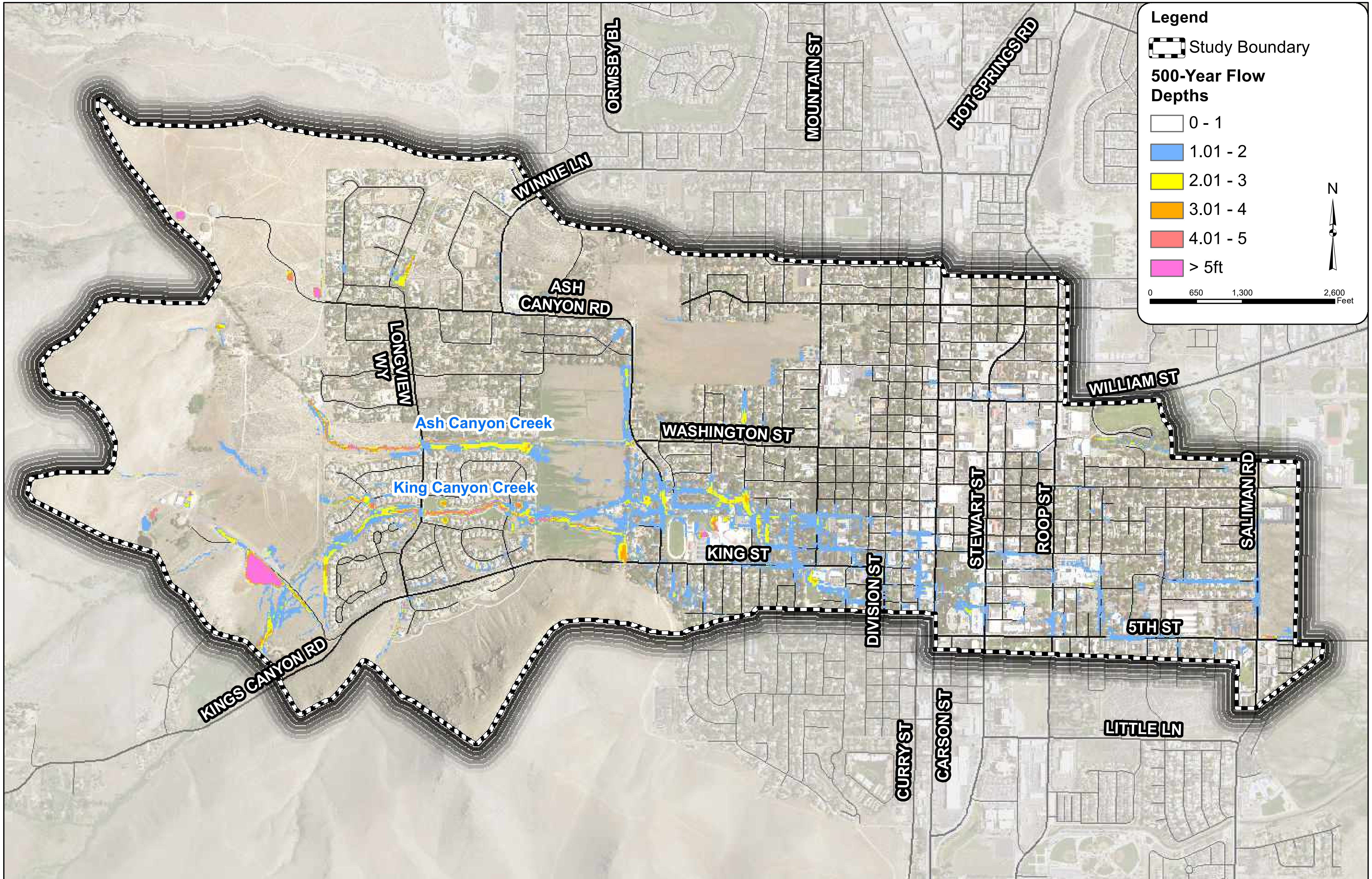
SCALE(H):1"=1300'
SCALE(V):NONE
DESIGNED BY: ATC
DRAWN BY: RDK
CHECKED BY: ATC
DATE: 06/2021

West Carson City ADP
Ash & Kings Canyon Basins
Proposed Conditions 100-Year Impact Map

PROJECT NO.
291417000

DRAWING NAME
ASH & KINGS
100-YR IMPACTS

Figure 47



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Phoenix, Arizona 85020 (602) 944-5500

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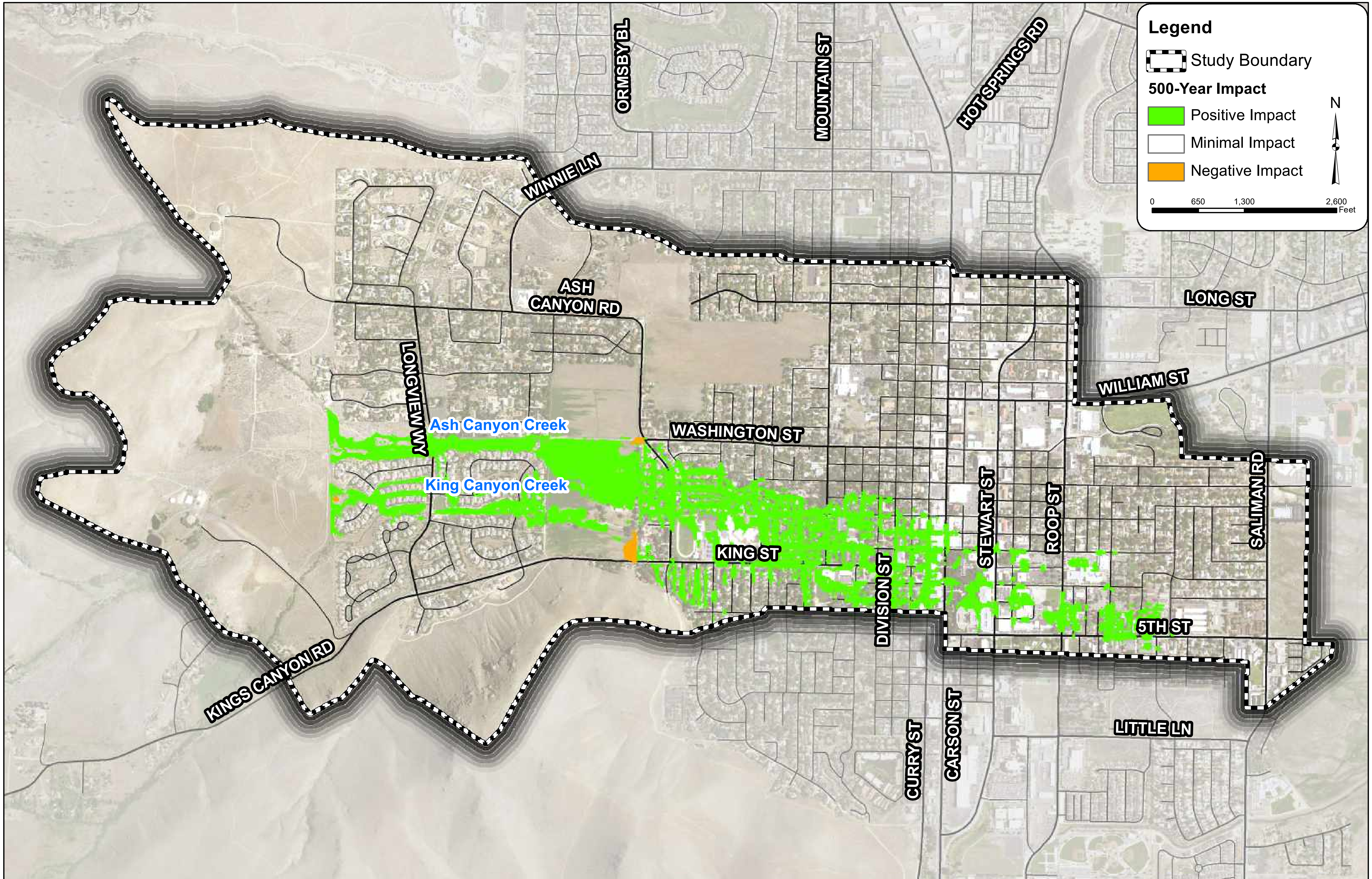
SCALE(V):NONE
DESIGNED BY: ATC
DRAWN BY: RDK
CHECKED BY: ATC
DATE: 06/2021

West Carson City ADP
Proposed 500-Year Flow Depths

PROJECT NO.
291417000

DRAWING NAME
PROP. 500-YR
FLOW DEPTHS

Figure 48



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Phoenix, Arizona 85020 (602) 944-5500

SCALE(H):1"=1300'
SCALE(V):NONE
DESIGNED BY: ATC
DRAWN BY: RDK
CHECKED BY: ATC
DATE: 06/2021

West Carson City ADP
Ash & Kings Canyon Basins
Proposed Conditions 500-Year Impact Map

PROJECT NO.
291417000

DRAWING NAME
ASH & KINGS
500-YR IMPACTS

Figure 49

7 Conclusion

The WCCADP developed detailed two-dimensional FLO-2D/SWMM models that used HEC-1 inputs, recent LiDAR terrain, and current hydrologic and hydraulic methodologies to define existing flood hazard conditions for the 10-, 25-, 50-, 100-, and 500-year storm events. Existing condition results were presented to residents in the study area for validation. Residents were also queried for any additional anecdotal flood data. Results from these analyses and public input were used to define flood prone areas.

Because of physical constraints in the study area, it was determined that upstream storage was the only viable mitigation alternative for this portion of Carson City. Initially, a 100-year design solution was targeted. The 100-year design solution required approximately 740 ac-ft of storage. Potentially available open space and topographic constraints made this volume of storage unfeasible such that smaller storm event mitigation was also evaluated. A 10-year basin configuration was formulated that stores the smaller more frequent events, but that also substantially reduces flood flows for larger events. Conceptual plans and cost were developed for this configuration.

The next step in advancing a flood mitigation project would be to further the design and analyses of the basin configuration either through a design concept report or a FEMA scoping project via a BRIC grant. This process would refine the hydrologic and hydraulic analyses, conduct required environmental evaluations, and advance the plans and cost closer to construction document level. A scope refinement process would also establish a benefit cost ratio to evaluate the fiscal benefits of the project.

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Appendices

Appendix A: Hydrologic Analyses for Carson City Restudy Flood Insurance Study Carson City, Nevada Excerpts

TASK ORDER 36

HYDROLOGIC ANALYSES FOR CARSON CITY RESTUDY

FLOOD INSURANCE STUDY

CARSON CITY, NEVADA

Prepared for:

Federal Emergency Management Agency- Region IX

1111 Broadway, Suite 1200

Oakland, CA 94607

Prepared by:

HDR, Inc.

2365 Iron Point Road, Suite 300

Folsom, CA 95630

June 2010

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Appendix

1.0 Introduction

1.1 Background and Purpose

The Federal Emergency Management Agency (FEMA) contracted with HDR Engineering Inc. (HDR) to conduct a restudy for portions of Kings Canyon Creek, Kings Split, Ash Canyon Creek, Vicee Canyon Creek, and Combs Canyon Creek (herein referred to the Carson City Restudy). The study stream reaches are delineated on **Figure 1**. The study stream reach names and corresponding lengths are listed in **Table 1**.

Table 1 - Carson City Restudy Stream Reach Lengths

Stream Name	Proposed Study Length of Stream (mi)
Ash Canyon Creek	3.4
Kings Canyon Creek	3.9
Kings Split[1]	0.2
Vicee Canyon Creek	4
Combs Canyon Creek[2]	0.5
Total Stream Length	**12.0 miles**

1 - Kings Split is a tributary to Kings Canyon Creek

2 - Combs Canyon Creek drainage has been diverted and no longer affects the study area.

As part of the Carson City Restudy, HDR was tasked with conducting a review of hydrologic data provided by Carson City which included various past hydrologic study reports and hydrologic models. HDR was to review the data, make adjustments as necessary, and select peak discharges for the 10-, 50-, 100-, and 500-year storm events (10-, 2-, 1-, and 0.2-percent annual chance flood events) to be used in the hydraulic analysis of the study reaches. This Technical Memorandum (TM) describes the methodology and results of the hydrologic analysis conducted by HDR, a brief summary of previous hydrologic studies, and the peak discharges recommended for the hydraulic analysis of the study reaches.

1.2 Study Area Description

The following study area description was taken from the effective FEMA Flood Insurance Study Report published in January 16, 2009 for Carson City, Nevada, Independent City (herein referred to as the 2009 FIS):

Carson City, the State capital, lies at the west-centra1 edge of Nevada. It is bordered by Washoe and Lyon Counties to the north, Lyon County to the east, Douglas County to the south, and Placer County, California, to the west.

The city population center is located 30 miles south of Reno and 14 miles east of Lake Tahoe. U.S. Highways 50 and 395 intersect in the central business district, providing all-weather access to other points in Nevada and California.

The developed area of Carson City is located in Eagle Valley, an alluvial valley formed by streams draining the Carson and Virginia Ranges. These Carson River tributaries have caused flood damage since the time of the first settlement in the l850s. Carson City began its growth as a major commercial and transportation center in 1859 with the discovery of the Comstock Lode. Timber from adjacent mountain slopes was logged for use in the mines and new towns that were springing up throughout the area. Denuded watersheds resulted, causing increased flood severity and damage from sediment and debris in Carson City and adjacent areas (Nevada Department of Conservation and Natural Resources and U.S. Department of Agriculture, November 1973).

The corporate limits of Carson City encompass what was once Ormsby County. A single city-county organization now governs the approximately 147-square-mile area. The climate within the extensive corporate limits ranges from humid alpine conditions in the Sierra Nevada to semiarid steppe in the valleys to the east. Precipitation in the urban district averages 11.83 inches a year, 75 percent of which falls between October and March. Winter precipitation results from westerly cyclonic storms and can be in the form of rain or snow. Winter temperatures are cool, averaging 35.2°F. However, average daily temperature extremes during the winter vary from a high of 52°F to a low of 23°F. Summers are warm, averaging 66.7°F. Recorded annual temperature extremes range from -18°F to 103°F (U.S. Department of Agriculture, Nevada, Undated).

The watersheds that encompass the Carson City Restudy streams are approximately 18-mi^2 in combined drainage area.

1.3 Project Approach and Scope of Work

The approach and work tasks in the hydrologic evaluation presented in this TM include:

1. Research, collect, and review existing studies performed on Kings Canyon Creek, Kings Split, Ash Canyon Creek, and Vicee Canyon Creek within the study stream watersheds.
2. Evaluate the methodologies, parameters, and findings from previous and current hydrologic studies to develop peak flows for the points of interest in the Carson City Restudy.
3. Review and modify, the hydrologic data presented in previous studies as needed to reflect updated watershed conditions.
4. Compare and assess the reasonableness of the selected peak.
5. Recommend peak flows to be used in subsequent hydrologic analysis of the study stream reaches.

2.0 Previous Studies

Three sources of pertinent information are summarized below. These include:

1. The Hydrologic Analysis US 395 Bypass Freeway Carson City, Nevada Report (April 28, 1997)
2. The effective FEMA Flood Insurance Study Report (January 16, 2009)
3. The SW Carson City Regional Hydrologic Analysis Final Report (March 2010)

2.1 Hydrologic Analysis US 395 Bypass Freeway Carson City, Nevada

The April 1997 report entitled "*Hydrologic Analysis US 395 Bypass Freeway Carson City, Nevada*", by WRC Nevada Inc (WRC) documents the detailed hydrologic analysis executed for the purpose of determining design peak flows in and around Carson City. The analysis completed by. WRC was conducted for the Nevada Department of Transportation as part of an assessment for the future construction of the US 395 Freeway Bypass (herein referred to as the WRC 1997 Hydrologic Analysis). A brief summary of the methodology employed in the WRC 1997 Hydrologic Analysis is presented below. For a detailed description of analysis refer to the WRC 1997 Hydrologic Analysis complete report.

2.1.1 Methodology

This section focuses on the methodology presented in the WRC 1997 Hydrologic Analysis for determining the subsequent flows of a 1-percent annual chance flood events. The text below is composed of excerpts from various sections in the 1997 Hydrologic Analysis report describing the methodology used for calculating off-site flows:

> *The computer program, HEC-1, developed by the United States Army Corps of Engineers* (USACE) *was used to determine the amount of rainfall runoff. Within HEC-1, the Soil Conservation Service (SCS) Curve Number Method was used to compute rainfall excess and loss and the SCS Unit Hydrograph Method was utilized to generate runoff hydrographs for each sub-basin under consideration. Routing of runoff from the sub-basins was accomplished using the Muskingum-Cunge Method of hydrograph routing.*
>
> *The 100-year, 24-hour rainfall distribution was used for the hydrologic analysis and is based on the Draft Semiarid Precipitation Frequency Study* (SPFS) *by the National Weather Service dated Nov. 1995 and on the National Oceanic and Atmospheric Administration Atlas 2* (NOAA Atlas 2) *published by the National Weather Service in 1973.*

2.1.2 Results

In the WRC 1997 Hydrologic Analysis peak flows were developed for the 1-Percent Annual Chance Flood using both the SPFS and NOAA Atlas 2 precipitation data. No peak flows were calculated for other flood events for locations of relevance to the Carson Restudy. The results that are of interest to the Carson Restudy are presented in **Table 2**.

Table 2 - WRC 1997 Hydrologic Analysis 1-Percent Annual Chance Flood Peak Flows

Location	Precipitation Source	Drainage Area (mi^2)	Peak Flows (cfs)
Vicee Canyon (Node: DA 13) 6,400 ft upstream of Winnie Ln	WRC - SPFS	1.57	480
	WRC – NOAA Atlas 2		375
Ash Canyon (Node: DP 10) 1,200 ft downstream of Long View Way	WRC - SPFS	5.48	929
	WRC – NOAA Atlas 2		691
Kings Canyon (Node: DP 13) Near Canyon Drive	WRC - SPFS	4.99	1,166
	WRC – NOAA Atlas 2		939

Source: "*Hydrologic Analysis US 395 Bypass Freeway Carson City, Nevada*" by WRC Nevada Inc., Dated 1997

2.2 Effective FEMA FIS Report

The Effective FEMA Flood Insurance Study (FIS) Report was revised in January 2009. The revisions were completed in accordance with FEMA's Map Modernization Program under FEMA Region IX. The section below summarizes the hydrologic information presented in the 2009 FIS that were pertinent to the Carson Restudy. Additional information regarding the hydrologic evaluation is presented in the 2009 FIS report.

2.2.1 Methodology

The hydrologic analysis performed in the Carson Restudy area that was presented in the 2009 FIS was completed by Boyle Engineering Corporation (Boyle) in 1982. The following text is an excerpt from the 2009 FIS report describing the methodology used:

> *The NRCS publication, Computer Program for Project Formulation- Hydrology (U.S. Department of Agriculture, National Resources Conservation Service, Technical Release 20, 1965), was used in the hydrologic analysis of the Carson City watershed. The model was necessary because long-term streamflow records are lacking in the watershed. This rainfall-runoff model considers factors such as precipitation-duration-frequency data, hydrologic soil groups and land use, time of concentration, and storm type. The precipitation data were taken from National Oceanic Atmospheric Administration Atlas (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1973). Precipitation duration and distribution used in the model were those recommended by the NRCS.*

2.2.2 Results

The 2009 FIS presents peak flows for the 10-, 2-, 1-, and 0.2-percent annual chance floods events. **Table 3** summarizes the 2009 FIS peak flow locations of interest to the Carson Restudy.

Table 3 - Effective FEMA Peak Discharge Flows

Watershed	Location	Drainage Area, sq. mi	Peak Flows (cfs)			
			10 % Annual Chance	2 % Annual Chance	1 % Annual Chance	0.2 % Annual Chance
Vicee Canyon Creek	At Confluence with Ash Canyon Creek	2	45	250	475	1,950
Ash Canyon Creek	Near Longview Way	6	220	950	1,660	5,550
Kings Canyon Creek	Near Canyon Drive	5	160	765	1,390	5,065

Source: "*Effective Flood Insurance Study, Carson City, Nevada, Independent City*" by FEMA, Dated Jan. 2009

2.3 SW Carson City Regional Hydrologic Analysis

Manhard Consulting Ltd. (Manhard) completed a comprehensive regional hydrologic analysis of the South West Carson Watersheds in March 2010 presented in the report titled "*SW Carson City Regional Hydrologic Analysis, Final Report*" (herein referred to as the Manhard 2010 Hydrologic Analysis). HDR initially reviewed the Manhard 2010 Hydrologic Analysis as a draft report dated July 2009 (herein referred to the Manhard Draft 2010 Hydrologic Analysis) and later reviewed the Final report dated March 2010. A brief summary of the methodology employed in the Manhard 2010 Hydrologic Analysis is presented below, for a detailed description please refer to the Manhard 2010 Hydrologic Analysis report.

2.3.1 Methodology

The following text is an excerpt from the Manhard 2010 Hydrologic Analysis final report describing the methodology used in the hydrologic analysis:

The SW Carson Model is an EPA SWMM5 rainfall-runoff model developed using state-of the-science Geographic Information System (GIS) *applications and the PCSWMM.NET program. The model utilizes the Green & Ampt watershed abstraction method and the non-linear reservoir rainfall transformation method inherent in SWMM5. Regionally calibrated parameters determined by Manhard from analyses of similar watersheds in northern Nevada were used in the Green & Ampt Method. All other required modeling parameters were derived from data provided by the Maricopa County Drainage Design Manual and/or measured from and adjusted for the study area. Peak flow rates for several locations within the study area were determined for the 10, 50, 100, and 500-year, 24-hour storm events using the SW Carson Model.*

Because the Green & Ampt Method parameters used in the SW Carson Model were derived not within this study area, but from model calibration efforts on similar watersheds in northern Nevada, sensitivity tests were performed on the two most subjective parameters. A sensitivity test was performed on the Green & Ampt KSAT and DSTORE parameters by incrementally adjusting the originally assigned values and recording changes in the peak flow rate and total runoff volume modeling results. The KSAT *parameter test demonstrated there is a 2:1 relationship between KSAT value reductions and peak flow rate increases in the SW Carson Model (i.e., a 10% KSAT reduction produced a 5% flow rate increase). However, since the originally assigned KSAT values based on regional calibration efforts were already at the lower bounds of acceptable ranges, no downward adjustments were made to the originally assigned parameter values in the model. Values of the pervious DSTORE parameters (quasi Green & Ampt Method variables) were tested in a similar manner and found to be quite insensitive to adjustments in the SW Carson Model. Since the pervious DSTORE parameter values originally assigned in the SW Carson Model were derived from averages of published values, no adjustments were made.*

Regional regression equations were also used to estimate 100-year peak flow rates at seven key locations (key locations for the Manhard study area) for comparison. Unfortunately, regression equation input data for five of the seven locations, in one form or another, were beyond the applicable ranges for use in the equations. This rendered the regression equation results from these five locations invalid and undeserving of a detailed comparison with models flows. This reduced the usefulness of the regression equation results at two locations (Ash canyon and Kings Canyon Creek), *where comparisons to the SW Carson Model results are meaningful.* Locations applicable to HDR hydrologic analysis are Ash Canyon, Kings Canyon Creek watersheds, and Vicee Canyon Creek which were also evaluated but the location of interest was outside the applicable range for the Regional Regression Equation.

2.3.2 Results

In the Manhard 2010 Hydrologic Analysis, regional regression equations were used to estimate the 1-Percent Annual Chance Flood peak discharge for points of interest. Both the equations from the TM prepared for FEMA by Karl Mohr (FEMA, April 03, 1997) and the USGS regression equations for the Eastern Sierras (Thomas and others, 1994) were used to estimate peak discharges. The results reported in Manhard 2010 Hydrologic Analysis at points that are of interest for the Carson City Restudy are presented in **Table 4** -.

Table 4 - Manhard 2010 Hydrologic Analysis - Regional Regression 1-Percent Annual Chance Flood Peak Discharge Flows

Watershed	Location	Mohr Flows (cfs)	Thomas and others Flows (cfs)
Vicee Canyon Creek	At Detention Basin	392[1]	339[1]
Ash Canyon Creek	Near Longview Way	551	577
Kings Canyon Creek	Near Canyon Drive	696	656

Source: "*The SW Carson City Regional Hydrologic Analysis Final Report*" by Manhard, Dated March. 2010

1- Outside of range of explanatory variables for which Regression Equations are applicable (drainage area is outside of range set for equations).

The Manhard 2010 Hydrologic Analysis produced rainfall runoff hydrographs and corresponding peak discharge flow rates for the 10-, 2-, 1-, and 0.2-percent annual chance floods events. **Table 5** summarizes the peak discharge flows reported in Manhard 2010 Hydrologic Analysis at locations that are of interest for the Carson City Restudy.

Table 5 - Manhard 2010 Hydrologic Analysis - SWMM5 Peak Discharge Flows

Watershed	Location	Drainage Area, sq. mi	Peak Flows (cfs)			
			10 % Annual Chance	2 % Annual Chance	1 % Annual Chance	0.2 % Annual Chance
Vicee Canyon Creek	Inflow into Retention Basin	1.83	32	211	370	1,010
Vicee Canyon Creek	Outflow from Retention Basin	1.83	0	0	0	0
Ash Canyon Creek	Near Longview Way	5.28	145	619	1,006	2,533
Kings Canyon Creek	Near Canyon Drive	4.91	132	589	922	2,307

Source: "*The SW Carson City Regional Hydrologic Analysis Final Report*" by Manhard, Dated March. 2010

It should be noted that the Manhard 2010 Hydrologic Analysis reported that Vicee Canyon Retention Basin is able to collect and retain the total runoff from the upstream drainage area for a 0.2-percent annual chance flood event with more than 9 feet of freeboard.

3.0 HDR Hydrologic Analysis

3.1 INTRODUCTION

The primary objective in the hydrologic review and consequent hydrologic analysis that HDR conducted for the Carson City Restudy was to recommend peak flows that would be use in subsequent hydraulic analysis of the study area. As mentioned in Section 2, three primary studies were evaluated for reference material and as sources of data for the hydrologic analysis presented in this section. The Effective FEMA 2009 FIS for Carson City, the Manhard 2010 Hydrologic Analysis, and WRC 1997 Hydrologic Analysis were all reviewed and considered in the hydrologic evaluation conducted by HDR. Also, the Manhard 2010 Hydrologic Analysis, and WRC 1997 Hydrologic Analysis were utilized as the primary sources of data used to develop a rainfall-runoff model using HEC-1, which was used to conduct the hydrologic analysis comparison presented in this TM.

3.2 METHODOLOGY

The hydrologic analysis that was developed by HDR was based on the following applications and methodologies. The computer program, HEC-1, developed by the USACE was the primary application used for the Carson City Restudy hydrologic model. The SCS Curve Number Method was used to compute rainfall excess and losses. The SCS Unit Hydrograph Method was utilized as the rainfall runoff transformation within each sub-basin. Routing of runoff from the sub-basins was accomplished using the Muskingum-Cunge Method of hydrograph routing. The 100-year, 24-hour rainfall distribution was used for the hydrologic analysis and is based on the National Oceanic and Atmospheric Administration Atlas 14 (NOAA Atlas 14) published by the National Weather Service in 2004 and revised in 2006.

3.3 HEC-1 INPUT DATA AND PARAMETERS

3.3.1 Sub-Basins and Watersheds

HDR utilized the sub-basin delineations provided in the Manhard Draft dated 2010 Hydrologic Analysis and were used to update the sub-basins used in the WRC 1997 Hydrologic Analysis. New sub-basin delineations were utilized to incorporate new topographic data that was available; the topographic data is corresponding to the 2005 watershed conditions (topographic data developed by MapCon Mapping Inc.). HDR reviewed and made minor modifications to the delineation of a few sub-basins and provided comments to Manhard.

As the hydrologic and hydraulic analyses for the Carson City Restudy progressed, it became evident that modifications to the hydrology, including additional modifications to the sub-basin delineations, would be valid for comparison of the two methods. The sub-basin delineations were further modified to make the hydrology compatible with the hydraulic model in the complex urbanized area of the city. A series of iterations, involving the review of the hydraulic model results and making modifications to the hydrology were necessary and were conducted by HDR to ensure reliable information was being generated by the hydraulic model. The study area and final sub-basin delineation used by HDR for the Rainfall-Runoff HEC-1 and USACE Hydrologic Engineering Centers River Analysis System (HEC-RAS) models are shown in **Figure 2**.

It should be noted that the Combs Canyon sub-basin has been diverted and no longer drains into the study area analyzed in this TM. For more information on the diverted flow please refer to FEMA's Letter of Map Change (LOMC) Case Number 08-09-1740P. This LOMC is currently in the 90-day appeal/protest period, which began on or about May 19, 2010.

3.3.2 Soils Data, Land Use, and Curve Numbers

Soils data and parameters were adopted from the WRC 1997 Hydrologic Analysis, an evaluation of new soils maps from the NRCS were compared to the soils data that was utilized in the WRC 1997 Hydrologic Analysis and it was determined that the soils data used in the WRC 1997 Hydrologic Analysis are appropriate for this analysis. As presented in the WRC 1997 Hydrologic Analysis, the SCS Curve Number Method was used to compute rainfall excess and losses. **Table 6** provides a list of SCS Curve Numbers based on land use and soil types. Soil type map and land use maps provided in the WRC 1997 Hydrologic Analysis report can be seen in **Figure 3 - and Figure 4** respectively. The Curve Numbers for each sub-basin were estimated using the land use mps, soil map, areal photography, an average antecedent moisture condition II. **Table 11** (presented at the end of section **3.3.7**) shows the summary of all sub-basin HEC-1 parameters including the CN's that were calculated for each sub-basin.

Table 6 - Curve Numbers for various Land Uses and Soil Groups

Land Use	Curve Number			
	Soil Group A	Soil Group B	Soil Group C	Soil Group D
Developed Areas				
Commercial/Industrial/Office/Business	89	92	94	95
High Density Residential	81	88	91	93
Medium Density Residential	77	85	90	92
Low Density Residential	61	75	83	87
Rural/Suburban Residential	54	70	80	85
Open Space Golf Course/Parks/Cemeteries	41	62	75	81
Undeveloped Areas				
Barren Ground/Rock Quarry	77	86	91	94
Irrigated Agriculture	39	61	74	80
Rangelands				
Herbaceous (grasses)	40	62	74	85
Mixed Grass and Shrub	39	61	73	82
Heavy Shrub/Brush	35	56	70	77
Forest (Evergreen)	30	54	66	75

Source: "*Hydrologic Analysis US 395 Bypass Freeway Carson City, Nevada*" by WRC Nevada Inc., Dated 1997

3.3.3 Precipitation Data

Precipitation data for the HEC-1 model developed by HDR was obtained with the use of National Oceanic and Atmospheric Administration Atlas 14 (NOAA Atlas 14). Using GIS, centroid locations were calculated for each sub-basin and using NOAA Atlas 14, precipitation data was generated for the 10-, 2-, 1-, and 0.2-Percent Annual Chance Event at each centroids location. The precipitation frequency estimates were based on a partial duration series. The generated precipitation data was then applied to each corresponding sub-basin. The rainfall data can be obtained in the Technical Support Data Notebook (TSDN) of this FIS Restudy.

3.3.4 Time of Concentration and Lag Time

The Time of Concentration (T_c) and Lag Time were developed based on the SCS definition (Chow/Maidment/Mays, Applied Hydrology, 1988). Lag Time defined as the time from the center of mass of rainfall excess to the peak discharge and is used in determining the shape of the runoff hydrograph (McCuen, Hydrologic Analysis and Design, 2005). The Time of Concentration is the time it takes a particle of water to flow hydraulically from the most hydrologic distant point in the watershed to the outlet of the watershed or sub-basin. In this analysis all of the sub-basins were classified into two distinct types of sub-basins. The classifications consisted of evaluation of the drainage area and the slopes of the average sub-basin.

For drainage areas less than 1-mi^2 and with average slopes less than 10 percent, the Lag Times were calculated using the lag equation developed by the SCS.

Equation 1:

$$Lag = 0.6 \times T_c$$

Lag = Lag time, minutes

T_C = *Time of Concentration, minutes*

Typically the time of concentration is divided into two separate components: initial overland travel time (T_i) and channel travel time (T_t). Once the time for each component is determined, both time intervals are summed to develop the T_c.

Channel travel time (Tt) is calculated using **Equation 2:**

Equation 2*:*

$$T_t = L/(V \times 60)$$

T_t = *Channel travel time, minutes*

V = Average velocity of water in channel, feet/second

L = Length of channel, feet

An iterative process was used to estimate the channel velocity using preliminary hydrologic and hydraulic models developed for the Carson City Restudy. Values were assumed for initial HEC-1 runs and were verified or modified as the HEC-RAS model was refined. It was assumed that water flowing down these rough channels could not obtain supercritical flow.

Overland flow travel time (T_i) is calculated using **Equation 3:**

Equation 3:

$$T_i = \frac{1.8 \times (1.1 - K) L_o^{\frac{1}{2}}}{S^{\frac{1}{3}}}$$

T_i = Initial or overland travel time, minutes

K = Flow resistance coefficient

L_o = Length of overland flow, feet (500 feet maximum)

S = Slope, %

The slope is the average slope for overland travel and the flow resistance coefficient is determined using a 5-year Rational Method runoff coefficient. Resistance coefficients used in analysis are reported in **Table 7.**

Table 7 - Flow Roughness Coefficient

Character of Surface	Roughness Coefficient 5 Year Return Period (K)
Developed Areas	
Asphaltic	0.77
Concrete/roof	0.80
Grass Area (Avg. slope 2-7% slope)	
Poor Condition	0.40
Fair Condition	0.36
Good condition	0.32
Undeveloped Areas	
Cultivated Land (Avg. slope 2-7% slope)	0.38
Cultivated Land (Steep slope, over 7%)	0.42
Pasture/Range (Avg. slope 2-7% slope)	0.36
Pasture/Range (Steep slope, over 7%)	0.40
Forest/Woodlands (Avg. slope 2-7% slope)	0.34
Forest/Woodlands (Steep slope, over 7%)	0.39

Source: "*Applied Hydrology*" by Chow, Maidment, and Mays, Dated 1988

For drainage areas greater than 1-mi^2 and/or slopes greater than 10 percent, the lag times were calculated using the lag time equation developed by the US Bureau of Reclamation (USBR, Flood Hydrology Manual, 1989). The USBR has a different definition for Lag Time. The USBR defines lag as the time from the center of mass of rainfall excess to the time that 50 percent of the volume of the unit runoff has passed the design point.

Equation 4 is the equation developed by the USBR for calculating Lag Time.

Equation 4:

$$Lag = 26.0 \times K_n \times (L \times \frac{L_{ca}}{S^{0.5}})^{0.33}$$

Lag = Lag Time, hours

L= Distance of longest watercourse, miles

L_{ca} *= Distance to point opposite centroid of sub-basin, miles*

S = Average slope of sub-basin along longest water course, feet/mile

K_n *= Average Manning's roughness coefficient along longest water course*

Because the definitions of Lag given by the USBR and the SCS are different, an adjustment to the USBR equation was needed to make both methodologies consistent. By comparing and simplifying the two Lag Time equations, the following relationship was derived (WRC, Hydrologic Analysis US 395 Bypass Freeway, 1997).

$$Lag_{SCS} = 0.85 * Lag_{\ USBR}$$

By applying this relationship, a USBR Lag time equivalent to the SCS Lag time can be calculated using **Equation 5.**

Equation 5:

$$Lag = 22.1 \times K_n \times (L \times \frac{L_{ca}}{S^{0.5}})^{0.33}$$

Lag = Lag Time, hours

L= Distance of longest watercourse, miles

L_{ca} *= Distance to point opposite centroid of sub-basin, miles*

S = Average slope of sub-basin along longest water course, feet/mile

K_n *= Average Manning's roughness coefficient along longest water course*

Typical K_n values were provided in the USBR Flood Hydrology Manual for different sections of the country and different types of land use (USBR, Flood Hydrology Manual, 1989). The values supplied by the manual are for the probable maximum flood event. Based on correspondence that was done during the WRC 1997 Hydrologic Analysis between the WRC author and the USBR, it was determined that the K_n values for the probable maximum flood event should be multiplied by 1.5 to obtain K_n values that are representative for a 1-percent annual chance event. K_n values used in this analysis are presented in **Table 8**.

Table 8 - Manning's Roughness Coefficient

Land Use	Mannings's Roughness Coefficient (K_n)
Developed Areas	
Commercial/Industrial/Office/Business	0.05
High Density Residential	0.05
Medium Density Residential	0.05
Low Density Residential	0.07
Rural/Suburban Residential	0.08
Open Space Golf Course/Parks/Cemeteries	0.10
Undeveloped Areas	
Barren Ground/Rock Quarry	0.04
Irrigated Agriculture	0.10
Rangelands	
Herbaceous (grasses)	0.08
Mixed Grass and Shrub	0.09
Heavy Shrub/Brush	0.10
Forest (Evergreen)	0.15

Source: "*Hydrologic Analysis US 395 Bypass Freeway Carson City, Nevada*" by WRC Nevada Inc., Dated 1997

The variables used to calculate the Time of Concentration parameters were obtained using GIS and are based on topographic data of the watershed.

3.3.5 Reservoir Routing

For the purpose of this hydrologic analysis, the retention basin located near the upstream end of the Vicee Canyon Creek study reach (herein referred to as the Vicee Canyon Creek Retention Basin) was assumed to operate as a flood control facility. The stage-storage-discharge relationship for the retention basin was obtained from construction drawings of the basin, which were provided by Carson City. As an initial condition, the retention basin was assumed to be empty. **Table 9** contains the retention basin stage-storage-discharge rating characteristics for the Vicee Canyon Creek Retention Basin.

Table 9 - Vicee Canyon Creek Retention Basin Stage - Storage and Stage Discharge

Stage (ft)	Storage (Ac-Ft)	Storage Above Crest of Spillway (Ac-Ft)	Spillway Discharge (cfs)
4800	0	0	0
4842	165	0	0
4843	181	16	45
4844	197	32	150
4845	212	47	310

Source: "*Vicee Basin Expansion – Phase 2 Construction Drawings*" by Carson City Engineering Division, Dated 2008

3.3.6 Routing

Muskingum-Cunge Method for runoff routing was employed in the HEC-1 model developed by HDR. Required parameters for this routing methodology, including hydraulic length, slope, channel configuration, and Manning's (n), are included in **Table 10**.

Flow routing paths were independently mapped by HDR during the analysis. Routing paths were developed using a combination of surface topography data. A digital Triangular Irregular Network (TIN) covered portions of the eastern side of the study area, for all other areas that were not covered by the TIN, a surface was developed using USGS 7.5-minute topographic quadrangle maps (USGS Quads). Routing paths were mapped to capture recent development of the City's networks of canals and waterways. A routing map and corresponding HEC-1 model routing diagram are illustrated in **Figure 5 - and Figure 6 -** , respectively.

3.3.7 Summary of Parameters

Table 11 provides a summary of the values used for each parameter that were incorporated into the hydrologic model.

Table 10 - Carson Restudy HEC-1 Routing Parameters

Routing Name	Hydraulic Length (ft)	Slope (ft/ft)	Manning's n	Channel Shape	Bottom With	Side Slope (H:V)
Ash Canyon						
AC01 R	4,276	0.271	0.065	Trapezoidal	0	50:1
AC02 R	2,425	0.148	0.065	Trapezoidal	0	50:1
AC03 R	5,659	0.111	0.060	Trapezoidal	0	50:1
AC05 R	6,104	0.075	0.060	Trapezoidal	0	50:1
AC07 R	3,856	0.045	0.050	Trapezoidal	0	50:1
AC08 R	2,978	0.020	0.030	Trapezoidal	0	50:1
AC09 R	2,685	0.018	0.020	Trapezoidal	0	50:1
AC10 R	3,559	0.014	0.020	Trapezoidal	0	50:1
AC11 R	2,993	0.013	0.020	Trapezoidal	0	50:1
AC12 R	3,359	0.008	0.020	Trapezoidal	0	50:1
AC13 R	3,447	0.005	0.035	Trapezoidal	0	50:1
Kings Canyon Creek						
KC01 R	8,587	0.187	0.060	Trapezoidal	0	50:1
KC03 R	3,217	0.075	0.055	Trapezoidal	0	50:1
KC04 R	2,008	0.072	0.060	Trapezoidal	0	50:1
KC05 R	3,308	0.099	0.055	Trapezoidal	0	50:1
KC06 R	1,493	0.070	0.065	Trapezoidal	0	50:1
KC07 R	1,941	0.047	0.060	Trapezoidal	0	50:1
KC08 R	1,444	0.028	0.035	Trapezoidal	0	50:1
KC10 R	2,473	0.048	0.040	Trapezoidal	0	50:1
KC12 R	2,859	0.059	0.040	Trapezoidal	0	50:1
KC13 R	1,521	0.025	0.040	Trapezoidal	0	50:1
KC14 R	3,230	0.019	0.035	Trapezoidal	0	50:1
KC15 R	1,410	0.028	0.040	Trapezoidal	0	50:1
KC17 R	3,497	0.017	0.020	Trapezoidal	0	50:1
KC18 R	4,259	0.013	0.020	Trapezoidal	0	50:1
KC19 R	1,662	0.016	0.020	Trapezoidal	0	50:1
KC21 R	4,539	0.007	0.020	Trapezoidal	0	50:1
KC22 R	3,127	0.006	0.020	Trapezoidal	0	50:1
Vicee Canyon Creek						
VC01 R	12,085	0.079	0.065	Trapezoidal	0	50:1
VC02 R	3,342	0.025	0.050	Trapezoidal	0	50:1
VC03 R	2,852	0.014	0.035	Trapezoidal	0	50:1
VC04 R	4,027	0.011	0.020	Trapezoidal	0	50:1
VC05 R	2,060	0.011	0.020	Trapezoidal	15	50:1
VC06 R	4,958	0.004	0.020	Trapezoidal	15	50:1
Winnie Drain						
WD02 R	1,703	0.009	0.020	Trapezoidal	0	50:1
WD03 R	3,447	0.013	0.020	Trapezoidal	0	50:1

Table 11 - Carson Restudy HEC-1 Parameters

Subbasin Name	Drainage Area (ac)	Drainage Area (mi²)	SCS CN	Hydraulic Length (mi)	Hydraulic Length (ft)	Upstream EL HL (ft)	Downstream EL HL (ft)	Distance to Centroid (mi)	Distance to Centroid (ft)	Average Slope (ft/mi)	Average Slope (%)	Average Slope (ft/ft)	Kn	USBR converted to SCS Lag (hr)	SCS Method	Is it Residential	Flow Resist. Coef.	Overland Flow Length (ft)	Overland Flow Average Slope (%)	Channel Flow Length (ft)	Channel Flow Average Slope (%)	Channel Velocity (fps)	Overland Travel Time (min)	Channel Travel Time (min)	Time of Conc. (min)	SCS Lag (hr)
Ash Canyon Creek																										
AC 01	724	1.13	60	1.90	10,007	9,214	7,600	1.01	5,356	851.57	16.1	0.16	0.120	1.081	No											1.081
AC 02	677	1.06	56	2.03	10,737	9,000	6,440	0.90	4,737	1,258.91	23.8	0.24	0.137	1.137	No											1.137
AC 03	186	0.29	61	1.05	5,519	8,169	6,080	0.35	1,833	1,998.61	37.9	0.38	0.137	0.618	No											0.618
AC 04	594	0.93	64	1.82	9,614	8,577	6,000	0.85	4,463	1,415.26	26.8	0.27	0.137	1.054	No											1.054
AC 05	411	0.64	59	1.45	7,671	7,418	5,452	0.64	3,370	1,353.56	25.6	0.26	0.137	0.899	No											0.899
AC 06	364	0.57	66	1.87	9,863	8,006	5,452	0.82	4,324	1,367.44	25.9	0.26	0.137	1.058	No											1.058
AC 07	361	0.56	73	1.73	9,138	6,585	4,996	0.77	4,054	917.99	17.4	0.17	0.095	0.748	No											0.748
AC 08	62	0.10	48	0.75	3,950	5,005	4,824	0.36	1,913	242.17	4.6	0.05			Yes	No	0.40	210	7.6	3,740	4.6	5.30	9.27	11.76	21.03	0.210
AC 09	105	0.16	59	0.88	4,668	4,888	4,761	0.35	1,874	144.58	2.7	0.03			Yes	Yes				4,668	2.7	4.00	15.00	19.45	34.45	0.344
AC 10	255	0.40	57	1.71	9,039	5,562	4,762	0.86	4,530	467.32	8.9	0.09			Yes	No	0.40	500	25.2	8,539	7.9	4.50	9.61	31.63	41.24	0.412
AC 11	74	0.12	76	0.68	3,615	4,762	4,712	0.31	1,644	73.02	1.4	0.01			Yes	No	0.34	500	2.4	3,115	1.4	2.30	22.85	22.57	45.42	0.454
AC 12	53	0.08	93	0.72	3,827	4,717	4,671	0.42	2,207	63.04	1.2	0.01			Yes	Yes				3,827	1.2	2.60	15.00	24.53	39.53	0.395
AC 13	57	0.09	89	0.93	4,916	4,688	4,646	0.43	2,276	45.11	0.9	0.01			Yes	Yes				4,916	0.9	2.00	15.00	40.97	55.97	0.560
AC 14	48	0.07	92	0.65	3,454	4,648	4,628	0.32	1,715	30.58	0.6	0.01			Yes	Yes				3,454	0.6	1.25	15.00	46.05	61.05	0.610
Kings Canyon Creek																										
KC 01	594	0.93	67	2.04	10,757	9,170	6,800	1.12	5,900	1,163.35	22.0	0.22	0.130	1.176	No											1.176
KC 02	569	0.89	59	2.69	14,204	8,443	5,198	1.50	7,914	1,206.26	22.8	0.23	0.120	1.303	No											1.303
KC 03	839	1.31	64	2.02	10,661	7,929	5,440	0.59	3,124	1,232.69	23.3	0.23	0.120	0.869	No											0.869
KC 04	578	0.90	66	2.06	10,872	7,460	5,198	0.75	3,975	1,098.59	20.8	0.21	0.120	0.965	No											0.965
KC 05	480	0.75	56	2.12	11,202	7,891	5,379	0.99	5,213	1,183.92	22.4	0.22	0.130	1.141	No											1.141
KC 06	168	0.26	75	0.91	4,797	5,904	5,061	0.27	1,437	928.53	17.6	0.18	0.095	0.429	No											0.429
KC 07	79	0.12	80	0.49	2,591	5,249	4,950	0.22	1,178	608.57	11.5	0.12	0.090	0.333	No											0.333
KC 08	44	0.07	77	0.50	2,630	5,231	4,858	0.29	1,505	749.85	14.2	0.14	0.093	0.362	No											0.362
KC 09	35	0.05	77	0.47	2,455	5,133	4,854	0.27	1,442	600.02	11.4	0.11	0.085	0.331	No											0.331
KC 10	281	0.44	65	1.67	8,820	7,025	4,974	0.67	3,531	1,227.74	23.3	0.23	0.085	0.603	No											0.603
KC 11	26	0.04	77	0.49	2,572	5,134	4,856	0.28	1,503	570.21	10.8	0.11	0.085	0.343	No											0.343
KC 12	182	0.28	70	1.19	6,290	6,808	5,024	0.60	3,147	1,497.54	28.4	0.28	0.085	0.502	No											0.502
KC 13	188	0.29	80	0.97	5,106	5,380	4,856	0.38	2,002	542.38	10.3	0.10	0.084	0.469	No											0.469
KC 14	51	0.08	81	0.47	2,508	5,040	4,818	0.12	633	466.71	8.8	0.09			Yes	No	0.39	500	28.7	2,008	8.8	6.00	9.33	5.58	14.91	0.149
KC 15	193	0.30	77	1.50	7,935	5,940	4,856	0.65	3,457	721.16	13.7	0.14	0.093	0.690	No											0.690
KC 16	101	0.16	78	0.81	4,279	5,758	4,757	0.51	2,684	1,235.82	23.4	0.23	0.090	0.461	No											0.461
KC 17	65	0.10	77	0.62	3,261	4,859	4,758	0.33	1,744	164.61	3.1	0.03			Yes	Yes				3,261	3.1	3.25	15.00	16.73	31.73	0.317

Table 11 - Carson Restudy HEC-1 Parameters, Continued

Subbasin Name	Drainage Area (ac)	Drainage Area (mi²)	SCS CN	Hydraulic Length (mi)	Hydraulic Length (ft)	Upstream EL HL (ft)	Downstream EL HL (ft)	Distance to Centroid (mi)	Distance to Centroid (ft)	Average Slope (ft/mi)	Average Slope (%)	Average Slope (ft/ft)	Kn	USBR converted to SCS Lag (hr)	SCS Method	Is it Residential	Flow Resist. Coef.	Overland Flow Length (ft)	Overland Flow Average Slope (%)	Channel Flow Length (ft)	Channel Flow Average Slope (%)	Channel Velocity (fps)	Overland Travel Time (min)	Channel Travel Time (min)	Time of Conc. (min)	SCS Lag (hr)
Kings Canyon Creek Continued																										
KC 18	64	0.10	79	0.75	3,944	4,850	4,757	0.33	1,743	123.88	2.3	0.02			Yes	Yes				3,944	2.3	3.00	15.00	21.91	36.91	0.369
KC 19	171	0.27	82	0.90	4,771	4,761	4,698	0.30	1,567	69.73	1.3	0.01			Yes	Yes				4,771	1.3	2.25	15.00	35.34	50.34	0.503
KC 20	86	0.13	79	1.02	5,385	5,436	4,682	0.53	2,806	739.29	14.0	0.14	0.070	0.425	No											0.425
KC 21	82	0.13	92	0.67	3,545	4,706	4,672	0.27	1,410	50.64	1.0	0.01			Yes	Yes				3,545	1.0	2.00	15.00	29.54	44.54	0.445
KC 22	223	0.35	91	1.20	6,329	4,686	4,642	0.64	3,369	36.70	0.7	0.01			Yes	Yes				6,329	0.7	1.90	15.00	55.52	70.52	0.705
KC 23	120	0.19	91	0.66	3,498	4,648	4,622	0.27	1,448	39.09	0.7	0.01			Yes	Yes				3,498	0.7	0.90	15.00	64.79	79.79	0.798
Vicee Canyon Creek																										
VC 01	631	0.99	66	1.63	8,615	7,998	5,830	0.68	3,616	1,328.77	25.2	0.25	0.138	0.966	No											0.966
VC 02	539	0.84	66	2.66	14,053	6,722	4,880	1.48	7,814	692.07	13.1	0.13	0.116	1.364	No											1.364
VC 03	148	0.23	66	1.19	6,258	5,108	4,758	0.44	2,331	295.32	5.6	0.06			Yes	No	0.34	500	9.4	5,758	5.6	3.20	14.49	29.99	44.48	0.445
VC 04	82	0.13	78	0.67	3,526	4,759	4,718	0.37	1,974	61.39	1.2	0.01			Yes	No	0.39	500	2.2	3,026	1.2	1.70	21.97	29.67	51.64	0.516
VC 05	133	0.21	89	0.99	5,253	4,724	4,674	0.53	2,802	49.95	0.9	0.01			Yes	Yes				5,253	0.9	2.00	15.00	43.78	58.78	0.588
VC 06	73	0.11	94	0.70	3,703	4,700	4,652	0.38	2,016	69.15	1.3	0.01			Yes	Yes				3,703	1.3	2.25	15.00	27.43	42.43	0.424
VC 07	193	0.30	93	1.02	5,388	4,659	4,630	0.48	2,510	28.32	0.5	0.01			Yes	Yes				5,388	0.5	1.70	15.00	52.82	67.82	0.678
Winnie Drainage																										
WD 01	148	0.23	77	1.23	6,511	4,852	4,714	0.61	3,222	111.97	2.1	0.02			Yes	Yes				6,511	2.1	2.80	15.00	38.76	53.76	0.538
WD 02	149	0.23	85	1.25	6,581	4,820	4,714	0.54	2,833	84.97	1.6	0.02			Yes	Yes				6,581	1.6	2.60	15.00	42.19	57.19	0.572
WD 03	72	0.11	89	0.57	2,998	4,722	4,697	0.26	1,386	43.51	0.8	0.01			Yes	Yes				2,998	0.8	1.87	15.00	26.72	41.72	0.417

4.0 Results and Comparison

A comparison between methodologies and peak flows from previous studies, and the methodology and peak flows from the Carson City Restudy performed by HDR is presented in this section. The peak flows are compared at selected points for which flows were calculated in the various studies being compared and for which contributing drainage areas used in the different studies are relatively comparable in size. Comparable points were available for Vicee, Ash, and Kings Canyon Creeks; no comparable points were available for Kings Split. The comparison of the results for Vicee, Ash, and Kings Canyon Creeks at selected points will serve as an assessment of the reasonableness of the results from the HEC-1 model developed by HDR.

4.1 Results

Table 12 -summarizes the results obtained from the HEC-1 model developed by HDR at the points of interest.

Table 12 - HDR HEC-1 Peak Flows Results

Watershed	Node	Drainage Area, sq. mi	Peak Flows (cfs)			
			10 % Annual Chance	2 % Annual Chance	1 % Annual Chance	0.2 % Annual Chance
Vicee Canyon Creek (inflow to retention basin)	VC02C	1.83	96	265	370	722
Vicee Canyon Creek (outflow from retention basin)	VCB	1.83	0	0	0	117
Ash Canyon Creek	AC08C	5.28	269	762	1,065	2,092
Kings Canyon Creek	KC06C2	5.04	222	647	909	1,799

4.2 Results Comparison

Table 13 summarizes some of the key methodologies used for the various studies cited in this TM. For a detailed description of the methodologies employed in previous studies please refer to their respective reports.

Table 13 - Summary of methodologies for different studies

Study	Model	Precipitation Source	Infiltration/Runoff	Routing Method
2009 FIS	TM 20	NOAA Atlas	NA	NA
Manhard 2010 Hydrologic Analysis	SWMM5	NOAA Atlas 14	Green & Ampt	Dynamic Wave
WRC 1997 Hydrologic Analysis	HEC-1	NOAA Atlas 2	SCS CN	Muskingum-Cunge
HDR Carson City Restudy	HEC-1	NOAA Atlas 14	SCS CN	Muskingum-Cunge

NA: Not Available

Table 14 provides the hydrologic results of the three previous studies compared to the HEC-1 peak flow results developed by HDR.

Table 14 - General Summary of Results

2009 FIS Drainage Area	Manhard - SW Carson City Study Drainage Area	WRC - US 395 Bypass Freeway Study Drainage Area	HDR - Carson City Restudy Drainage Area	Peak Flows (cfs)															
				10-Percent Annual Chance				2-Percent Annual Chance				1-Percent Annual Chance				0.2-Percent Annual Chance			
				2009 FEMA FIS	Manhard - SW Carson City Study	WRC - US 395 Bypass Freeway Study	HDR - Carson City Restudy	2009 FEMA FIS	Manhard - SW Carson City Study	WRC - US 395 Bypass Freeway Study	HDR - Carson City Restudy	2009 FEMA FIS	Manhard - SW Carson City Study	WRC - US 395 Bypass Freeway Study	HDR - Carson City Restudy	2009 FEMA FIS	Manhard - SW Carson City Study	WRC - US 395 Bypass Freeway Study	HDR - Carson City Restudy
Vicee Canyon Creek – Inflow to Existing Basin																			
--	1.83	--	1.83	--	32	-- **	96	--	211	-- **	265	--	370	--	370	--	1,010	-- **	722
Vicee Canyon Creek - Outflow of Existing Basin[1]																			
2	1.83	1.57	1.83	45	0	**	0	250	0	**	0	475	0	485	0	1,950	0	**	117
Ash Canyon Creek - Near Longview Way																			
6	5.28	5.48	5.28	220	145	**	269	950	619	**	762	1,660	1,006	922	1,065	5,550	2,533	**	2,092
Kings Canyon Creek - Near Canyon Drive																			
5	4.91	4.99	5.04	160	132	**	222	765	589	**	647	1,390	922	1,011	909	5,065	2,307	**	1,799

HDR flows were developed from incorporating Manhard's watershed delineation and updating WRC HEC-1.
-- Basin was not in place during the modeling of Vicee Canyon Basin therefore inflow into the basin was not calculated.
** Return period event was not modeled.
1 The volume entering the basin is exceeded during 0.2 -percent annual chance flood event.

The following set of tables compares the HEC-1 peak flow results obtained in the Carson City Restudy to the results obtained in the Manhard 2010 Hydrologic Analysis and the WRC 1997 Hydrologic Analysis. Where applicable the percent differences in peak flows were calculated to assess the reasonableness of the peak flows generated by HDR for the Carson City Restudy.

Table 15 shows a comparison between the 1-Percent Annual Chance Flood peak flow results obtained in the 1997 Hydrologic Analysis and the results obtained in the Carson City Restudy.

***Table 15* - Comparison between HDR HEC-1 & WRC HEC-1 Peak Flows**

HDR HEC-1 Node	HDR HEC-1 Drainage Area (mi^2)	WRC HEC-1 Node	WRC HEC-1 Drainage Area (mi^2)	HDR HEC-1 1% Annual Chance Flood Peak Flow (cfs)	WRC Precipitation	WRC HEC-1 1% Annual Chance Flood Peak Flow (cfs)	Percent Difference (%)
Vicee Canyon Creek							
VC02C	1.83	DA 13	1.57	370	SPFS	480	25.9
					NOAA	375	1.3
Ash Canyon Creek							
AC09C	5.28	DP 10	5.48	1,065	SPFS	929	13.6
					NOAA	691	42.6
Kings Canyon Creek							
KC06C2	5.04	DP 13	4.99	909	SPFS	1,166	24.8
					NOAA	939	3.2

The comparison shown in **Table 15** indicates that the results obtained in the Carson City Restudy match relatively well with the results obtained in the WRC 1997 Hydrologic Analysis. While a significant difference (42.6-percent) was measured for Carson City Restudy node AC09C, when comparing to the NOAA precipitation results obtained by WRC, other results compare relatively well, mainly with the NOAA results at other locations (VC02C & KC06C2) where a difference of less than 4-percent was measured in each location. Although there is a large difference between the HDR HEC-1 result and the WRC 1997 Hydrologic Analysis (using NOAA precipitation) at node AC09C, it was concluded that there was anomaly in the data set or the model. This was determined by reviewing the flows per unit area. The evaluation of the flow per unit area showed consistency between all locations using different methodologies with the only exception being the WRC 1997 Hydrologic Analysis (using NOAA precipitation) at node AC09C.

Table 16 shows a comparison between the peak flow results obtained in the Carson City Restudy using HEC-1 and the peak flow results obtained in the Manhard 2010 Hydrologic Analysis using SWMM5.

Table 16 - Comparison between HDR HEC-1 & Manhard SWMM5 Model Results

HDR HEC-1 Node	HEC-1 Drainage Area (mi^2)	SWMM5 Drainage Area (mi^2)	Percent Annual Chance Flood	HDR HEC-1 Peak Flows (cfs)	Manhard SWMM5 Peak Flows (cfs)	Percent Difference (%)
Vicee Canyon Creek (Inflow to Basin)						
VC02C	1.83	1.83	10 (10 Yr)	96	32	100
			2 (50 Yr)	265	211	22.7
			1 (100 Yr)	370	370	0
			0.2 (500 Yr)	722	1,010	33.3
Vicee Canyon Creek (Outflow to Existing Basin)						
VCB	1.83	1.83	10 (10 Yr)	0	0	0
			2 (50 Yr)	0	0	0
			1 (100 Yr)	0	0	0
			0.2 (500 Yr)	117	0	200
Ash Canyon Creek (Near Longview Way)						
AC09C	5.28	5.28	10 (10 Yr)	269	145	59.9
			2 (50 Yr)	762	619	20.7
			1 (100 Yr)	1,065	1,006	5.7
			0.2 (500 Yr)	2,092	2,533	19.1
Kings Canyon Creek (Near Canyon Drive)						
KC06C2	5.04	4.91	10 (10 Yr)	222	132	50.8
			2 (50 Yr)	647	589	9.4
			1 (100 Yr)	909	922	1.4
			0.2 (500 Yr)	1,799	1,307	31.7

The comparison provided in **Table 16** shows that consistent and relatively similar results were obtained in both the Manhard 2010 Hydrologic Analysis and the HDR Carson City Restudy even though two different methodologies were utilized. One item to notice is that a larger percent difference is consistently calculated for the smaller events. This is expected in these types of comparisons because the percent difference is magnified by the low values being compared (a small change in cubic feet per second (cfs) will be noticed more when the initial value is relatively small). However, it should be noted that both studies obtained remarkably similar results for the 1-Percent Annual Chance Flood, ranging in difference from 0- to 6-percent, even though each study was largely independent of one another with different software and methodologies.

4.3 Conclusion

While comparing the results of their hydrologic evaluation, HDR found that similar and relatively consistent findings had been published in previous studies. Consequently, a level of confidence can be assigned to the HEC-1 results obtained in the hydrologic analysis portion of the Carson City Restudy. HDR recommends that the flows obtained in the HDR HEC-1 analysis be used for the consequent hydraulic analysis portion of the Carson City Restudy. **Table 17** summarized the peak flows recommended for the hydraulic analysis portion of the Carson City Restudy. **Appendix A** contains the rainfall-runoff HEC-1 model outputs for the 10-, 2-, 1-, and 0.2-percent annual chance flood event models. Any hydraulic analysis that will use this hydrologic analysis should incorporate additional points of interested based on engineering judgment. Points of interest can be determined using the rainfall-runoff HEC-1 model results printout (See **Appendix A**) and **Figure 2**.of this report.

Table 17 - Recommended Peak Flows to be used in Hydraulic Analysis Portion of the Carson City Restudy

Watershed	Node	Drainage Area, sq. mi	Peak Flows (cfs)			
			10 % Annual Chance	2 % Annual Chance	1 % Annual Chance	0.2 % Annual Chance
Vicee Canyon Creek	VC02C	1.83	96	265	370	722
Vicee Canyon Creek	VCB	1.83	0	0	0	117
Ash Canyon Creek	AC09C	5.28	269	762	1,065	2,092
Kings Canyon Creek	KC06C2	5.04	222	647	909	1,799

5.0 References

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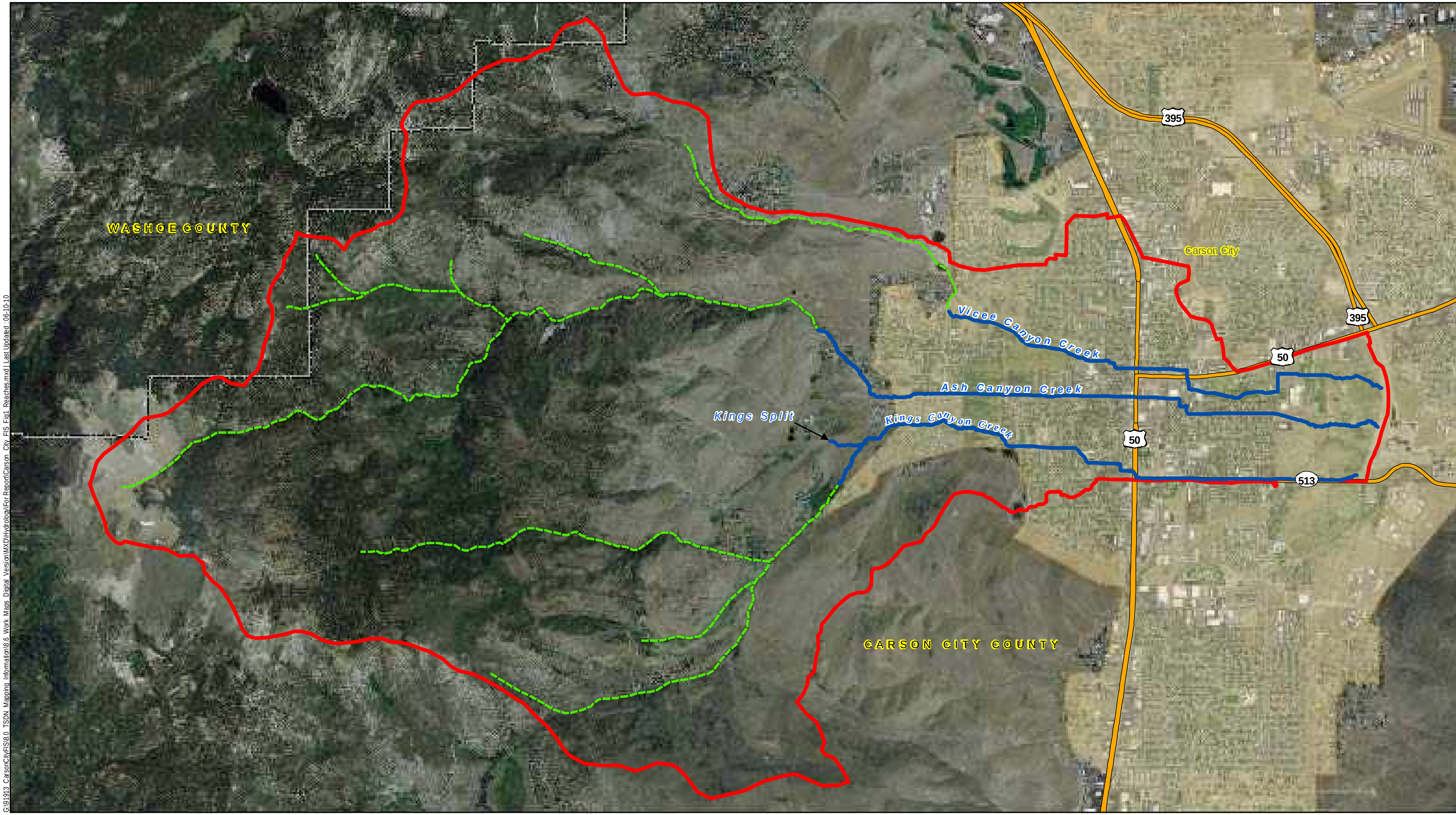

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FEMA

HDR
ONE COMPANY | *Many Solutions*™

Legend

- Carson City Watershed
- Stream Reaches Study Area
- Stream Reaches (Non Study)
- Major Roads
- Urbanized Area
- Counties *

* Carson City County and City boundaries coincide

N

1 inch = 3,000 feet

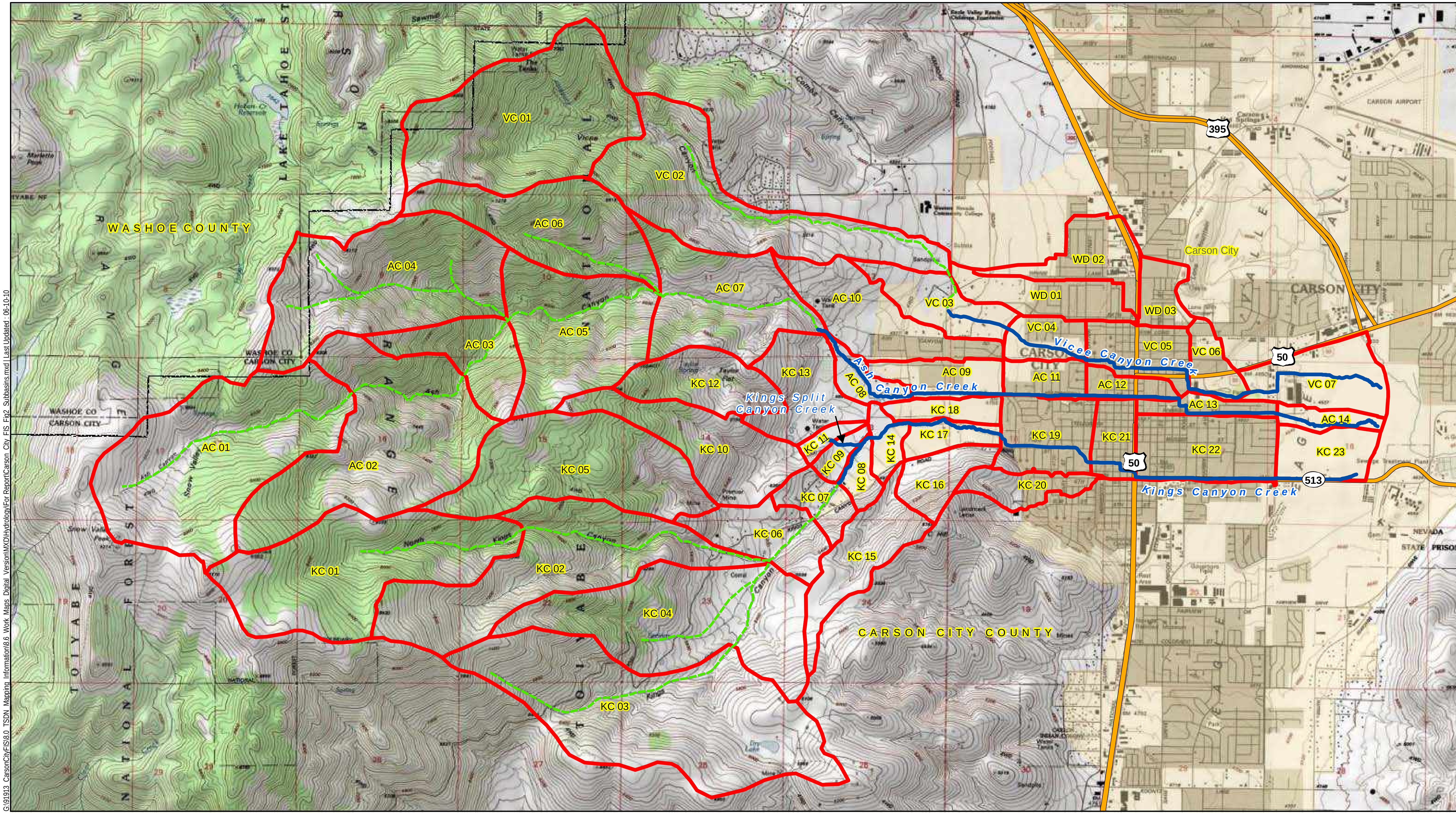
0 1,500 3,000 6,000 9,000 12,000 Feet

Carson City Restudy - Stream Reaches

Figure 1

Image Source: NAIP 2006
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988
Date: 06-10-10

Flood Insurance Study for Carson City, NV | Project # 91913, T.O. 36



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FEMA

HDR ONE COMPANY | *Many Solutions*

Legend

- Sub-basins
- Stream Reaches Study Area
- Stream Reaches (Non Study)
- Major Roads
- Urbanized Area
- Counties *

* Carson City County and City boundaries coincide

N

1 inch = 3,000 feet

0 1,500 3,000 6,000 9,000 12,000 Feet

Carson City Restudy - Sub-basins

Figure 2

Image Source: NGS_Topo_US_2D, 2009
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988
Date: 06-10-10

Flood Insurance Study for Carson City, NV | Project # 91913, T.O. 36

Appendix B: USGS LiDAR Survey Report

NV Reno Carson Urban Lidar 2017 B17

SURVEY REPORT

USGS Contract: G16PC00044

Task Order Number: G17PD01257

Government Point-of-Contact (POC)

Organization: USGS/NGTOC

Telephone: (573) 308-3756

Address: Gail Dunn

1400 Independence Road, MS 663

Rolla, MO 65401

Contractor Point-of-Contact (POC)

Address: Digital Aerial Solutions, LLC

Telephone: (813) 628-0788

ATTN: Joshua Helton (VP)

4027 Crescent Park Drive

Riverview, FL 33578

Table of Contents

OVERVIEW

Digital Aerial Solutions, LLC (DAS) with contract number G16PC00044 was contracted by the USGS/NGTOC under task order number G17PD01257 collect a high resolution LiDAR data set covering 1534 square miles affecting Carson City, Douglas, Lyon, Sierra, Storey and Washoe counties in Nevada. Each of these categories was spread out as evenly as possible throughout the Area of Interest (AOI). The survey was completed using the Global Positioning System (GPS). Each observation was identified in the field and surveyed utilizing GPS receivers, collecting GNSS and GLONASS information and utilizing a Leica Smart-Net RTK network. In accordance with section C.1.b.(viii) of the task order, the spatial reference system used was:

Spatial Reference System:

Coordinate System:	Universal Transverse Mercator 11 North
Horizontal Datum:	North American Datum 1983 of (2011)
Vertical Datum:	North American Vertical Datum of 1988
Units:	Meters
Geoid Model:	Geoid 12B

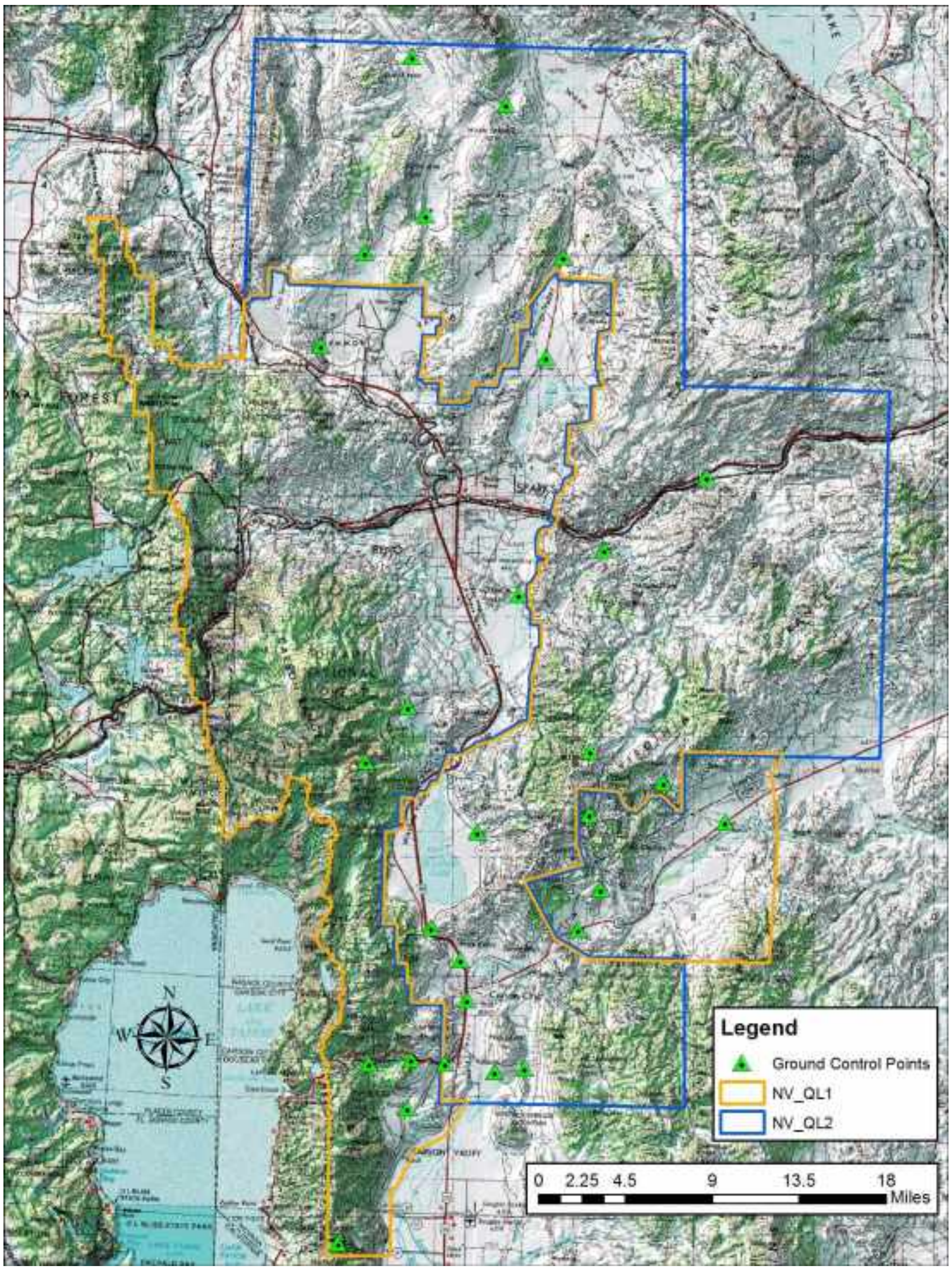
Section C.1.b.(ix) of the task order outlines the ground control minimum requirements and specifications for this LiDAR project. 30 Supplemental ground control points were collected and used to support the airborne GPS solution and positional accuracy. DAS also collected more than the required number of Non-Vegetated Vertical Accuracy (NVA) and Vegetated Vertical Accuracy (VVA) Quality Checkpoints as stated in the task order. These checkpoints serve as an independent delivery to the client and were not incorporated into the vertical solution.

Glossary of Terms

Term		Definition
ATTN	-	Attention
BG	-	Bare-Ground Checkpoint (see NVA)
CO	-	Colorado, USA
CTRL	-	Control
DAS	-	Digital Aerial Solutions, LLC
Ellip	-	Ellipsoid Height
FIPS	-	Federal Information Processing Standard
FL	-	Florida
GPS	-	Global Positioning Systems
HVEG	-	High Vegetation(see VVA)
ID	-	Identification
LVEG	-	Low Vegetation (see VVA)
LiDAR	-	Light Detection and Ranging
MVEG	-	Medium Vegetation (see VVA)
NAD83	-	North American Datum of 1983
NAVD88	-	North American Vertical Datum of 1988
NGS	-	National Geodetic Survey
NGTOC	-	National Geospatial Technical Operations Center
NVA	-	Non-Vegetated Vertical Accuracy
Ortho	-	Orthometric Height
POC	-	Point of Contact
PT	-	Pavement(see NVA)
RTK	-	Real Time Kinematics
SD	-	Sand(see NVA)
USGS	-	United States Geological Survey
VP	-	Vice President
VVA	-	Vegetated Vertical Accuracy

Supplemental Ground Control

The Map shows the overall distribution of the Supplemental Ground Control throughout the AOI. The following tables contain a list of the control using Easting, Northing, and Orthometric height. The coordinate system displayed is UTM 11N, NAD83 (2011), NAVD88, Geoid 12B and using Meters for measurement.



Appendix C: Public Meeting #1

Virtual Public Meeting Summary

Meeting Information:

Project Name: West Carson City Area Drainage Plan
Location: Zoom Webinar
Date: Wednesday, December 9, 2020
Time: 6 pm – 7:30 pm PST
Number of Attendees: 16

Notification Efforts:

- 2700 Postcards
- Social Media Posts

Presentation Topics (see attached presentation):

- Project Partners
- Project Purpose
- Project Goals
- Purposed Study Area
- Project Schedule
- Next Steps

Media Coverage:

n/a

Media Results:

n/a

Area Representation:

Individual Residents
Carson City
Carson Water Subconservancy District

Project Team Attendees:

Team:

Robb Fellows, Carson City Public Works
Dan Stucky, Carson City Public Works
Randall Rice, Carson City Public Works
Edwin James, Carson Water Subconservancy District
Geoff Brownell, Kimley-Horn
Andrew Chill, Kimley-Horn
Amalia Deslis-Andrews, Kimley-Horn
Jordan King, Kimley-Horn
Devin Burgraff, Kimley-Horn

Summary of Comments:

Many stakeholder comments focused on how flooding has affected them in their neighborhoods and how the project would mitigate these impacts in the future. Questions and comments were gathered using the Q&A chat in zoom and were addressed by Geoff and Robb live in the meeting.

Action Items:

None

Attachments:

- Postcard
- Social Media Post
- Registration Report
- Question and Answer Report
- Sign in Sheet
- Project Presentation

West Carson City Area Drainage Plan
Virtual Information Meeting

Have you experienced flood damage?

Residents and property owners are invited to learn about the
West Carson City Area Drainage Plan
and share your concerns, comments, and past flood experience with drainage experts at our *virtual information meeting!*

Please join us on
Wednesday, December 9, 2020
6 – 7:30 pm

(a short presentation will begin at 6 pm)

Zoom (virtual) Meeting Information:
tinyurl.com/WestCCDrainageMeeting

Or use the QR Code above to j

Your comments and concerns are valuable to the West Carson City Area Drainage Plan!

To view preliminary flood hazard maps please visit
WestCCDrainagePlan.com
and download a Google Map overlay file under
What's New (instructions are on the website)
or write us at

Email: info@westccdrainageplan.com

Address: CCPW – Stormwater, 3505 Butti Way,
Carson City, NV 89701

to share photos and comments.

Carson City Public Works
3505 Butti Way
Carson City, NV 89701

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WEST CARSON CITY AREA DRAINAGE PLAN
Virtual
Information
Meeting
DECEMBER 9, 2020 AT 6 PM PST
A SHORT PRESENTATION WILL BEGIN AT 6 PM PST
REGISTER NOW! VISIT
WESTCCDRAINAGEPLAN.COM
CARSON CITY
PUBLIC WORKS
CARSON WATER
SUBCONSERVANCY DISTRICT
FEMA

West Carson City Area Drainage Plan Virtual Information Meeting Registration Report

Webinar ID	Scheduled Time	Duration (minutes)	# Registered	# Cancelled	# Approved
930 6953 5666	12/9/2020 19:00	90	30	1	30

Attendee Details					
First Name	**Last Name**	**Email**	**Zip/Postal Code**	**Registration Time**	**Approval Status**
SHYLA	LEMONS	SLEMONS@CARSON.ORG	89703	12/1/2020 11:02	approved
Rafael	Perez	rpj73@me.com	89703	12/2/2020 17:54	approved
Dan	Stucky	dstucky@carson.org	89701	12/2/2020 19:16	approved
Denise	Roe	Kwrheault@aol.com	89703	12/4/2020 14:32	approved
Jim	Estes	jestes7723@yahoo.com	89703	12/4/2020 15:06	approved
John	Rowett	samuel412@sbcglobal.net	89703-4547	12/5/2020 14:45	approved
Jasmine	Tenney	Jasminetenney116@gmail.com	89703	12/6/2020 14:40	approved
jack	pishnak	marienjack1964@yahoo.com	89703-8505	12/7/2020 2:33	cancelled by self
Andrew	Chill	andrew.chill@kimley-horn.com	85020	12/7/2020 7:54	approved
Anne	Knowles	aknowles@nevadaappeal.com	89701	12/7/2020 12:34	approved
Karen	Trefz	karentrefz@sbcglobal.net	89703	12/7/2020 16:38	approved
Vincent	Lopresti	Vlopresti@hotmail.com	89703	12/7/2020 20:27	approved
Mike	Drews	Mdrews@greatbasingroup.com	89703	12/8/2020 18:32	approved
Christine	Butson	cgris@prodigy.net	89701	12/8/2020 20:03	approved
Devin	Burgraff	devin.burgraff@kimley-horn.com	84111	12/9/2020 9:10	approved
Geoff	Brownell	Geoff.brownell@kimley-horn.com	85032	12/9/2020 9:52	approved
Ellen	DeChristopher	dechristopher11@aol.com	89703	12/9/2020 11:56	approved
Lolene	Terry	lolene.terry@gmail.com	89703	12/9/2020 15:03	approved
Tim	Rochelle	Rochelle.tim@yahoo.com	89703	12/9/2020 18:04	approved
John	Walsh	agplus2016@gmail.com	89703	12/9/2020 18:24	approved
Melanie	Meehan-Crossley	melanie-art@charter.net	89703	12/9/2020 18:26	approved
Amalia	A.	Oscar.amalia@gmail.com	84047	12/9/2020 18:47	approved
Barbara	Singer	sbjsingerfamily@sbcglobal.net	89703	12/9/2020 18:57	approved
Debbie	Neddenriep	debbie@cwsd.org	89701	12/9/2020 18:58	approved
Margo	Hornung	hornungs@nvbell.net	89703	12/9/2020 18:58	approved
Roy	Mickle	roymickle@yahoo.com	89703	12/9/2020 18:59	approved
Reid	Kaiser	nevadareid2@gmail.com	89703-4586	12/9/2020 18:59	approved
Mark	Rotter	Rotterfam@gmail.com	89703	12/9/2020 18:59	approved
Dennis	Pederson	pedersondd@gmail.com	89703-3619	12/9/2020 19:02	approved
Robert	Parvin	rparvinr@gmail.com	89703	12/9/2020 19:07	approved
Francheska	Ibarra	francheskaibarra.fi@gmail.com	3500	12/9/2020 19:56	approved

West Carson City Area Drainage Plan Virtual Information Meeting Q&A Report

Webinar ID	Actual Start Time	Actual Duration (minutes)	# Question
930 6953 5666	12/9/2020 18:39	111	23

Question Details

Question Number	Question	Asker Name	Asker Email	Answer(s)
1	I notice that Kings creek flows intermittently. Where and how is the flow of Kings creek regulated?	Anonymous Attendee		live answered
2	What are the differences between red and blue depths just in general— like 1-5 feet is blue and 5-10 is red? What depth is a pedestrian hazard?	Lolene Terry	lolene.terry@gmail.com	live answered
3	Yes answered the question-thanks— What is the goal of the mitigation— complete 100 year relief? or partial relief? Is there a cost benefit- and would we be asked to pay something for that mitigation.	Lolene Terry	lolene.terry@gmail.com	live answered
4	What year would we expect a project if Carson City received a grant?	Reid Kaiser	nevadareid2@gmail.com	live answered
5	Would CC have to get a special use permit for this type of project?	Reid Kaiser	nevadareid2@gmail.com	live answered
6	Can you show the location of the proposed basin(s)?	Mark Rotter	Rotterfam@gmail.com	live answered
7	When you look at the blue flood areas— they seem to follow streets- does that mean the house near the street could get flooded then or is it just curb to curb	Lolene Terry	lolene.terry@gmail.com	live answered
8	We were impacted by the 1997 storm with 10" of water in our basement. The year before last we had your crews behind our back fence trying to create a creek in the middle of the night. Yet the map does not seem to show these flooding issues just south of Long (1500 Andorra Drive). Why?	Margo Hornung	hornungs@nvbell.net	live answered
9	my home at he corner of Mountain and W Musser (east side of Mountain street) has flooded in the past. How do I find out if storm drain improvement for that corner will be effective. The problem was water was diverted to run down Mountain toward king but it didnt get to King because of low lyng street in front of my Mountain street driveway. My basement flooded as well as the yard.	Melanie Meehan-Crossley	melanie-art@charter.net	live answered
10	I have only been here since 2013 however in the 2017 the water did go over the road at Thames	Lolene Terry	lolene.terry@gmail.com	live answered
11	You may have already answered this question, but will this basin just west of The Highlands, reduce the flow coming down Ash Creek or just Kings Creek?	Reid Kaiser	nevadareid2@gmail.com	live answered
12	The city cleaned out the willows and so that seemed to help	Lolene Terry	lolene.terry@gmail.com	live answered
13	Another issue is the ground is steep and then gets really flat downstream of Thames	Lolene Terry	lolene.terry@gmail.com	live answered
14	Would a project potentially force the city to expand draingage capacity down either KIngs or Ash Creeks?	Reid Kaiser	nevadareid2@gmail.com	live answered
15	Through the developement?	Reid Kaiser	nevadareid2@gmail.com	live answered
16	Flows during the 2005 flood were contained by curb and gutter in the neighborhood just east of Carson Middle School	Mike Drews	Mdrews@greatbasingroup.com	live answered

17	Rob, I'm assuming that you got that History of Flooding in Carson and Eagle Valley document that we talked about	Mike Drews	Mdrews@greatbasingroup.com	live answered
18	Thank you for the information very informative.	Lolene Terry	lolene.terry@gmail.com	Thanks for your attendance and participation!
19	Can folks view maps at project website? Can they see their house on maps?	Debbie Neddenriep	debbie@cwsd.org	live answered
20	It looks like most of the high risk areas follow designed flood basins or flood ways. Why is there an anonaly to the west and north of Carson Middle. That is essentially the flow of the 2005 flood.	Mike Drews	Mdrews@greatbasingroup.com	live answered
21	What's the plan for mitigating flood waters on Anderson property after it's developed? Seems to be a lot of flood waters on this open space.	Debbie Neddenriep	debbie@cwsd.org	live answered
22	Does the city have an drainage infrastructure inventory / plan for maintenance?	Debbie Neddenriep	debbie@cwsd.org	live answered
23	Didn't there used to be 2-3 seperate water systems? State of Nevada, Carson City, and Marlette?	Debbie Neddenriep	debbie@cwsd.org	live answered

West Carson City Area Drainage Plan Virtual Information Meeting Sign In Sheet					
First Name	**Last Name**	**Email Address**	**Mobile Phone Number (xxx-xxx-xxxx)**	**Zip Code**	**How did you hear about the virtual meeting?**
Margo	Hornung	hornungs@nvbell.net	(775) 888-9111	89703	Postcard from Carson City Public Works (thanks!)
Mike and LouAnn	Drews	mdrews@greatbasingroup.com	(775) 560-5074	89703	Post Card
Barbara	Singer	sbjsingerfamily@sbcglobal.net	(775) 722-2816	89703	postcard
Lolene	Terry	lolene.terry@gmail.com	(702) 862-9915	89703	Post card
Melanie	Meehan-Crossley	melanie-art@charter.net	(775) 297-3911	89703	city sent postcard
Andrew	Chill	andrew.chill@kimley-horn.com	(480) 239-2370	85020	Consultant
Reid	Kaiser	nevadareid2@gmail.com	(775) 220-5335	89703	mail
Karen and George	Trefz	karentrefz@sbcglobal.net	(916) 869-4397	89703	Post Card
Deborah	Neddenriep	debbie@cwsd.orh	(775) 887-1260	89701	work for entity that funded study
Ellen	DeChristopher	ellen.huronout@gmail.com	(775) 232-9455	89703	Postcard

Appendix D: Public Meeting #2

Public Meeting Plan

Client	Carson City Public Works
Project Name	West Carson City Area Drainage Plan
Meeting Name	Virtual Public Information Meeting

Virtual Public Meeting Date/Time/Location
Tuesday, May 11, 2021
6:00 – 7:30 pm PST
https://kimley-horn.zoom.us/s/94222284524

Meeting Attendees

- Carson City Representatives
  - Shyla
  - Robb Fellows, Chief Storm Water Engineer
  - Dan Stuckey (PW Dir)
  - Ed James (Funding Agency, Carson Water Subconservancy District Director)

- Kimley-Horn Team
  - Geoff Brownell, KH Project Manager
  - Andrew Chill, KH Project Engineer
  - Amalia Andrews, KH Project Team
  - Jordan King, KH Project Team
  - Devin Burgraff, KH Project Team

- Potential attendees
  -
  -

Meeting Notification

- Postcard
  - Mailed ~2700 postcards – received in homes on May 1
  - Postcard includes project website and link to register and access the meeting

- Project Website Page (https://www.westccdrainageplan.com)

- Zoom Registration Reminder Email – sent from project email address
  - May 11 (1 hour prior to meeting)

- Social Media Post

Virtual Public Meeting

- Logistics
  - Location: Remote (Kimley-Horn Offices)
  - Platform: Zoom Webinar
  - Presenters/Panelists: Geoff and Andrew
  - Moderator/Facilitator: Jordan
  - Technical Support: Devin
  - Details
    - Start meeting at 5:15 to test sound
    - Turn silent at 5:40
    - Soft start at 6:00 with meeting starting at 6:10
    - Jordan will welcome and run through meeting logistics
    - Zoom webinar registration will suffice for a sign in sheet

- Presentation
    - Lead: Geoff Brownell
    - Powerpoint

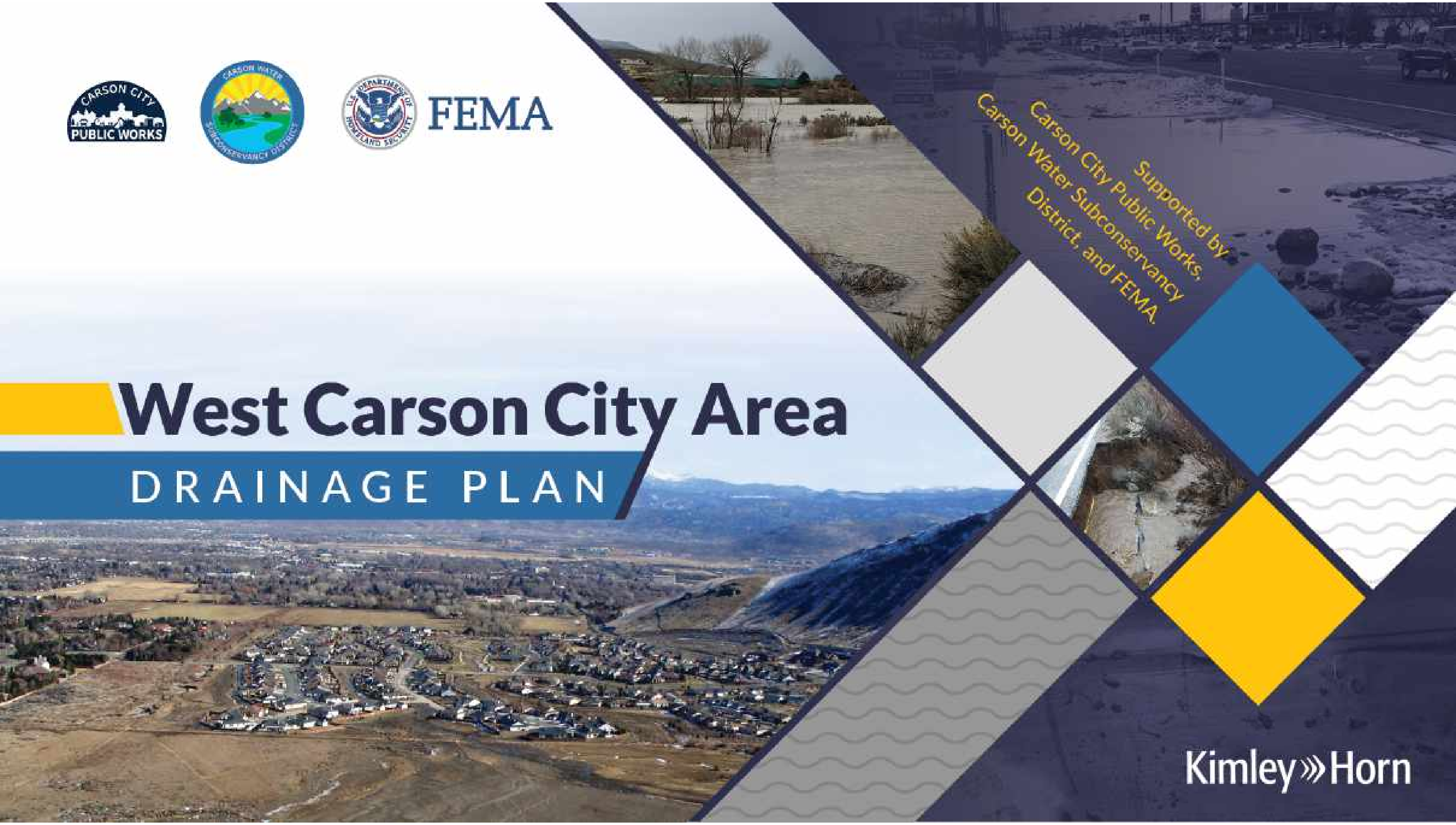
Presentation Template

Project partners
Project purpose
Project goals
Overview of last meeting
Proposed plan
Maps – flood complaints map
Photos
Next Steps
Questions

Dry run Monday, May 10

West Carson City Area

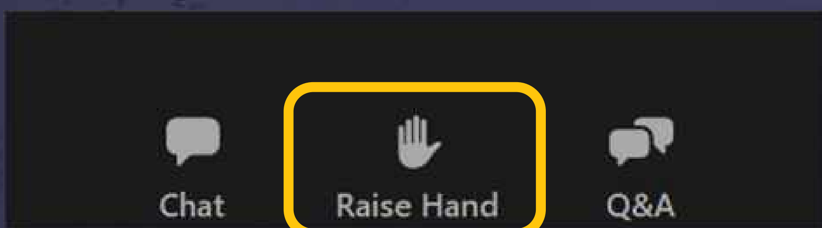
DRAINAGE PLAN

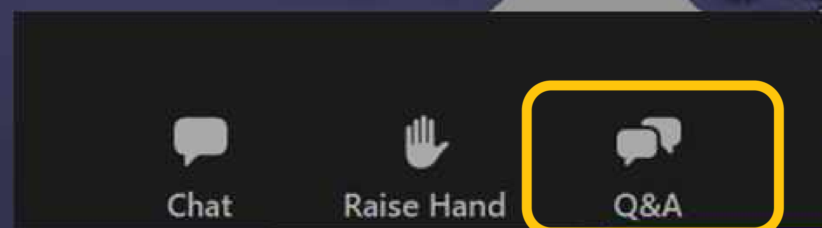


How to Participate

If you would like to ask a question verbally, please use the "**Raise Hand**" button located on the bottom of your screen to notify us of a question

Questions can also be asked in the Q&A chat. To access the chat, press the "**Q&A**" button at the bottom of the screen.





Project Team

Geoff Brownell

Project Manager
Kimley-Horn

Robb Fellows

Carson City Public Works
Chief Stormwater Engineer

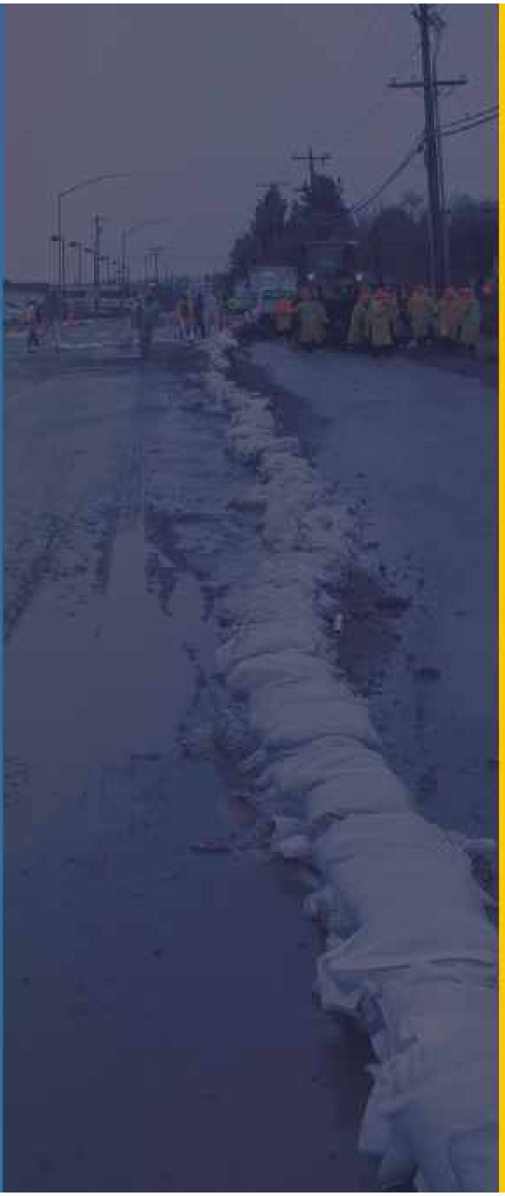
Andrew Chill

Project Engineer
Kimley-Horn

Amalia Andrews

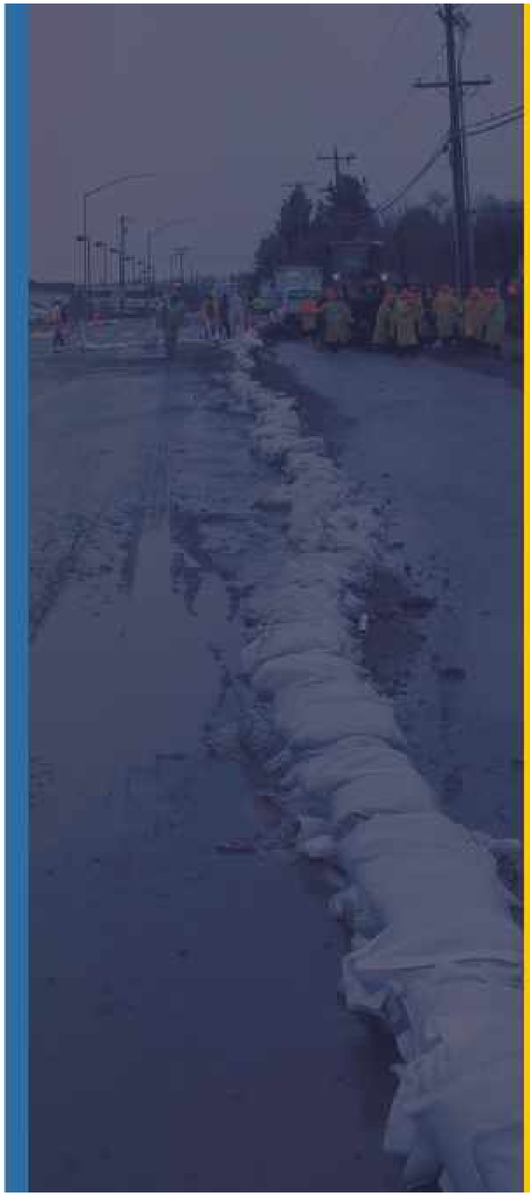
Project Team
Kimley-Horn

West Carson City Area
DRAINAGE PLAN



Project Partners

- Carson City Public Works
- Carson Water Subconservancy District
- FEMA

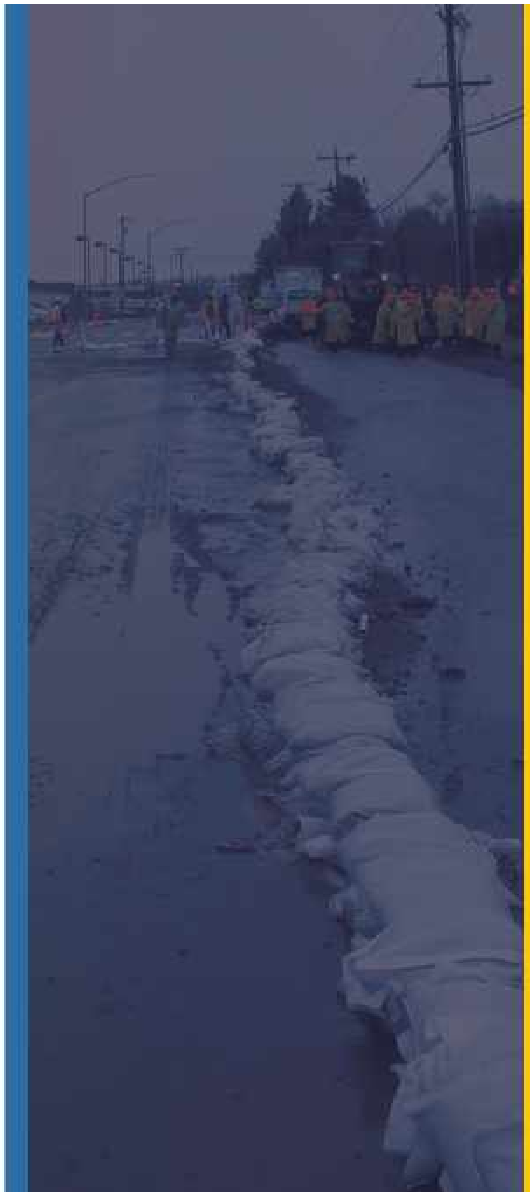


West Carson City Area DRAINAGE PLAN

Project Purpose

- Project will more accurately define flood hazards in the area
- Build on previous hydrologic and hydraulic studies
- Reduce flood hazards and increase community resiliency in the future

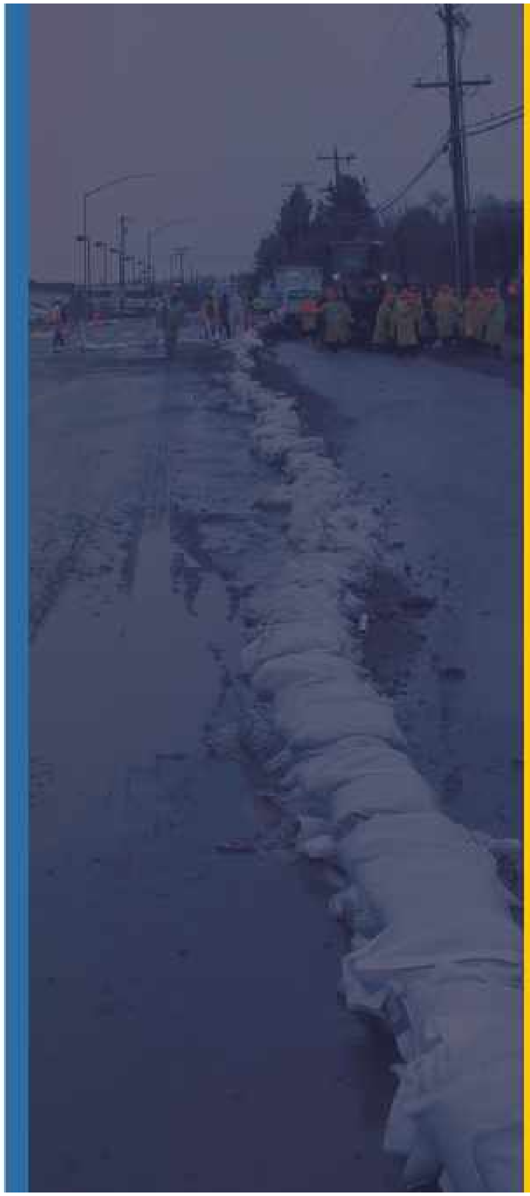
West Carson City Area
DRAINAGE PLAN



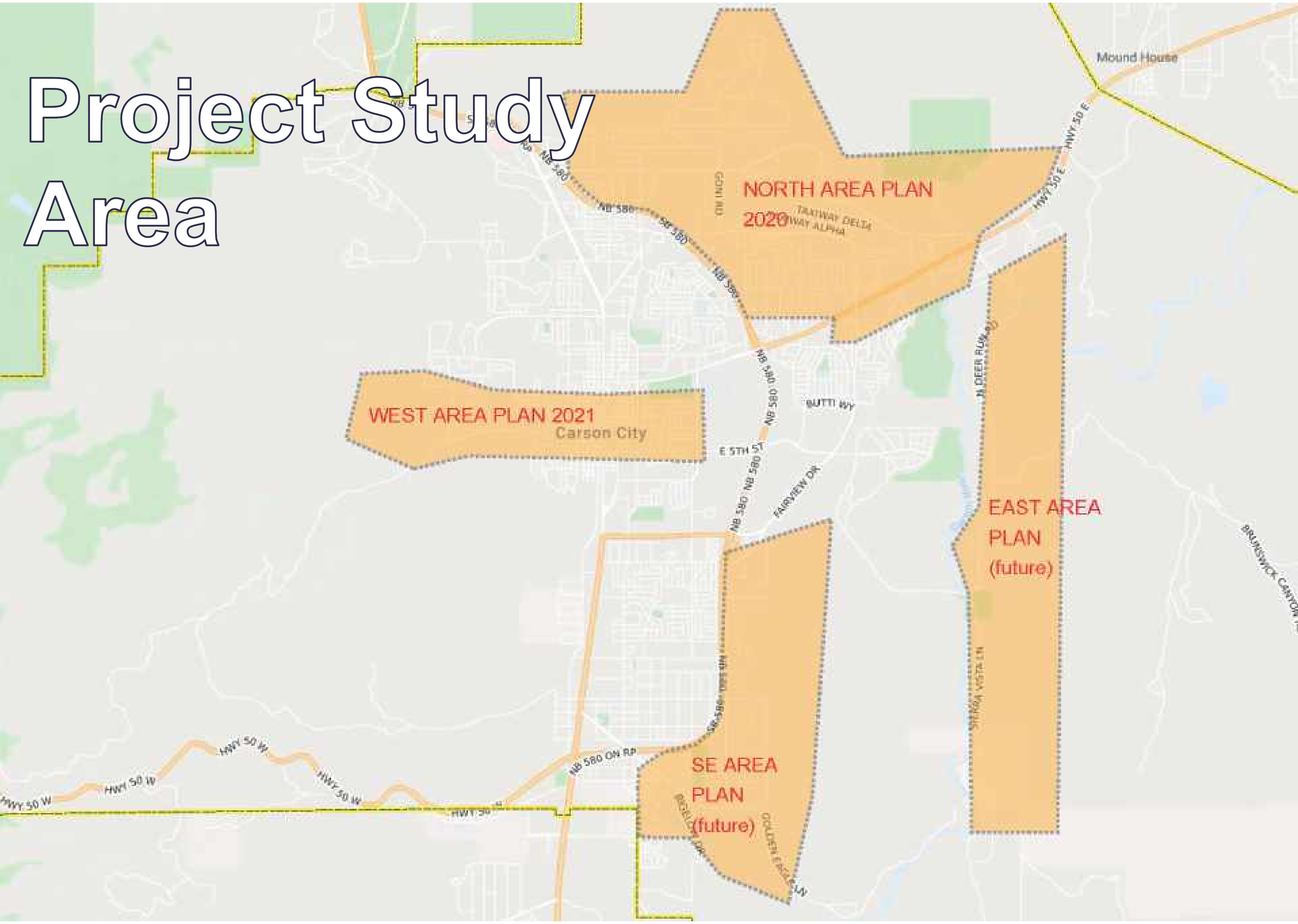
Project Goals

- Identify mitigation solutions for areas impacted by flood flows along Kings Canyon Creek and Ash Canyon Creek.
- Investigate the feasibility of a storm water basin immediately upstream of Longview Way
- Develop conceptual mitigation solutions for the urban areas downstream of Longview Way

West Carson City Area
DRAINAGE PLAN



Project Study Area



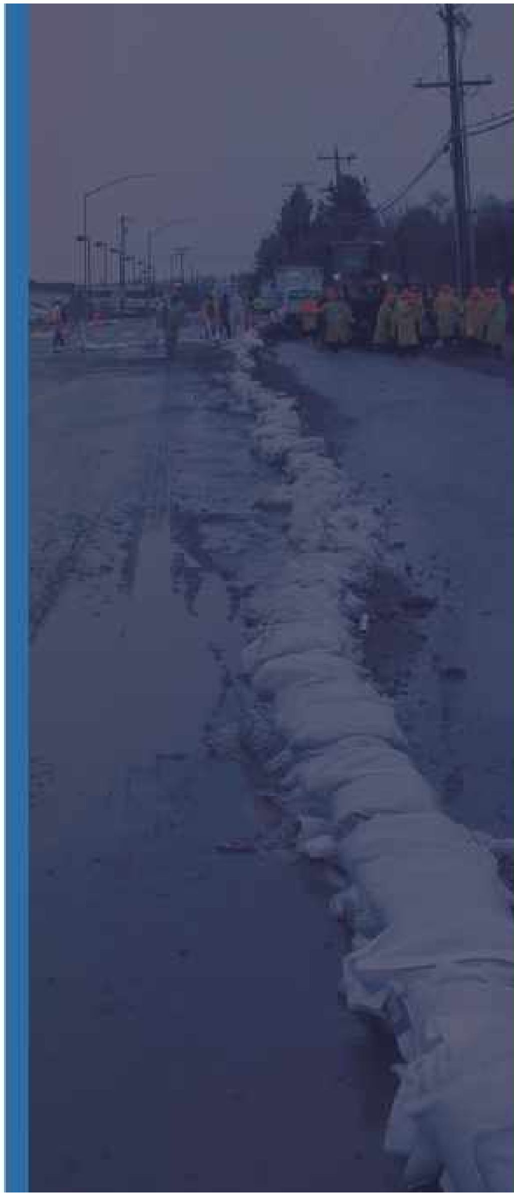
MAP FOR REFERENCE ONLY
NOT A LEGAL DOCUMENT

Carson City , NV makes no claims and no warranties, expressed or implied, concerning the validity or accuracy of the GIS data presented on this map.

Geometry updated 11/17/2018
Data updated 11/17/2018

1st Virtual Information Meeting

- December 9, 2020
- Existing conditions and initial results
- Collect public input



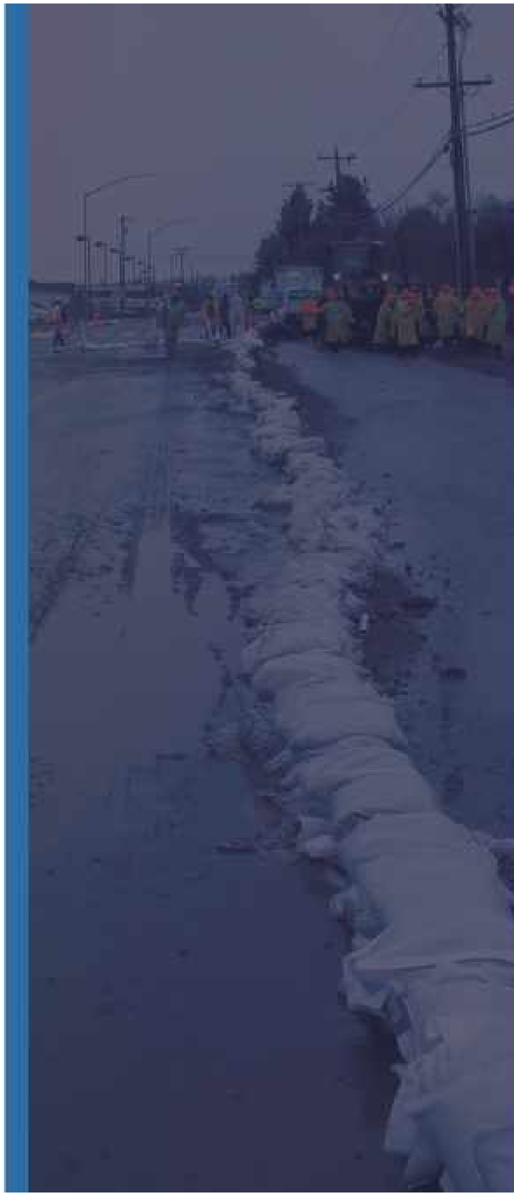
West Carson City Area
DRAINAGE PLAN

Next Steps

- June 2021 – Finalize and present plan to Board of Supervisors

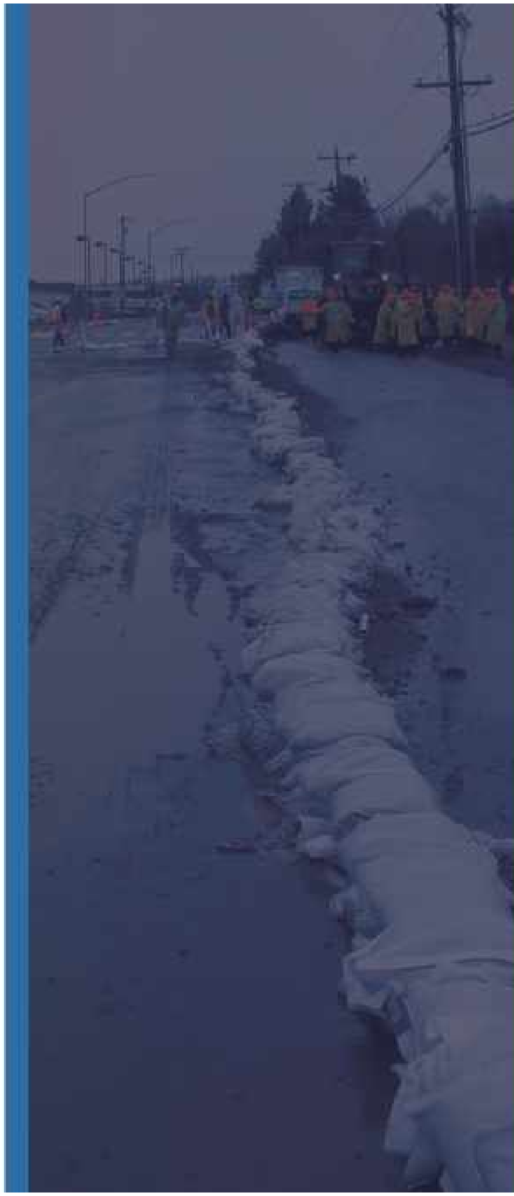
- With Board approval:
  - Develop grant application for FEMA funding for construction
  - Construct improvements
  - Revise FEMA floodplains

West Carson City Area
DRAINAGE PLAN



Contact Us

- Website: westccdrainageplan.com
- Email: info@westccdrainageplan.com
- Mailing Address: CCPW – Stormwater, 3505 Butti Way, Carson City, NV 89701



West Carson City Area DRAINAGE PLAN

Q&A

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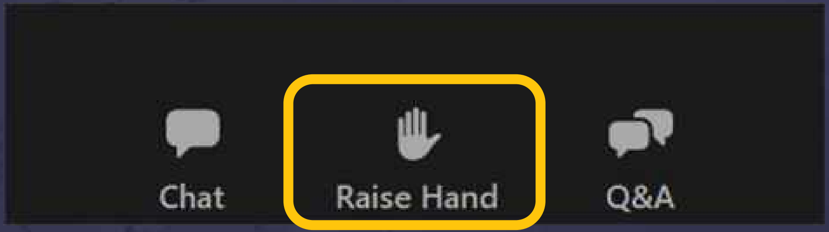
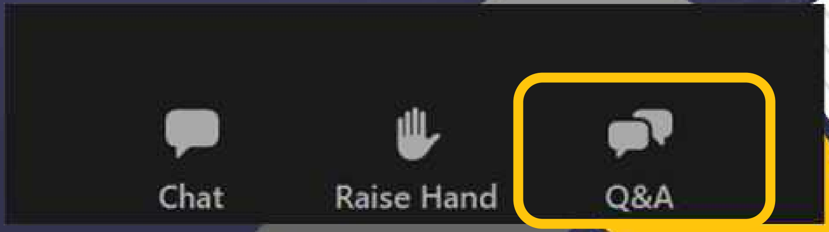





Thank you!

Appendix E: Rating Tables

Worksheet for 2' Pipe

Project Description	
Solve For	Discharge

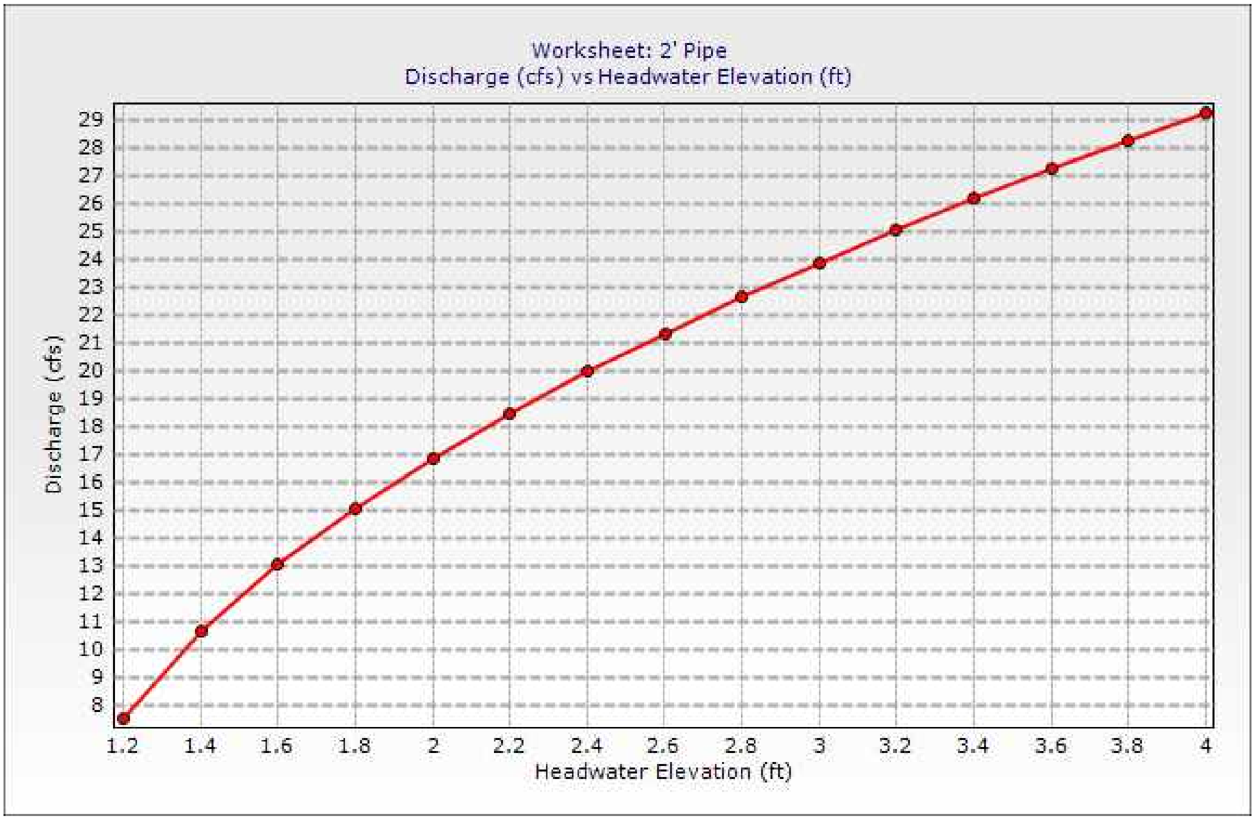
Input Data	
Headwater Elevation	3.00 ft
Centroid Elevation	1.00 ft
Tailwater Elevation	1.00 ft
Discharge Coefficient	0.670
Diameter	2.0 ft

Results	
Discharge	23.88 cfs
Headwater Height Above Centroid	2.00 ft
Tailwater Height Above Centroid	0.00 ft
Flow Area	3.1 ft^2
Velocity	7.60 ft/s

Rating Curve for 2' Pipe

Project Description	
Solve For	Discharge

Input Data	
Headwater Elevation	3.00 ft
Centroid Elevation	1.00 ft
Tailwater Elevation	1.00 ft
Discharge Coefficient	0.670
Diameter	2.0 ft



Rating Table for 2' Pipe

Project Description

Solve For	Discharge

Input Data

Headwater Elevation	3.00 ft
Centroid Elevation	1.00 ft
Tailwater Elevation	1.00 ft
Discharge Coefficient	0.670
Diameter	2.0 ft

Headwater Elevation (ft)	Discharge (cfs)	Velocity (ft/s)
0.00		(N/A)
0.20		(N/A)
0.40		(N/A)
0.60		(N/A)
0.80		(N/A)
1.00		(N/A)
1.20	7.55	2.40
1.40	10.68	3.40
1.60	13.08	4.16
1.80	15.10	4.81
2.00	16.88	5.37
2.20	18.50	5.89
2.40	19.98	6.36
2.60	21.36	6.80
2.80	22.65	7.21
3.00	23.88	7.60
3.20	25.04	7.97
3.40	26.16	8.33
3.60	27.23	8.67
3.80	28.25	8.99
4.00	29.25	9.31

Worksheet for 2.5' Pipe

Project Description

Solve For	Discharge

Input Data

Headwater Elevation	3.50 ft
Centroid Elevation	1.25 ft
Tailwater Elevation	1.25 ft
Discharge Coefficient	0.670
Diameter	2.5 ft

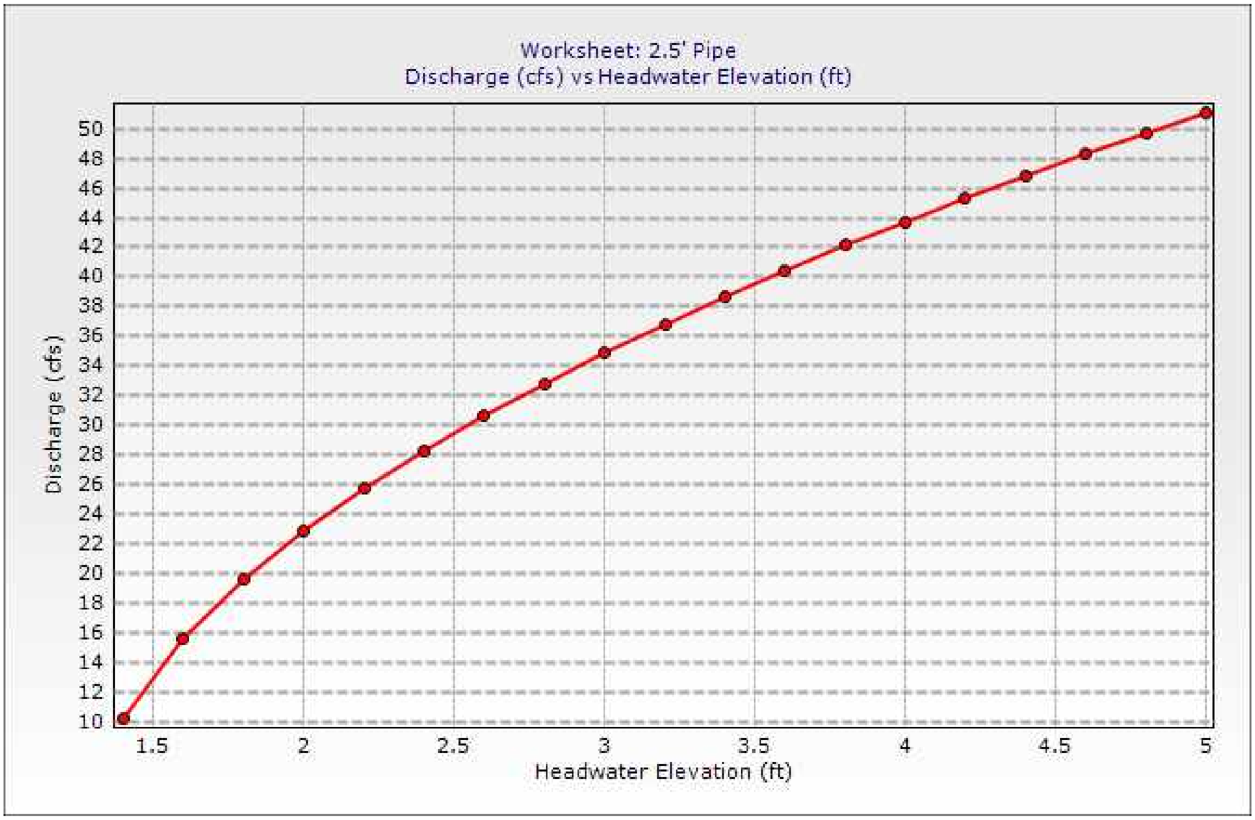
Results

Discharge	39.57 cfs
Headwater Height Above Centroid	2.25 ft
Tailwater Height Above Centroid	0.00 ft
Flow Area	4.9 ft^2
Velocity	8.06 ft/s

Rating Curve for 2.5' Pipe

Project Description	
Solve For	Discharge

Input Data	
Headwater Elevation	3.50 ft
Centroid Elevation	1.25 ft
Tailwater Elevation	1.25 ft
Discharge Coefficient	0.670
Diameter	2.5 ft



Rating Table for 2.5' Pipe

Project Description	
Solve For	Discharge

Input Data	
Headwater Elevation	3.50 ft
Centroid Elevation	1.25 ft
Tailwater Elevation	1.25 ft
Discharge Coefficient	0.670
Diameter	2.5 ft

Headwater Elevation (ft)	Discharge (cfs)	Velocity (ft/s)
0.00		(N/A)
0.20		(N/A)
0.40		(N/A)
0.60		(N/A)
0.80		(N/A)
1.00		(N/A)
1.20		(N/A)
1.40	10.22	2.08
1.60	15.61	3.18
1.80	19.57	3.99
2.00	22.85	4.65
2.20	25.71	5.24
2.40	28.29	5.76
2.60	30.65	6.24
2.80	32.85	6.69
3.00	34.90	7.11
3.20	36.84	7.51
3.40	38.68	7.88
3.60	40.44	8.24
3.80	42.13	8.58
4.00	43.75	8.91
4.20	45.31	9.23
4.40	46.82	9.54
4.60	48.29	9.84
4.80	49.71	10.13
5.00	51.09	10.41

Worksheet for 3.5' Pipe

Project Description	
Solve For	Discharge

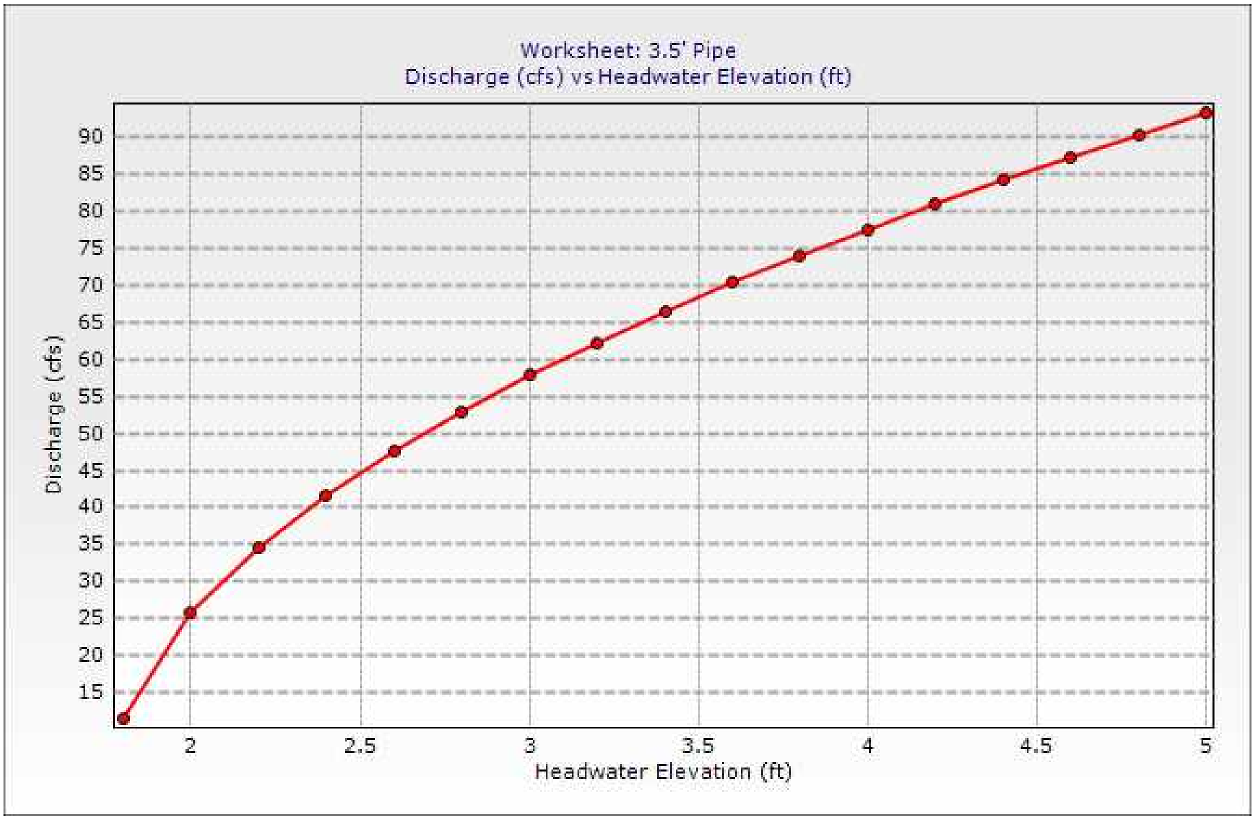
Input Data	
Headwater Elevation	4.50 ft
Centroid Elevation	1.75 ft
Tailwater Elevation	1.75 ft
Discharge Coefficient	0.670
Diameter	3.5 ft

Results	
Discharge	85.75 cfs
Headwater Height Above Centroid	2.75 ft
Tailwater Height Above Centroid	0.00 ft
Flow Area	9.6 ft^2
Velocity	8.91 ft/s

Rating Curve for 3.5' Pipe

Project Description	
Solve For	Discharge

Input Data	
Headwater Elevation	4.50 ft
Centroid Elevation	1.75 ft
Tailwater Elevation	1.75 ft
Discharge Coefficient	0.670
Diameter	3.5 ft



Rating Table for 3.5' Pipe

Project Description	
Solve For	Discharge

Input Data	
Headwater Elevation	4.50 ft
Centroid Elevation	1.75 ft
Tailwater Elevation	1.75 ft
Discharge Coefficient	0.670
Diameter	3.5 ft

Headwater Elevation (ft)	Discharge (cfs)	Velocity (ft/s)
0.00		(N/A)
0.20		(N/A)
0.40		(N/A)
0.60		(N/A)
0.80		(N/A)
1.00		(N/A)
1.20		(N/A)
1.40		(N/A)
1.60		(N/A)
1.80	11.56	1.20
2.00	25.85	2.69
2.20	34.69	3.61
2.40	41.69	4.33
2.60	47.67	4.96
2.80	52.99	5.51
3.00	57.81	6.01
3.20	62.27	6.47
3.40	66.42	6.90
3.60	70.33	7.31
3.80	74.04	7.70
4.00	77.56	8.06
4.20	80.94	8.41
4.40	84.18	8.75
4.60	87.30	9.07
4.80	90.31	9.39
5.00	93.22	9.69
5.20	96.05	9.98
5.40	98.79	10.27
5.60	101.46	10.55

Worksheet for 4' Pipe

Project Description

Solve For	Discharge

Input Data

Headwater Elevation	5.00 ft
Centroid Elevation	2.00 ft
Tailwater Elevation	2.00 ft
Discharge Coefficient	0.670
Diameter	4.0 ft

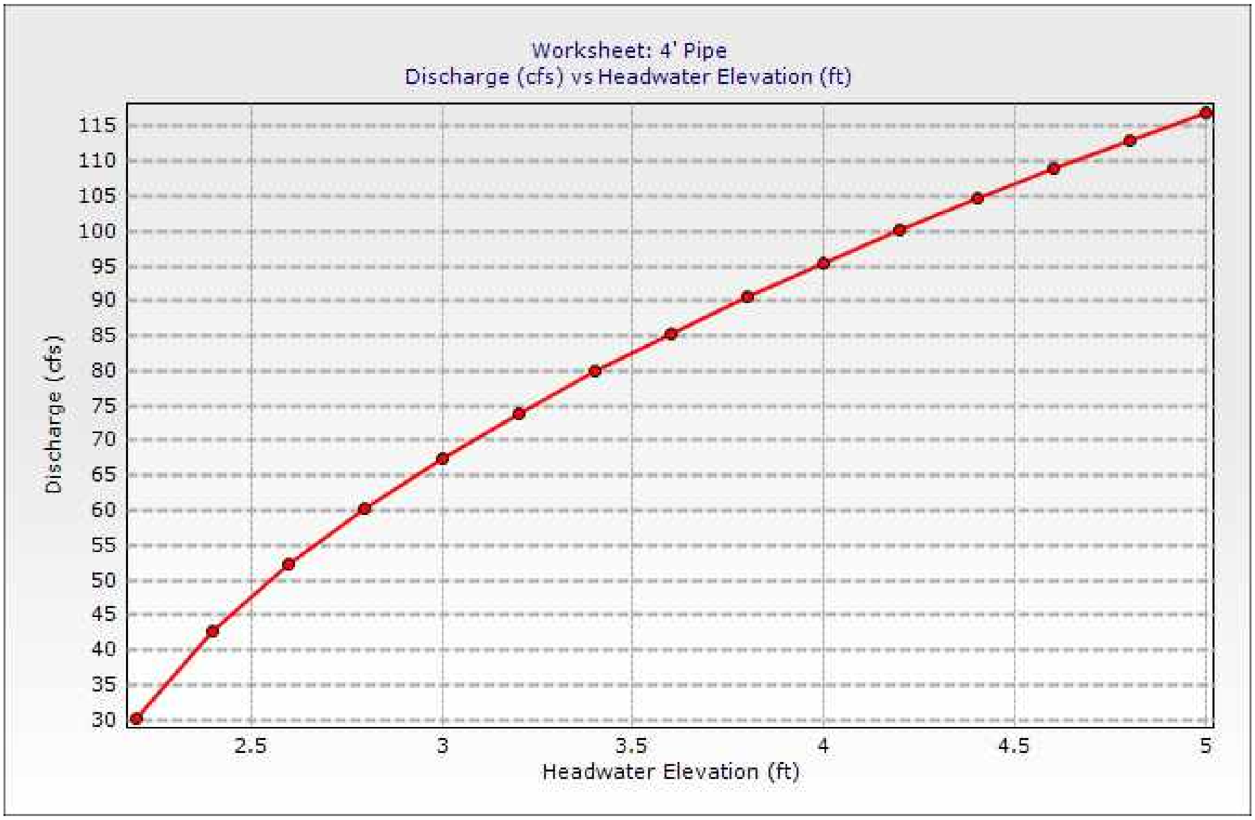
Results

Discharge	116.98 cfs
Headwater Height Above Centroid	3.00 ft
Tailwater Height Above Centroid	0.00 ft
Flow Area	12.6 ft²
Velocity	9.31 ft/s

Rating Curve for 4' Pipe

Project Description	
Solve For	Discharge

Input Data	
Headwater Elevation	5.00 ft
Centroid Elevation	2.00 ft
Tailwater Elevation	2.00 ft
Discharge Coefficient	0.670
Diameter	4.0 ft



Rating Table for 4' Pipe

Project Description

Solve For	Discharge

Input Data

Headwater Elevation	5.00 ft
Centroid Elevation	2.00 ft
Tailwater Elevation	2.00 ft
Discharge Coefficient	0.670
Diameter	4.0 ft

Headwater Elevation (ft)	Discharge (cfs)	Velocity (ft/s)
0.00		(N/A)
0.20		(N/A)
0.40		(N/A)
0.60		(N/A)
0.80		(N/A)
1.00		(N/A)
1.20		(N/A)
1.40		(N/A)
1.60		(N/A)
1.80		(N/A)
2.00		(N/A)
2.20	30.20	2.40
2.40	42.72	3.40
2.60	52.32	4.16
2.80	60.41	4.81
3.00	67.54	5.37
3.20	73.98	5.89
3.40	79.91	6.36
3.60	85.43	6.80
3.80	90.61	7.21
4.00	95.51	7.60
4.20	100.18	7.97
4.40	104.63	8.33
4.60	108.90	8.67
4.80	113.01	8.99
5.00	116.98	9.31

Worksheet for Combination Inlet In Sag - R-3295

Project Description

Solve For	Spread

Input Data

Discharge	0.50 cfs
Gutter Width	1.50 ft
Gutter Cross Slope	0.110 ft/ft
Road Cross Slope	0.020 ft/ft
Local Depression	2.0 in
Local Depression Width	36.0 in
Grate Width	1.50 ft
Grate Length	3.0 ft
Grate Type	P-50 mm (P-1 -7/8")
Clogging	50.0 %
Curb Opening Length	3.0 ft
Opening Height	0.5 ft
Curb Throat Type	Horizontal
Throat Incline Angle	90.00 degrees

Options

Calculation Option	Use Both

Results

Spread	1.6 ft
Depth	0.1 ft
Gutter Depression	1.6 in
Total Depression	3.6 in
Open Grate Area	2.0 ft²
Active Grate Weir Length	4.5 ft

Rating Curve for Combination Inlet In Sag - R-3295

Project Description	
Solve For	Spread

Input Data	
Discharge	0.50 cfs
Gutter Width	1.50 ft
Gutter Cross Slope	0.110 ft/ft
Road Cross Slope	0.020 ft/ft
Local Depression	2.0 in
Local Depression Width	36.0 in
Grate Width	1.50 ft
Grate Length	3.0 ft
Grate Type	P-50 mm (P-1 -7/8")
Clogging	50.0 %
Curb Opening Length	3.0 ft
Opening Height	0.5 ft
Curb Throat Type	Horizontal
Throat Incline Angle	90.00 degrees

Options	
Calculation Option	Use Both

Rating Table for Combination Inlet In Sag - R-3295

Project Description

Solve For	Spread

Input Data

Discharge	0.50 cfs
Gutter Width	1.50 ft
Gutter Cross Slope	0.110 ft/ft
Road Cross Slope	0.020 ft/ft
Local Depression	2.0 in
Local Depression Width	36.0 in
Grate Width	1.50 ft
Grate Length	3.0 ft
Grate Type	P-50 mm (P-1 -7/8")
Clogging	50.0 %
Curb Opening Length	3.0 ft
Opening Height	0.5 ft
Curb Throat Type	Horizontal
Throat Incline Angle	90.00 degrees

Options

Calculation Option	Use Both

Discharge (cfs)	Spread (ft)	Depth (ft)
0.00		
0.50	1.6	0.1
1.00	1.9	0.2
1.50	2.2	0.2
2.00	2.4	0.2
2.50	2.6	0.3
3.00	2.8	0.3
3.50	3.0	0.3
4.00	10.8	0.4
4.50	12.1	0.4
5.00	13.4	0.4
5.50	14.5	0.4
6.00	15.6	0.4
6.50	16.6	0.5
7.00	17.6	0.5
7.50	18.6	0.5
8.00	19.6	0.5