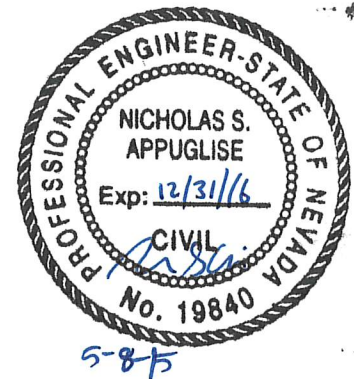


**GOWAN NORTH BUFFALO BRANCH –
LONE MOUNTAIN TO WASHBURN**

**15% Alternative Alignment Study
(GOBU 0112 and GOBU 0136)**

May 7, 2015

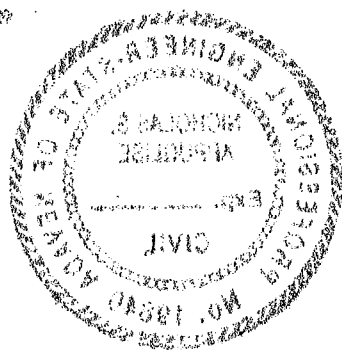
**Prepared for:
City of Las Vegas**



Prepared By:

**Parsons Brinckerhoff
3753 Howard Hughes Parkway
Suite 135
Las Vegas, NV 89169
TEL: 702-697-8100
FAX: 702-697-8170**

THIS PAGE INTENTIONALLY LEFT BLANK



EXECUTIVE SUMMARY

The purpose of the Project is to design for construction, the Gowan North Buffalo Branch – Lone Mountain to Washburn storm drain (Project) to collect major storm flows generated within the Project's watershed. The Project is a Clark County Regional Flood Control District (CCRFCD) Master Plan flood control facility designated within the 2013 CCRFCD Master Plan Updated (MPU) as GOBU 0112 and GOBU 0136. This facility will be the final extension of the Gowan North Buffalo Branch system. This Project includes the design of a 100-year CCRFC storm drain system and associated drop inlets and laterals.

The limits of the watershed tributary to the Project extend from Buffalo Drive on the east to El Capitan Way on the west and from Lone Mountain Road on the south to Ann Road on the north. The Project watershed includes MPU drainage basins GD24AA-C, GD 20AA-C and GC20AB-C. The watershed is mostly low density residential with some higher density residential, a school, and pockets of undeveloped desert lots.

This Alternative Alignment Study has been prepared to analyze and recommend the preferred alignment for the Project. Three alignments were evaluated against key factors including storm water collection, dry lane criteria, cost effectiveness, facility functionality, constructability, mitigation of sediment displacement, and utility conflicts and relocations.

Hydrologic analysis was performed using the HEC-1 computer program to develop 100-year design flows. These design flows are subsequently used in the hydraulic analysis for preliminary analysis and sizing of the conveyance and collection facilities.

The layouts of the MPU basins were reviewed. The external boundaries of the watershed's tributary area were verified based on aerial topography obtained for the Project and field reviews of the Project area. However, the basin boundaries within the Project limits were adjusted to coincide with aerial contour mapping. Additionally, split flow calculations were prepared at key roadway intersections to further refine the flow rates and directions.

The three alignments analyzed in this report are:

Alignment A - Buffalo Drive

The base alternative, which provides an MPU facility within Buffalo Drive between Lone Mountain Road and Washburn Road. Laterals are provided within Lone Mountain Road and Washburn Road.

Alignment B Conough Lane

Proposes an MPU facility on Lone Mountain Road between Buffalo Drive and Conough Lane, and on Conough Lane between Lone Mountain Road

and Washburn Road. Laterals are provided within Lone Mountain Road, Buffalo Drive, and Washburn Road.

Alignment C - Cimarron Road

Proposes an MPU facility on Lone Mountain Road between Buffalo Drive and Cimarron Road, and on Cimarron Road between Lone Mountain Road and Washburn Road. Laterals are provided within Lone Mountain Road, Buffalo Drive, and Washburn Road.

The table below shows the evaluation criteria and scoring for each alternative.

No.	Criterion	Alignment A	Alignment B	Alignment C
1	Hydraulics	54	81	63
2	Street Spread Criteria	32	72	72
3	Local Drainage Issues	20	45	35
4	Constructability	28	49	42
5	Maintenance	12	20	20
6	Right of Way	1	1	1
7	Cost	48	24	30
-	Total Alignment Score	195	292	263
Criterion	Alignment Rank	3	1	2

The alternative analysis is recommending Alignment B - Conough Lane be selected for design and construction. Alignment B is the most efficient storm drain system, aligned with the existing flow pattern, maximizing the available capacity of the existing tie in facility, and providing storm drain slopes that reduce facility sizes and improve hydraulics. Alignment B also provides the most beneficial use to the community, addressing local drainage issues and providing for future expansion. This alignment will require an MPA, which should be performed prior to the 90% design submittal.

Street Spread Criteria

2

32

72

72

3

Local Drainage Issues

20

45

35

4

Constructability

28

49

42

5

Maintenance

12

20

20

GOWAN NORTH BUFFALO BRANCH - LONE MOUNTAIN TO WASHBURN

15% ALTERNATIVE ALIGNMENT STUDY

6

Right of Way

1

TABLE OF CONTENTS

1.0 INTRODUCTION AND PURPOSE	9
1.1 Location of Project	9
1.2 Project Description	9
1.3 Drainage Design Scope	9
1.4 Alternative Alignment Study Scope	10
2.0 GENERAL DRAINAGE DESCRIPTION	11
2.1 Project Site Characteristics and Drainage Patterns	11
2.2 Ownership and Zoning	11
2.3 FEMA Flood Insurance Rate Maps	11
2.4 Reference Studies	12
2.5 Regional Flood Control Facilities	12
2.6 Existing Local Facilities	13
2.7 Existing Drainage Concerns	14
2.7.1 Cimarron Road and Lone Mountain Road	14
2.7.2 Conough Lane and La Madre Way	21
2.7.3 Lone Mountain Road West of Buffalo Drive	25
2.7.4 Buffalo Drive North of Lone Mountain Road	30
3.0 HYDROLOGY	32
3.1 Design Criteria	32
3.2 Hydrologic Method	32
3.2.1 Rainfall Area and Intensities	32
3.2.2 Curve Number, Soil Types and Land Use	32
3.2.3 Time of Concentration and Lag Time	32
3.3 Watershed Boundaries	33
3.4 Ultimate Condition Hydrology	34
3.5 Flow Splits	34
3.6 Alignment Specific Hydrology	37
3.6.1 Alignment A – Buffalo	37
3.6.2 Alignment B – Conough	37
3.6.3 Alignment C – Cimarron	38
4.0 HYDRAULICS	39
4.1 Design Criteria	39
4.1.1 Street Capacity	39
4.1.2 Drop Inlets	39
4.1.3 Storm Drain	40
4.2 Existing Street Capacity	40
4.3 Existing Regional Facility Capacity	40
4.4 Alignment Specific Storm Drain Hydraulics	42
4.4.1 Alignment A – Buffalo	42
4.4.2 Alignment B – Conough	42
4.4.3 Alignment C – Cimarron	43
5.0 DROP INLET ALTERNATIVES	44
6.0 QUANTITY AND COST ESTIMATE	47
7.0 ALIGNMENT ALTERNATIVE EVALUATION	48

7.1	Evaluation Criteria	48
7.1.1	Hydraulics.....	48
7.1.2	Street Spread Criteria.....	50
7.1.3	Local Drainage Issues	50
7.1.4	Constructability.....	51
7.1.5	Maintenance	52
7.1.6	Right of Way	53
7.1.7	Cost.....	53
7.2	Weighting Factors.....	53
7.3	Alignment Selection.....	54
8.0	RECOMENDATION	55
9.0	REFERENCES.....	56

LIST OF TABLES

Table 2. 1:	Regional Flood Control Facilities.....	12
Table 2. 2:	Photo Log at Cimarron Road and Lone Mountain Road.....	14
Table 2. 3:	Photo Log at Conough Lane and La Madre Way	21
Table 2. 4:	Photo Log along Lone Mountain Road	25
Table 2. 5:	Photo Log along Buffalo Drive.....	30
Table 3. 1:	Basin Parameters and Flows.....	34
Table 3. 2:	Sub-Basin Flows	35
Table 5. 1:	Inlet Evaluation.....	45
Table 6. 1:	Preliminary Cost by Alternative	47
Table 7. 1:	Evaluation Criteria	48
Table 7. 2:	Hydraulics.....	49
Table 7. 3:	Street Spread Criteria.....	50
Table 7. 4:	Local Drainage Issues.....	51
Table 7. 5:	Constructability.....	52
Table 7. 6:	Maintenance.....	53
Table 7. 7:	Right of Way	53
Table 7. 8:	Cost.....	53
Table 7. 9:	Weighting Factors	54
Table 7. 10:	Alignment Selection.....	54

APPENDICES

Appendix A - Figures & Maps

- A.1 - Vicinity Map
- A.2 - Alternative Alignments Map
- A.3 - 2013 MPU Hydrologic Map
- A.4 - 2013 MPU Facilities Map
- A.4A - 2013 MPU Facility Inventory
- A.5 - FEMA FIRM Panels
- A.6 - McCarran Airport Rainfall Area - HCDDM Figure 513
- A.7 - 10-year Depth-Duration-Frequency - Values - HCDDM Figure 503
- A.7A - 100-year Depth-Duration-Frequency - Values - HCDDM Figure 506
- A.8 - Depth-Duration-Frequency-Values - HCDDM Table 505
- A.9 - Six Hour Storm Distributions (SDN3) - HCDDM Table 503
- A.10 - Six Hour Depth - Area Reduction Factors - HCDDM Table 502

Appendix B - Hydrology

- B.1 - Revised Major Basin Drainage Map
- B.2 - HEC-1 Output
- B.3 - Dimensional Simplification of Manning's Equation
- B.4 - Flow Split Table
- B.5 - Flow Split Map
- B.6 - Alignment A - Facility and Flow Map
- B.7 - Alignment B - Facility and Flow Map
- B.8 - Alignment C - Facility and Flow Map

Appendix C - Hydraulics

- C.1 - Dry Lane in Lone Mountain Road Figure
-
-

Appendix D - Reference

- D.1 - As-Builts
- D.2 - Meeting Minutes
- D.3 - Citizen Complaint for Bubbler System

Appendix E - CD

- E.1 - Half Street Capacity for Flow Splits
- E.2 - Normal Depth Calculations in Existing Lone Mountain Road
- E.3 - Flowmaster Output for Alternative Alignments

THIS PAGE INTENTIONALLY LEFT BLANK

1.0 INTRODUCTION AND PURPOSE

1.1 Location of Project

The three alternatives studied in this report are for Gowan North Buffalo Branch – Lone Mountain to Washburn (Project). The alternative alignments are located between Buffalo Drive to the east, Cimarron Road to the west, Washburn Road to the north and Lone Mountain Road to the south. The proposed improvements fall within two jurisdictions, the City of Las Vegas (City) and Clark County (County). The Project is located in Township 19 south, Range 60 east, in Sections 33 and 34, with a portion of the Project falling within Township 20 south, Range 60 east, Sections 3 and 4. Refer to Appendix A.1 for the vicinity map.

1.2 Project Description

The purpose of the Project is to provide a Clark County Regional Flood Control District (CCRFCD) Master Plan flood control facility to collect major storm flows generated within the Project watershed. The facility is designated within the 2013 CCRFCD Master Plan Updated (MPU) as GOBU 0112 and GOBU 0136. This facility will be the final extension of the Gowan North Buffalo Branch system.

1.3 Drainage Design Scope

In addition to this alternative analysis study, the Project includes the design and preparation of contract drawings, special provisions and cost estimates for the Gowan North Buffalo Branch – Lone Mountain to Washburn storm drain (GOBU 0112 and 0136). The facility will be designed according to City of Las Vegas and Clark County drainage design criteria.

For the purpose of this report, the following basic definitions are used:

- Existing condition: Condition of the watershed as it exists today with existing MPU facilities in place.
- Interim condition: Condition where the Project improvements are in place while development within the watershed and other MPU facilities remain as they exist today.
- Ultimate condition: Condition where the Project improvements are in place with all existing and proposed MPU facilities built out and fully functional and all future development is considered constructed based on the current land use zoning.

The MPU facility will be designed to convey the ultimate condition 100-year storm flows. The system will also be evaluated for impacts in the interim condition. Design includes analysis of offsite and onsite flows, evaluation of existing storm drain facilities, identification of potential utility conflicts and relocations, and proposing new local storm drain systems as required.

1.4 Alternative Alignment Study Scope

This 15% Alternative Alignment Study will evaluate three storm drain collection system alternatives to determine which alignment is the most effective and recommend a preferred alternative for detailed design and construction. Each alignment studied includes a main line storm drain, with lateral collection systems not to exceed a quarter mile in length. The study also includes an evaluation of three different types of catch basins to maximize capture efficiency in undeveloped, rural roadway segments. The following alignments are considered. See Appendix A.2 for an Alternative Alignment Map.

Alignment A: Buffalo Drive

Main Line – Buffalo Drive from Lone Mountain Road to Washburn Road

Lateral – Washburn Road from Buffalo Drive to Conough Lane

Lateral – Lone Mountain Road from Buffalo Drive to Conough Lane

Alignment B: Conough Lane

Main Line – Lone Mountain Road from Buffalo Drive to Conough Lane

Main Line – Conough Lane from Lone Mountain Road to Washburn Drive

Lateral – Buffalo Drive from Lone Mountain Road to La Madre Way

Lateral – Lone Mountain Road from Conough Lane to Cimarron Road

Lateral – Washburn Drive from Conough Lane to Cimarron Road.

Alignment C: Cimarron Road

Main Line – Lone Mountain Road from Buffalo Drive to Cimarron Road

Main Line – Cimarron Road from Lone Mountain Road to Washburn Drive

Lateral – Buffalo Drive from Lone Mountain Road to Washburn Drive

Lateral – Washburn Drive from Cimarron Road to Tomsik Street

Alignment A is the base alternative, matching the alignment presented in the MPU. Alignment B or C, would require a Master Plan Amendment (MPA).

2.0 GENERAL DRAINAGE DESCRIPTION

2.1 Project Site Characteristics and Drainage Patterns

The limits of the watershed tributary to the Project extend from Buffalo Drive on the east to El Capitan Way on the west and from Lone Mountain Road on the south to Ann Road on the north. The Project watershed includes MPU drainage basins GD24AA-C, GD20AA-C and GC20AB-C. The watershed is mostly low density residential with some higher density residential, a school, a park, and pockets of undeveloped desert lots. Refer to Appendix A.3 - 2013 MPU Hydrologic Map.

The drainage pattern is generally from northwest to southeast, with the streets either carrying flow south or east as it flows towards the intersection of Buffalo Drive and Lone Mountain Road. The primary drainage conveyance facilities within the watershed are streets and small swales alongside the streets. There are existing inlets and storm drain pipe along Durango Road and Lone Mountain Road.

The existing Gowan North Buffalo Branch MPU facility provides flood protection for US95 and conveys storm runoff south to the existing Upper Gowan North Detention Basin (GONO 0008). The system begins near the intersection of Alexander Road and Buffalo Drive, and extends north, terminating at the intersection of Buffalo Drive and Lone Mountain Road (GOBU 0000, GOBU 0032, GOBU 0058, and GOBU 0085). Per the MPU, runoff from the Project watershed is collected and conveyed to the upstream end of GOBU 0085. Refer to Appendix A.4 and A.4A for the 2013 MPU Facilities Map and Inventory.

2.2 Ownership and Zoning

The Project watershed is primarily within County jurisdiction, with sporadic pockets of City jurisdiction.

The City and County have different offsite requirements for land development. As a result, most of the roads within the Project watershed have intermittent curb and gutter that starts and stops based on jurisdictional boundaries. Much of the Project watershed is comprised of rural residential neighborhoods. Within the County, there is a Residential Neighborhood Preservation (RNP) overlay, which was established to ensure that the rural character of residential development is preserved. As such, many communities within RNP preserve unpaved shoulders within street right of way.

2.3 FEMA Flood Insurance Rate Maps

Special Flood Hazard Areas (SFHA) for the Project are outlined in the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) 32003C1745 E and 3200C2135 F, dated September 27, 2002 and November 16, 2011 respectively. These two maps have a Letter of Map Change that revalidates the determinations for properties in the referenced community, dated

November 17, 2011. Upon reviewing Map Numbers 32003C1745 E and 3200C2135 F, the proposed site lies within a FEMA designated Zone X. This area is described to be outside of the 0.2% annual chance floodplain, which indicates the Project area is not located within a FEMA floodplain. Refer to Appendix A.5.

2.4 Reference Studies

The following reference materials were reviewed:

- 2013 CCRFCD MPU study is referenced to identify the most current developments and existing regional flood control facilities within the Project watershed.
- GC Wallace, 1999 Drainage Study for Road Improvements for Buffalo Drive Between Cheyenne Avenue and Lone Mountain Road. This report covers design of the existing Gowan North Buffalo Branch system.
- Technical Drainage Studies from land development within City and County.
- As-built plans from utility companies. The companies contacted include Southwest Gas, Nevada Energy, Clark County Water Reclamation District, Century Link, City of Las Vegas, Cox Communications, and Las Vegas Valley Water District. A utility matrix can be found in Appendix C.

A full list of references can be found in Section 9.0 References.

2.5 Regional Flood Control Facilities

The following regional flood control facilities drain north to south and are referenced directly from the 2013 MPU.

Table 2. 1: Regional Flood Control Facilities

Condition	Facility ID	From	To	RCB Size	MPU Flow
(-)	(-)	(-)	(-)	(W ft x H ft)	(cfs)
Proposed	GOBU 0136	Washburn Road	La Madre Way	7 x 6	344
Proposed	GOBU 0112	La Madre Way	Lone Mountain Road	8 x 6	484
Existing	GOBU 0085	Lone Mountain Road	Red Coach Avenue	11 x 5	614
Existing	GOBU 0058	Red Coach Avenue	Craig Road	(2) 11 x 4	745
Existing	GOBU 0032	Craig Road	Hickam Avenue	(2) 12 x 5	850
Existing	GOBU 0000	Hickam Avenue	Alexander Road	(2) 12 x 6	961

The Buffalo Branch system ultimately connects to the 921 ac-ft Gowan North Detention Basin (GONO 0008).

See Appendix A.4 for MPU facility map. As-built plans for facility GOBU 0085 are provided in Appendix D.

2.6 Existing Local Facilities

The following is a summary of the existing, locally maintained storm drain facilities in the Project's watershed area. See Appendix A.4 for a map of their locations.

Lone Mountain Road System

There is an existing storm drain system located within Lone Mountain Road between Buffalo Drive and Conough Lane. The trunkline consists of a 48-inch Reinforced Concrete Pipe (RCP) which transitions to a 60-inch RCP just before connecting to Regional facility GOBU 0136. There are four (4) 20-foot long curb opening and grate inlets located on Lone Mountain Road just west of Buffalo Drive, two (2) on the north side and two (2) on the south side. There are additional inlets along the curb on the south half of Lone Mountain Road, west of Buffalo Drive. One is located approximately 80 feet east of Miller Lane. Another is at the southwest corner of the Miller Lane intersection and the last is at the southeast corner of the Conough Lane intersection.

At the corner of Cimarron Road and Lone Mountain Road, there is a bubbler system that collects runoff from the Cimarron Estates Community, conveys flow under Cimarron Road in an 18-inch RCP, then bubbles out on the east side of Cimarron Road.

A concrete swale lined with rock, located from Cimarron Road to Conough Lane, drains to an 18-inch concrete culvert at the southwest corner of Lone Mountain Road and Conough Lane. The flow continues east in a 42-inch RCP under Lone Mountain Road.

A 4-foot by 2-foot reinforced concrete box (RCB) at the southwest corner of Durango Drive and Lone Mountain Road collects flow from Mountain Crest Park. The RCB crosses underneath Durango Drive to a bubbler grate at the southeast corner. The flow spills out of the grate and continues east on Lone Mountain Road.

Durango Drive System

The Durango Drive local storm drain system runs from the intersection of Lone Mountain Road to Hammer Lane. The system starts at Hammer Lane as a 24-inch RCP and runs south to Lone Mountain Drive, increasing in size to a 30-inch RCP, 36-inch RCP and 42-inch RCP. The system connects to the 4-foot by 2-foot RCB system located in Lone Mountain Drive. Storm drain inlets are located along Durango Drive on both the west and east sides.

Buffalo Drive System

There are existing storm drain inlets at the northwest and northeast corners of the intersection of Buffalo Drive and Lone Mountain Road. These inlets connect to an existing 8-foot by 3-foot RCB in Buffalo Drive, which continues south on Buffalo Drive.

2.7 Existing Drainage Concerns

There are several areas of local flooding within the Project watershed. The following sections summarize several key locations.

2.7.1 Cimarron Road and Lone Mountain Road

CCRFC D has received citizen complaints about the frequent flooding at this intersection. See Appendix D for a citizen complaint about this intersection, received on October 15, 2014. The complaint cites that waters continually back up to the properties. The existing bubbler system is ineffective and roadway runoff ponds at the corner.

Table 2. 2: Photo Log at Cimarron Road and Lone Mountain Road

Photo	Description
Photo 2.1	These photos are taken several days after a minor storm. The photos show the condition of the bubbler system and evidence of high water marks for a frequent storm. It is evident that flows fill the ditch and roadway, reaching a depth above the curb height. Sediment is deposited during a storm and can be observed in the post storm photos.
Photo 2.2	
Photo 2.3	
Photo 2.4	
Photo 2.5	
Photo 2.6	
Photo 2.7	These photos are taken during a minor storm event. The photos show extensive ponding at the intersection, with flow completely covering Cimarron Road and spreading into Lone Mountain Road.
Photo 2.8	
Photo 2.9	

Cimarron Road and Lone Mountain Road	
Photo 2. 1: Cimarron Road at Lone Mountain Road looking S Date: 9/11/2014, several days after a minor storm	
Photo 2. 2: Ditch at headworks of bubbler system, looking S Date: 9/11/2014, several days after a minor storm	

Cimarron Road and Lone Mountain Road	
Photo 2. 3: Sediment after ponding, looking S Date: 9/11/2014, several days after a minor storm	
Photo 2. 4: Evidence of ponding above top of curb, looking SW Date: 9/11/2014, several days after a minor storm	

Cimarron Road and Lone Mountain Road	
Photo 2. 5: Bubbler system headworks, looking E Date: 9/11/2014, several days after a minor storm	
Photo 2. 6: Outlet of bubbler system on northeast corner, looking NE Date: 9/11/2014, several days after a minor storm	

Cimarron Road and Lone Mountain Road

Photo 2. 7: Ponding above top of curb, west half of Cimarron Road, looking SW

Date: 9/26/2014, during a minor storm



Cimarron Road and Lone Mountain Road

Photo 2. 8: Ponding, crown of Cimarron Road, looking S

Date: 9/26/2014, during a minor storm



Cimarron Road and Lone Mountain Road

Photo 2. 9: Minimal ditch capacity, E half of Cimarron Road, looking S

Date: 9/26/2014, during a minor storm



2.7.2 Conough Lane and La Madre Way

The gradual slopes at poorly defined street sections at the intersection of Conough Lane and La Madre Way result in shallow flooding and ponding. Flow from the west hits the intersection, crosses Conough Lane, and splits to the east and south. Flow traveling south ponds south of the intersection, on the east half of Conough Lane.

Table 2. 3: Photo Log at Conough Lane and La Madre Way

Photo	Description
Photo 2.10	These photos show flow spreading across the intersection, spilling across Conough Lane and ponding on the east half of Conough Lane.
Photo 2.11	
Photo 2.12	Flow ponding within Conough Lane south of La Madre

Conough Lane and La Madre Way
Photo 2. 10: Flow split and ponding in Conough Lane, looking N
Date: 9/26/2014, during a minor storm



Conough Lane and La Madre Way

Photo 2. 11: Ponding on E half of Conough Lane, S of La Madre Way, looking E

Date: 9/26/2014, during a minor storm



Conough Lane and La Madre Way

Photo 2. 12: Ponding across Conough Lane, S of La Madre Way, looking S

Date: 9/26/2014, during a minor storm



2.7.3 Lone Mountain Road West of Buffalo Drive

The stretch of Lone Mountain Road between Buffalo Drive and Cimarron Road currently experiences significant spread and flow depths. As an arterial roadway, this road is expected to be subject to high traffic volumes in the future. The following photos show observed flow depths during a frequent storm.

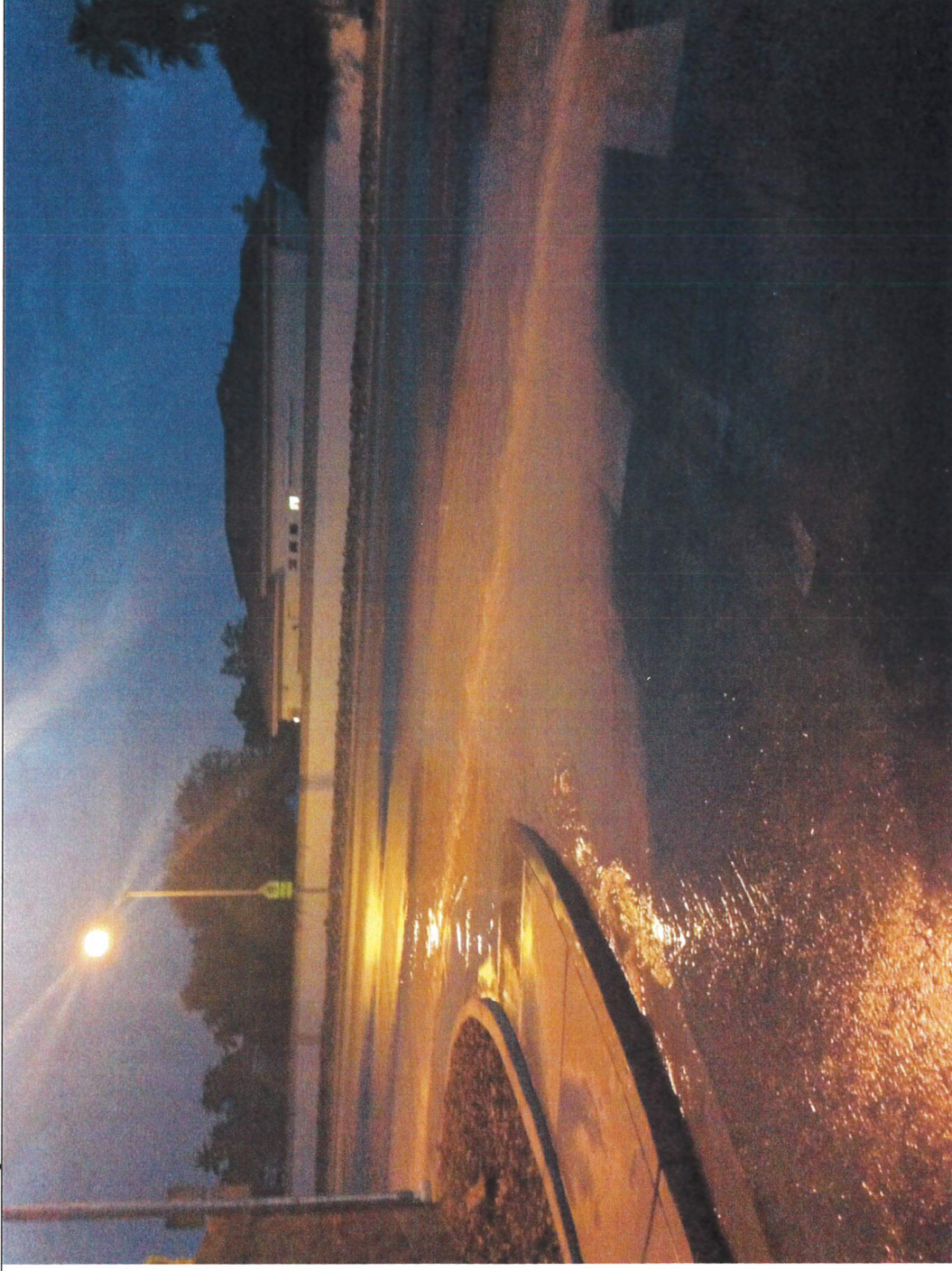
Table 2. 4: Photo Log along Lone Mountain Road

Photo	Description
Photo 2.13	Shows flow depths above top of curb within Lone Mountain Road at Valadez Street
Photo 2.14	Shows flows within the north half of Lone Mountain Road at Conough Lane with depths approaching the crown of Lone Mountain Road.
Photo 2.15	
Photo 2.16	Photo showing flows spreading into travel lane of Lone Mountain Road during a minor storm.

Lone Mountain Road

Photo 2. 13: Lone Mountain Road at Valadez Street, looking S.
Flow depths above top of curb

Date: 9/26/2014, during a minor storm



Lone Mountain Road

Photo 2. 14: Lone Mountain Road at Conough Lane, looking S.
Flows crossing Conough Lane

Date: 9/26/2014, during a minor storm



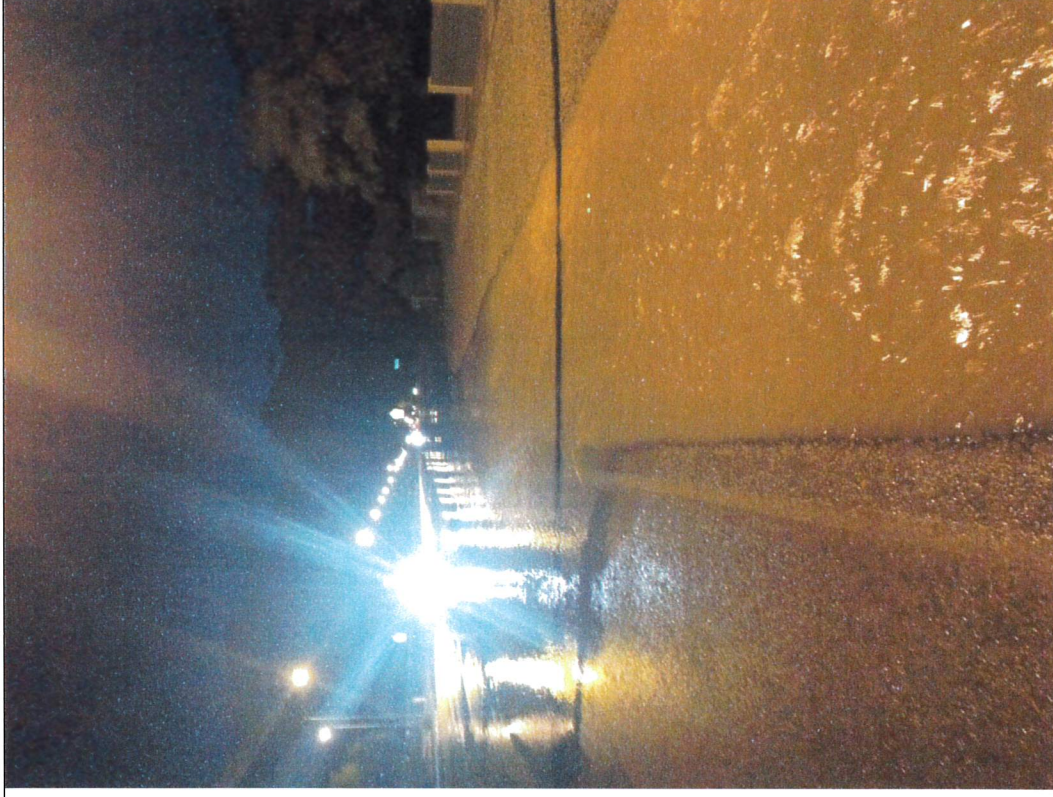
Lone Mountain Road
Photo 2. 15: Lone Mountain Road at Conough Lane, looking SE. Ponding on E half of Conough Lane, flow depths approaching crown in Lone Mountain Road Date: 9/26/2014, during a minor storm


Lone Mountain Road

Photo 2. 16: N half of Lone Mountain Road W of Buffalo Drive, looking W.

Spread encroaching into travel lane, nearing crown

Date: 9/26/2014, during a minor storm



2.7.4 Buffalo Drive North of Lone Mountain Road

Buffalo Drive is superelevated to the east, north of Lone Mountain Road. The transition from crown to superelevation causes flow to sheet east over Buffalo Drive. The following photos show flow crossing Buffalo Drive.

Table 2. 5: Photo Log along Buffalo Drive

Photo	Description
Photo 2.17	Photos show runoff sheet flowing over Buffalo Drive and draining in a ditch on the east half of Buffalo Drive.
Photo 2.18	

Buffalo Drive and Lone Mountain Road	
Photo 2. 17: Buffalo Drive N of Lone Mountain Road, looking N	Photo 2. 18: Sheet flow over Buffalo Drive at Verde Way, looking N
Date: 9/26/2014, during minor storm	Date: 9/26/2014, during minor storm
	

3.0 HYDROLOGY

3.1 Design Criteria

The design events evaluated for this Project were the 10-year and 100-year events, for a 6-hour return period, per the design criteria set forth in the CCRFCD Hydrologic Criteria and Drainage Design Manual (HCDDM).

3.2 Hydrologic Method

The US Army Corps of Engineers computer software HEC-1 Flood Hydrograph Package (USACOE, 1998) was used to develop peak flows to assess impacts to the Project site. The HEC-1 model for the Project is based on the Series A, SDN 3 Gowan Watershed MPU model, which was last updated in 2008. Series A is selected because the watershed is upstream of detention, where storm centering controls. The model was truncated to focus on the Project watershed, and modified to reflect the watershed parameters determined as part of this detailed study.

3.2.1 Rainfall Area and Intensities

The Project watershed site is located within the McCarran Airport Rainfall Area, in Sections 33 and 34 of Township 19 south, Range 60 east, Clark County, Nevada. Refer to Appendix A.6. The Depth-Duration-Frequency curves from Figures 503 and 506 of HCDDM are used to obtain the rainfall depths. Refer to Appendix A.7 and A.7A. The 10-year and 100-year 6-hour rainfall depths are 1.58 inches and 2.77 inches respectively. Refer to Appendix A.8. An SCS Type II SDN3 storm distribution was used due to the total drainage area being less than 8 square miles. Refer to Appendix A.9 and A.10 for the storm distribution and depth-area reduction factor tables.

3.2.2 Curve Number, Soil Types and Land Use

Precipitation losses were determined using the SCS Curve Number Method in accordance with Section 603 of HCDDM. The curve number is a parameter assigned to the drainage basin and used in the HEC-1 model to estimate rainfall loss from infiltration. The value of the curve number (CN) is based on the basin land use, soil type, and antecedent moisture condition (AMC). For the Las Vegas valley, an AMC-II condition is used for determining storm runoff.

The Project watershed lies within a partially developed rural area with most of the area being residential lots and pockets of undeveloped desert lots. The Project watershed consists of B and D soil types. The CN values utilized for the runoff calculations for the Project were calculated using the soil group and ultimate condition land use information provided in the 2013 MPU.

3.2.3 Time of Concentration and Lag Time

For the HEC-1 model, the time of concentration (Tc) and lag time calculations are performed per the procedures in the HCDDM.

3.3 Watershed Boundaries

The MPU basins are long and narrow, and are shown to drain from west to east until they reach Buffalo Drive. The MPU assumes that basins GD24AA-C and GD20AA-C contribute to proposed facility GOBU 0136 in Buffalo Drive. The MPU then assumes that basin GD20AB-C drains west to east to Buffalo Drive and is added to the total flow within proposed facility GOBU 0112.

The MPU takes a broad scale, planning level view of the drainage pattern within the valley and delineates basins that contribute to each facility. As part of this study, a detailed review of the Project watershed was performed to confirm watershed boundaries and flow pattern. Aerial survey was collected for the portion of the Project watershed between Cimarron Road and Buffalo Drive. Additional ground survey was attained at ten (10) key intersections. Numerous site visits were performed as well as review of Technical Drainage Studies in the neighborhoods. This extensive review resulted in a detailed view of the drainage pattern and flows that are being routed along roadways within the Project watershed.

It was confirmed that the outer boundary of the Project watershed matches what is presented in the MPU for basins GD24AA-C, GD20AA-C and GD20AB-C. The western boundary of the Project watershed is defined by the future MPU facility GOEC 0000 through GOEC 0076. This is an appropriate assumption since the MPU facility will be designed to ultimate condition, which includes construction of the GOEC system. The northern boundary of the watershed at Ann Road is preserved by a distinct highpoint within Durango Road just south of Ann Road that prevents any flow north of Ann Road entering into the Project watershed. In addition, there is a similar high point in Durango Road, just south of Lone Mountain Road, that prevents flow from leaving the watershed on the southern boundary. The only exception found is that the existing 4-foot x 2-foot RCB at the corner of Lone Mountain Road and Durango Drive contributes approximately 48 cfs in the 100-year event to the Project watershed. This runoff is generated within Mountain Crest Park, which is located outside of the watershed boundary.

Within the Project watershed it was found that the drainage pattern differs from what is presented in the MPU. In general, it was found that a large portion of the watershed drains south to Lone Mountain Road before traveling east to the collection point at Lone Mountain Road and Buffalo Drive. This is mostly due to existing roadway geometry at certain intersections. For example, there is an existing concrete valley gutter at the corner of Cimarron Road and La Madre Way that directs flow to drain from north to south through the intersection. The Project watershed has been divided into three (3) major basins. Basin LNMTN drains south toward Lone Mountain Road, BUFF-S drains east towards Buffalo Drive, and BUFF-N drains to Washburn Road and is conveyed to the north end of Buffalo Drive. See Appendix B for the major drainage basins as determined in this study. Once the overall drainage pattern was identified, the hydrology was

further refined by evaluating flow splits at key intersections. Section 3.5 discusses the refinement of sub-basins, evaluates flow splits and presents the existing drainage pattern accounting for flow splits.

3.4 Ultimate Condition Hydrology

The alternative alignment analysis has been performed based on the ultimate condition hydrology, which is the design condition for the MPU facility.

For the 15% design, the HEC-1 model was only run for the 100-year storm event. The 10-year flowrate was then established based on a ratio of 0.57, which is the ratio of 10-year rainfall depth to 100-year rainfall depth.

Table 3.1 summarizes the design parameters and flowrates for the three (3) major drainage basins that make up the Project watershed.

Table 3. 1: Basin Parameters and Flows

Basin ID	Area	CN	Lag	Q10	Q100
(-)	(sq-mi)	(-)	(hr)	(cfs)	(cfs)
BUFF-N	0.12	77.3	0.250	43	75
BUFF-S	0.14	78.0	0.400	44	77
LNMTN	0.90	78.0	0.750	183	321

See Appendix B for HEC-1 output.

3.5 Flow Splits

The 100-year design storm will produce higher magnitude flowrates that will exceed the capacity of roadway intersections. This creates the potential for flow splits, which would affect the overall drainage pattern within the Project watershed.

The three (3) major drainage basins were divided into sub-basins that were named according to the adjacent street intersection. For the purpose of the 15% analysis, the 100-year flow rate for each sub-basin was determined by multiplying the sub-basin/basin area ratio to the basin flow rate of the major drainage basin it falls within. Table 3.2 summarizes the sub-basins contributing to each intersection.

Table 3. 2: Sub-Basin Flows

Intersection	Sub-Basin Name	Sub-Basin Area	Major Basin Name	Area Ratio of Major Basin	Sub-Basin 100-year Flow
(-)	(-)	(sq-ft)	(-)	(-)	(cfs)
Buffalo & La Madre	BUF-LAM	930145	BUFF-S	0.233	18.0
Buffalo & Lone Mountain	BUF-LNM	327024	BUFF-S	0.082	6.3
Buffalo & Rosada	BUF-ROS	768880	BUFF-S	0.193	14.9
Cimarron & Rosada	CIM-ROS	293641	BUFF-S	0.074	5.7
Cimarron & La Madre	CIM-LAM	2558528	LNMTN	0.102	32.7
Conough & La Madre	CON-LAM	921257	BUFF-S	0.231	17.8
Conough & Lone Mountain	CON-LNM	606000	LNMTN	0.024	7.7
Conough & Rosada	CON-ROS	729426	BUFF-S	0.183	14.1
Durango & Fisher	DUR-FIS	1574744	LNMTN	0.063	20.1
Durango & Hammer	DUR-HAM	4155191	LNMTN	0.166	53.1
Durango & Lone Mountain	DUR-LNM	6825498	LNMTN	0.272	87.3
Durango & Washburn	DUR-WAS	2237465	LNMTN	0.089	28.6
Lone Mountain & Buffalo	LNM-BUF	1437787	LNMTN	0.057	18.4
Lone Mountain & Cimarron	LNM-CIM	1022691	LNMTN	0.041	13.1
Lone Mountain & Conough	LNM-CON	1365875	LNMTN	0.054	17.5
Lone Mountain & Tomsik	LNM-TOM	2493165	LNMTN	0.099	31.9
Tomsik & Rosada	TOM-ROS	599391	LNMTN	0.024	7.7
Washburn & Buffalo	WAS-BUF	187202	BUFF-N	0.058	4.4
Washburn & Cimarron	WAS-CIM	886392	BUFF-N	0.277	20.7
Washburn & Conough	WAS-CON	288912	BUFF-N	0.090	6.8
Washburn & Tomsik	WAS-TOM-N	1823191	BUFF-N	0.569	42.7
Washburn & Tomsik	WAS-TOM-S	240746	LNMTN	0.010	3.1

Many of the roads within the Project watershed are rural roads with paved travel lanes but no curb, gutter or sidewalk. Drainage is provided in shallow roadside ditches. This means that the intersections often lack well defined flow lines. Conventional methods for determining flow splits at intersections rely heavily on knowledge about the gutter flow lines. For the purpose of this 15% analysis, flow split calculations have been simplified. If a well defined crown is present in one of the intersecting roads, a half street capacity calculation was performed. If the half street capacity exceeds the total runoff contributing to the intersection, it is assumed that all flow is contained within the half street. If the flowrate contributing to the intersection exceeds the half street capacity, the excess flow is split according to the roadway width and slope of the two downstream streets. By simplifying the Manning's equation, it can be shown that the total flow contributing to an intersection Q_T can be represented as a function of roadway width W and longitudinal slope S .

$$Q_T \propto WS^{\frac{1}{2}}$$

By conservation of mass and energy, it can also be said that the total flow entering the intersection Q_T must equal the combined flow leaving the intersection via the south and east roads

$$Q_T = Q_S + Q_E$$

It is then possible to solve the two equations to estimate the flow splitting to the south versus east using a ratio based on the width and slope of the south and east roads.

$$Q_S = \frac{Q_T \left(\frac{W_S S_S^{1/2}}{W_E S_E^{1/2}} \right)}{\left[1 + \left(\frac{W_S S_S^{1/2}}{W_E S_E^{1/2}} \right) \right]}$$

See Appendix B for a worksheet showing the dimensional simplification of the Manning's equation to a ratio based on roadway geometry.

See Table in Appendix B for the application of this ratio and a summary of flow splits at eight (8) key intersections in the Project watershed.

See Appendix E, on CD, for half street capacity calculations in support of flow split calculations.

The following summarizes a few roadway sections and intersections of note that affect the overall existing drainage pattern.

- Durango Road between Hammer Lane and Fisher Avenue: Durango Road is superelevated to the east. All flow within Durango Road will drain east.
- Durango Road at Washburn: Durango Road is in crown and the west half street capacity of Durango Road can contain the 100-year flow. The same goes for Durango Road at La Madre Way. Hence, all runoff generated west of Durango Road and south of Fisher Avenue drains south to Lone Mountain Road.
- Washburn Road at Tomsik Street: A flow split occurs, with 70% of flow draining east down Washburn Road.
- Washburn Road between Tomsik Street and Conough Lane: Washburn Road is superelevated to the north and the north street capacity contains the 100-year flow. Between Conough Lane and Buffalo Drive, Washburn Road switches back to a crown section, with minimal runoff contributing to the south half. Runoff is conveyed east to Buffalo Drive.
- Tomsik Street at Rosada Way: A flow split occurs with 66% of the flow draining south towards Lone Mountain.
- Cimarron Road at La Madre Way: A valley gutter on the west half of the intersection contains the 100-year flow and conveys all runoff south towards Lone Mountain Road.
- Conough Lane at La Madre Way: An approximately even flow split occurs.
- Buffalo Drive at Rosada Way: There is a dip in Buffalo Drive allowing flow to drain from west to east at Rosada Way and exit the basin area.

Overall it was determined that a large portion of the Project watershed drains south towards Lone Mountain Road rather than east toward Buffalo Drive. Approximately 58% of the Project watershed (276 cfs) will contribute to the design point at Buffalo Drive and Lone Mountain Road via Lone Mountain Road. Meanwhile, approximately 7% of the Project watershed (33 cfs) will contribute to the design point via Buffalo Drive. The remaining 35% (165 cfs) of the Project watershed currently drains east and would exit the watershed by crossing Buffalo Drive at Washburn Road and Rosada Way. In order to convey this flow to the design point, a north-south storm drain system will have to be constructed to cut off this flow.

See Appendix B.5 for a summary of the drainage pattern and flow splits within the Project watershed for the 100-year storm.

3.6 Alignment Specific Hydrology

3.6.1 Alignment A – Buffalo

Alignment A is the base alternative, which provides an MPU facility within Buffalo Drive between Lone Mountain Road and Washburn Road. Laterals are provided within Lone Mountain Road and Washburn Road to help facilitate the capture of flow within these streets. In this alternative, 100% of the Project watershed, 474 cfs, can be captured and routed to the design location. The only flow that would leave the watershed boundary would be nuisance inlet bypass. In general, Alignment A would result in 165 cfs being conveyed within the MPU facility in Buffalo Drive. The remaining flow from the Project watershed would be captured by the lateral facility within Lone Mountain Road. This alignment does not address local drainage issues at La Madre Way and Conough Lane or the bubbler at Lone Mountain Road and Cimarron Road, nor does it address spread issues within Lone Mountain Road.

See Appendix B.6 for a figure showing the total flow contributing to each facility in Alignment A.

3.6.2 Alignment B – Conough

Alignment B proposes an MPU facility on Lone Mountain Road between Buffalo Drive and Conough Lane, and on Conough Lane between Lone Mountain Road and Washburn Road. Laterals are provided within Lone Mountain Road, Buffalo Drive and Washburn Road to help facilitate the capture of flow within these streets. This alternative provides facilities that would address the existing flooding issues at La Madre Way and Conough Lane, as well as along Lone Mountain Road. A lateral within Lone Mountain Road extending to Cimarron Road would address the bubbler at this intersection. In this alternative, all of the Project watershed can be captured except for 19 cfs, which is generated east of Conough Road, north of La Madre Way. In general, Alignment B would result in 431 cfs being conveyed within the MPU facility in Lone Mountain Road. An additional 24 cfs from the Project watershed would be captured by the lateral

facility within Buffalo Drive, while 19 cfs leaves the watershed, crossing Buffalo Drive. This alignment address the local drainage issues at La Madre Way and Conough Lane as well as the bubbler at Lone Mountain Road and Cimarron Road, and the spread issues within Lone Mountain Road.

See Appendix B.7 for a figure showing the total flow contributing to each facility in Alignment B.

3.6.3 Alignment C – Cimarron

Alignment C proposes an MPU facility on Lone Mountain Road between Buffalo Drive and Cimarron Road, and on Cimarron Road between Lone Mountain Road and Washburn Road. Laterals are provided within Buffalo Drive, and Washburn Road to help facilitate the capture of flow within these streets. This alternative provides facilities that would address the existing flooding issues along Lone Mountain Road and the bubbler at Lone Mountain Road and Cimarron Road but would not address the intersection of La Madre Way and Conough Lane. In this alternative, all of the Project watershed can be captured except for 40 cfs, which is generated east of Cimarron Road, north of La Madre Way. In general, Alignment C would result in 400 cfs being conveyed within the MPU facility in Lone Mountain Road. An additional 33 cfs from the Project watershed would be captured by the lateral facility within Buffalo Drive, while 40 cfs leaves the watershed, crossing Buffalo Drive. This alignment address the bubbler at Lone Mountain Road and Cimarron Road, and the spread issues within Lone Mountain Road, but does not address the local drainage issues at La Madre Way and Conough Lane.

See Appendix B.8 for a figure showing the total flow contributing to each facility in Alignment C.

4.0 HYDRAULICS

The hydraulic analysis of the storm drain system is performed according to the procedures and criteria presented in CCRFCD HCDDM. The HCDDM criteria are presented below.

4.1 Design Criteria

4.1.1 Street Capacity

Street capacity calculations are based on CCRFCD criteria for the allowable capacity of a street in minor (10-year) and major (100-year) storm events:

Minor Storm – 10-year (Street right-of-way width $\geq$ 80 feet)

- A 12-foot wide dry lane shall be maintained in each direction (center turning lane cannot be used for a dry lane)
- The depth of flow at intersections with other streets with right of way widths greater than or equal to 80 feet shall be curb height (typically 6 inches) or less.
- The product of the flow depth (feet) in the gutter flow line times the average flow velocity (feet per second (fps)) shall be less than or equal to 6.

Minor Storm – 10-year (Street right-of-way width $<$ 80 feet)

- The depth of flow in the gutter flow line shall be less than or equal to 1 foot.
- The product of the flow depth (feet) in the gutter flow line times the average flow velocity (fps) shall be less than or equal to 6.

Major Storm – 100-year

- The product of the flow depth (feet) in the gutter flowline times the average flow velocity (fps) shall be less than or equal to 8.
- The depth of flow in the gutter flowline shall be less than or equal to 2 feet.
- The transverse street flow on through traffic streets shall be at a depth less than or equal to 1 foot and a depth times velocity less than or equal to 8. This shall not be used to determine the allowable transverse flow depth for a culvert.

4.1.2 Drop Inlets

A clogging factor of 50% has been applied to all drop inlets.

4.1.3 Storm Drain

- The minimum slope for storm drains is 0.25% and a minimum velocity of 3 fps shall be maintained.
- The minimum pipe size for storm drain laterals is 18 inches.
- The Hydraulic Grade Line (HGL) for storm drains will be 1 foot below the finished grade.
- Manholes are spaced at a maximum of 400 feet.

4.2 Existing Street Capacity

The analysis of the flow patterns within the tributary area show substantial flows on Lone Mountain Road (276 cfs). Because of these flows, CCRFCD dry lane criteria was checked on this roadway.

Lone Mountain Road (> 80-foot right-of-way) between Buffalo Drive and Cimarron Road does not meet dry lane criteria.

Cross sections were taken along Lone Mountain Road upstream of crossing intersections and at existing drop inlets. Normal depth was calculated using Flowmaster. At Cimarron Road the north half of Lone Mountain Road has minimal capacity. The capacity issue is exasperated by high flows entering the intersection and the existing bubbler system. Therefore, the majority of the 100-year flow weirs over the crown in Lone Mountain Road to the south half. There is an existing ditch within the right of way (ROW) on the south half of Lone Mountain Road that helps to convey this flow. 73 cfs is conveyed in the ditch while 125 cfs is conveyed within the street. At Conough Lane the ditch ends and flow from within this ditch is piped into the existing storm drain system within Lone Mountain Road. Heading east, the trend continues. The north half of Lone Mountain Road has minimal capacity, while the south half carries the burden. Existing inlets along Lone Mountain Road capture some of the runoff, but not enough to meet spread criteria. It is only at Buffalo Drive where the four (4) existing 20-foot inlets upstream of the intersection are able to capture the 100-year flow. Spread criteria is met downstream of the inlets, however, approximately 13 cfs does bypass the inlets

See Appendix C.1 for an exhibit showing the cross section locations and 100-year flow rates present within the street at each section as well as within the existing storm drain.

See Appendix E, on CD, for the normal depth calculations.

4.3 Existing Regional Facility Capacity

The existing MPU facility GOBU 0085 was designed prior to the 2008 MPU. During the 2008 update land use values were revised throughout the valley to reflect current zoning, resulting in higher peak flows in many watersheds. For the Project watershed, the MPU flows increased from 354 cfs (2002 MPU) to 484 cfs (2008 MPU). GOBU 0085 was designed for lower peak flows. As the

downstream tie in facility for the Project, it is critical to be sure that the proposed alignment selected would not surcharge the existing GOBU 0085 system.

A WSPG-W (windows) hydraulic model was developed to establish the conveyance capacity of the existing GOBU system. The existing Buffalo Storm Drain system was modeled based on as-builts of the system. The system was modeled from south of Red Coach Avenue up to the Lone Mountain Road and Buffalo Drive intersection. This section of the system consists of an existing 8-foot by 3-foot RCB, north of Lone Mountain Road, that transitions to a 11-foot by 5-foot RCB south of the Lone Mountain Road. A 60-inch RCP west of the Lone Mountain Road and Buffalo Drive intersection connects to the 11-foot by 5-foot RCB. The 11-foot by 5-foot RCB continues south to the Red Coach Avenue intersection, where it transitions to two (2) parallel 11-foot by 4-foot RCBs. A lateral system west of Red Coach Avenue connects to the system in Buffalo Drive. Storm drain inlets are located on both the west and east sides of the roadway throughout this stretch of the existing system.

The existing storm drain capacity of the regional facility was determined by seeing what peak flow rate could be placed in the system, while maintaining the CCRFCD requirement of having at least 1 foot of separation between the HGL and the finished grade. First, a comparison was made between the GC Wallace WSPG model output and the output generated by PB when building the WSPG-W model. Both outputs yielded similar results, using the same flowrates. Assumptions made for this analysis include having inlets capture 100% of the street flow and minor storm drain laterals not being included in the WSPG-W model. The model was then run again with increased flow to determine the maximum capacity. The WSPG-W model shows that the existing regional facility can take approximately 612 cfs before the 1-foot HGL criteria is not met in the 11-foot by 5-foot RCB.

The capacity of the existing system is sufficient for the Project watershed. The Project watershed generates a total of 474 cfs, so the 612 cfs capacity will not be exceeded. This means that the additional 48 cfs that contributes to the design point from the Mountain Crest Park outside of the Project watershed can be accommodated in the design.

The GC Wallace study performed in 1999 shows that the facility was designed to convey 441 cfs. The study included independent hydrology and complex routing which resulted in higher peak flows than the 2002 MPU. The GC Wallace as-builts also show that the HGL is contained within the box culvert, and is approximately four (4) feet below finished grade. This helps to confirm the findings that additional conveyance capacity is available.

4.4 Alignment Specific Storm Drain Hydraulics

A proposed WSPG-W model was built to attain preliminary storm drain sizes required for each alternative alignment. These models are rudimentary at the 15% level. The following assumptions were made:

- The model begins along the existing GOBU facility at station "B" 235+25.00, with the stationing being based off of the GC Wallace Study Plans.
- The downstream control water surface elevation was set to 2343.50 feet which is equivalent to the box flowing full.
- Minor storm drain laterals are excluded.
- Inlets capture 100% of street flow
- The model has the proposed alignments built approximately 450 feet upstream from the Buffalo Drive and Lone Mountain Road intersection to check the HGL elevation in comparison to the finish grade. The proposed facilities were not sized further upstream of this using WSPG-W. Instead Flowmaster software was used to size the facilities past this point.

The tie-in invert of the existing GOBU 0085 facility is a controlling factor. The existing system is relatively shallow, which limits the available slope for the proposed system. Each alignment alternative has been optimized to maximize slope and reduce facility size while still meeting cover and HGL criteria.

4.4.1 Alignment A – Buffalo

Alignment A results in the following preliminary facility sizes:

Main Line – Buffalo Drive from Lone Mountain Road to Washburn Road

- 5-foot x 5-foot RCB @ 0.40% slope

Lateral – Washburn Road from Buffalo Drive to Conough Lane

- 48-inch RCP @ 0.40% slope

Lateral – Lone Mountain Road from Buffalo Drive to Conough Lane

- 5-foot x 5-foot RCB @ 1.06% slope

See Appendix B.6 for facility sizes and flow rates for Alignment A.

See Appendix E, on CD, for Flowmaster output for preliminary hydraulic results of Alignment A.

4.4.2 Alignment B – Conough

Alignment B results in the following preliminary facility sizes:

Main Line – Lone Mountain Road from Buffalo Drive to Conough Lane

- 7-foot x 5-foot RCB @ 1.06% slope

Main Line – Conough Lane from Lone Mountain Road to Washburn Drive

- 5-foot x 5-foot RCB @ 0.30% slope

Lateral – Buffalo Drive from Lone Mountain Road to La Madre Way

- 36-inch RCP @ 0.40% slope

Lateral – Lone Mountain Road from Conough Lane to Cimarron Road

- 6-foot x 5-foot RCB @ 0.50% slope

Lateral – Washburn Drive from Conough Lane to Cimarron Road.

- 48-inch RCP @ 1.09% slope

See Appendix B.7 for facility sizes and flow rates for Alignment B.

See Appendix E, on CD, for Flowmaster output for preliminary hydraulic results of Alignment B.

4.4.3 Alignment C – Cimarron

Alignment C results in the following preliminary facility sizes:

Main Line – Lone Mountain Road from Buffalo Drive to Conough Lane

- 7-foot x 5-foot RCB @ 0.92% slope

Main Line – Lone Mountain Road from Conough Lane to Cimarron Road

- 7-foot x 5-foot RCB @ 0.60% slope

Main Line – Cimarron Road from Lone Mountain Road to Washburn Drive

- 60-inch RCP @ 0.60% slope

Lateral – Buffalo Drive from Lone Mountain Road to La Madre Way

- 36-inch RCP @ 0.46% slope

Lateral – Washburn Drive from Cimarron Road to Royer Ranch Road

- 48-inch RCP @ 1.50% slope

Alignment C has the longest main line facility, which in conjunction with the controlling downstream invert and upstream finished grades, results in the shallowest storm drain slopes. The shallow slopes result in greater facility sizes.

See Appendix B.8 for facility sizes and flow rates for Alignment C.

See Appendix E, on CD, for Flowmaster output for preliminary hydraulic results of Alignment C.

5.0 DROP INLET ALTERNATIVES

Each of the alternative alignments will require drop inlets to be placed in unimproved shoulders. To efficiently capture surface flows, with readily available drop inlet designs and literature review was conducted to select three suitable catch basin types for analysis. Three types of catch basins were selected to conduct the performance evaluation for this project. They are Type 2B (NDOT), Flat Grate (R-2565G, Neenah) and Beehive Grate (R-2560E1, Neenah). The evaluation process only focuses on the physical parameters of the grate but not others such as the connecting drainage system, surface flow spread and depth. To set the baseline for comparison, the connecting pipe riser is set for all cases at 24-inch in diameter.

The evaluation criteria are based on the following:

- Hydraulic Performance and Efficiency – orifice (for submerged condition) and weir (non-submerged condition) equations are mainly applied to calculate hydraulic capacity of a catch basin. Surface opening (feet²) and weir parameters (feet) are listed as part of the evaluation criteria.
- Clogging Potential – unit area opening (feet²) suggests the sediment particle size to be trapped or flow through.
- Pedestrian Safety – unit area opening (feet²) and vertical rise (feet) will assist the evaluation of the tripping potential of pedestrian and/or bicycle rider.
- Durability – structure integrity of the grate to sustain any vertical loading and impact.

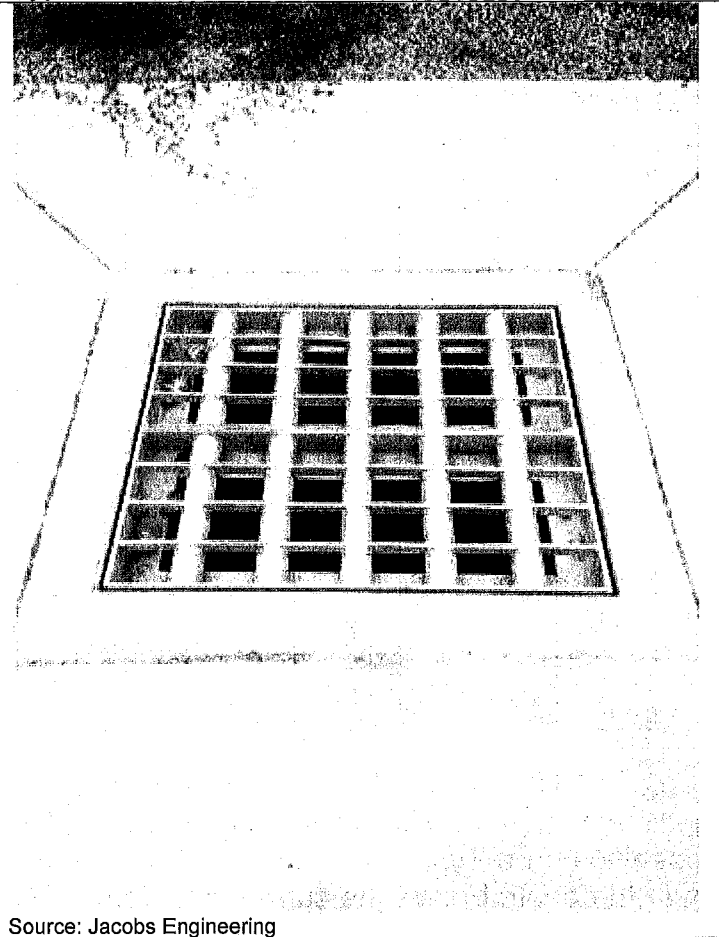
The evaluation is summarized in the table presented below. The scoring ranges from 1 to 3, with 3 as the best performance and 1 is the lowest score. The total scores are listed for reference.

Table 5. 1: Inlet Evaluation

		NDOT Type II		Flat Grate		Beehive Grate	
				(Neenah R-2565G)		(Neenah R-2560E1)	
		Dimension	Score	Dimension	Score	Dimension	Score
Hydraulic Performance	Riser Internal Diameter	24 in	2	24 in	2	24 in	2
	Total Space Opening	2.3 ft ²	3	1.6 ft ²	2	1.4 ft ²	1
	Weir Parameter	10 ft	3	7.1 ft	2	6.7 ft	1
Clogging Potential	Unit/Internal Space Opening	3 in	3	1.5 in	2	1.2 in	1
Public Safety	Pedestrian/ Handicapped Tripping Potential (vertical rise)	0 in	2	0"	3	6 in	1
Durability	Loading Strength		3		2		1
Total Score			16		13		7

As indicated by the total ranking score, NDOT Type 2B inlet will provide the most benefits for surface runoff and sediment capture. However, being nicknamed the "ankle breaker" inlet, the large openings on a Type 2B also present the greatest hazard to pedestrian. As shown in the photo below, the current standard NDOT grate detail includes additional horizontal vanes that reduce the hazard.

Type 2B Inlet with additional horizontal vanes



Source: Jacobs Engineering

Americans with Disabilities Act (ADA) regulation should be considered for public and pedestrian safety when choosing inlet types. Necessary marking and / or signage shall be installed to raise public attention.

6.0 QUANTITY AND COST ESTIMATE

Preliminary cost estimates are provided below for each alignment. The purpose of these estimates is to provide an order of magnitude cost variation between alternatives. It is critical to note that these estimates only include the main storm drain facility and do not include other factors contributing to Project costs such as inlets, small lateral systems, transition structures, removals, utility relocation, etc.

Table 6. 1: Preliminary Cost by Alternative

ALIGNMENT A - BUFFALO ALTERNATIVE

Item No.	Item Description	Unit of Meas.	Approx. Quantity	Unit Price	Total Price
202.09	REMOVAL OF 48" RCP	LF	0	\$40	\$0
202.10	REMOVAL OF 54" RCP	LF	0	\$40	\$0
202.11	REMOVAL OF 60" RCP	LF	0	\$40	\$0
603.06	48-INCH REINFORCED CONCRETE PIPE (CLASS III)	LF	1,348	\$296	\$399,008
603.09	5-FOOT X 5-FOOT REINFORCED CONCRETE (CLASS III)	LF	4,056	\$536	\$2,174,016
609.04	TYPE II STORM DRAIN MANHOLE	EA	11	\$7,779	\$85,569
609.05	TYPE III STORM DRAIN MANHOLE	EA	2	\$8,568	\$17,136
					\$2,675,729

ALIGNMENT B - CONOUGH ALTERNATIVE

Item No.	Item Description	Unit of Meas.	Approx. Quantity	Unit Price	Total Price
202.09	REMOVAL OF 48" RCP	LF	0	\$40	\$0
202.10	REMOVAL OF 54" RCP	LF	0	\$40	\$0
202.11	REMOVAL OF 60" RCP	LF	0	\$40	\$0
603.04	36-INCH REINFORCED CONCRETE PIPE (CLASS III)	LF	300	\$200	\$60,000
603.06	48-INCH REINFORCED CONCRETE PIPE (CLASS III)	LF	1,357	\$296	\$401,672
603.09	5-FOOT X 5-FOOT REINFORCED CONCRETE (CLASS III)	LF	2,774	\$536	\$1,486,864
603.10	6-FOOT X 5-FOOT REINFORCED CONCRETE (CLASS III)	LF	1,387	\$581	\$805,847
603.11	7-FOOT X 5-FOOT REINFORCED CONCRETE (CLASS III)	LF	1,395	\$622	\$867,690
609.04	TYPE II STORM DRAIN MANHOLE	EA	12	\$7,779	\$93,348
609.05	TYPE III STORM DRAIN MANHOLE	EA	3	\$8,568	\$25,704
					\$3,741,125

ALIGNMENT C - CIMARRON ALTERNATIVE

Item No.	Item Description	Unit of Meas.	Approx. Quantity	Unit Price	Total Price
202.09	REMOVAL OF 48" RCP	LF	0	\$40	\$0
202.10	REMOVAL OF 54" RCP	LF	0	\$40	\$0
202.11	REMOVAL OF 60" RCP	LF	0	\$40	\$0
603.04	36-INCH REINFORCED CONCRETE PIPE (CLASS III)	LF	1,407	\$200	\$281,400
603.06	48-INCH REINFORCED CONCRETE PIPE (CLASS III)	LF	679	\$296	\$200,984
603.08	60-INCH REINFORCED CONCRETE PIPE (CLASS III)	LF	2,779	\$356	\$989,324
603.11	7-FOOT X 5-FOOT REINFORCED CONCRETE (CLASS III)	LF	2,816	\$622	\$1,751,552
609.04	TYPE II STORM DRAIN MANHOLE	EA	15	\$7,779	\$116,685
609.05	TYPE III STORM DRAIN MANHOLE	EA	2	\$8,568	\$17,136
					\$3,357,081

7.0 ALIGNMENT ALTERNATIVE EVALUATION

Evaluation criteria have been identified in order to select an alignment. Initially, in section 7.1, unweighted scores are assigned to each alignment for each criterion on a scale of 1 to 10. A higher value indicates a favorable disposition. Scores are assigned as a relative performance compared to the other alignments for the specific criterion. Then, in section 7.2, a weighting factor is determined for each criterion based on the importance of each criterion in the decision making process. Lastly, in section 7.3, the alignment scores are adjusted by the weighting factor and a preferred alignment is identified.

7.1 Evaluation Criteria

Seven (7) criteria have been identified to evaluate each alternative alignment. Table 7.1 shows each criterion and their related issues and considerations.

Table 7. 1: Evaluation Criteria

No.	Criterion	Issues / Considerations
1	Hydraulics	Flow Pattern Watershed Capture Rate Inlet Efficiency Storm Drain Hydraulics
2	Street Spread Criteria	Street Spread Criteria
3	Local Drainage Issues	Removes Bubbler Addresses Ponding Future Expandability
4	Constructability	Topography Utility Conflicts
5	Maintenance	Watershed Contribution of Sediment Inlet (sediment)
6	Right of Way	Right of Way Ownership Easements
7	Cost	Capital Cost Cost Uncertainty and Contingencies

7.1.1 Hydraulics

During progress meetings with the City and Regional Flood, it was determined that the most important factor in selecting an alignment is designing an efficient hydraulic system. Meeting minutes from progress meetings can be found in Appendix D.

Flow Pattern

During hydrologic analysis it was determined that the majority of storm runoff from the Project watershed contributes to Lone Mountain Road, with a minority contributing to Buffalo Drive. Therefore, an MPU facility within Lone Mountain Road would better facilitate the capture of storm runoff.

Watershed Capture Rate

A factor in selecting an alignment is designing a system that captures as much of the Project watershed as possible. An alignment within Buffalo Drive would cut off surface flows within Buffalo Drive, capturing 100% of the Project watershed.

Alignments within Conough Lane or Cimarron Road would allow a small portion of the Project watershed to drain downstream.

Inlet Efficiency

From past experience and preliminary inlet calculations, it is found that area drains are significantly less efficient than curb opening and grate inlets along curb and gutter. It can take several area drains to capture the same amount of runoff as one (1) curb opening and grate inlet constructed in a road with the same longitudinal and cross slope. Therefore, it is highly beneficial to design systems with curb opening and grate inlets where feasible. However, curb and gutter is sporadically available within the Project watershed. Buffalo Drive has no curb and gutter. Lone Mountain has curb and gutter on the south half but almost none on the north half. Washburn Road has curb and gutter on the north half, and a small amount on the south half, west of Buffalo Drive. Conough Lane and Cimarron Road both have intermittent curb and gutter. In addition, most of the roads within the Project watershed are unlikely to be developed to full roadway section with curb and gutter in the near future. During conversations with the City, it was established that Buffalo Drive is significantly less likely to be fully developed in the future than Lone Mountain Road, which is due to its expected traffic volumes as an arterial road.

Storm Drain Hydraulics

The proposed alignment should facilitate a storm drain design that is able to efficiently convey the flows captured, within the HCDDM design criteria, without over taxing the capacity of the downstream tie-in facility.

Table 7. 2: Hydraulics

Issues / Considerations	Alignment A	Alignment B	Alignment C
Flow Pattern	MPU facility is not aligned well with existing watershed flow pattern	MPU facility in Lone Mountain Road is aligned well with existing watershed flow pattern	MPU facility in Lone Mountain Road is aligned well with existing watershed flow pattern
Capture Rate	Captures 100% of Project watershed	Captures 96% of Project watershed	Captures 91% of Project watershed
Inlet Efficiency	Relies on area drains in Buffalo. Minimal curb opening inlets in Lone Mountain to capture majority of flow.	Additional curb opening inlets in Lone Mountain at Cimarron and in Conough would improve capture efficiency.	Additional curb opening inlets in Lone Mountain at Cimarron and in Cimarron would improve capture efficiency.
Storm Drain Hydraulics	Hydraulic design feasible. Shallow storm drain slopes necessitating larger facility sizes.	Hydraulic design feasible. Best storm drain slopes, allowing for smaller facility sizes.	Hydraulic design feasible. Adequate storm drain slopes, larger facility sizes.
Unweighted Score	6	9	7

7.1.2 Street Spread Criteria

According to the HCDDM, development within a roadway requires improvements to meet street spread criteria. Any system designed as part of this Project would be required to reduce spread in the street to be within design criteria. Currently Lone Mountain Road does not meet spread criteria. A system within Lone Mountain Road would address this issue.

Table 7. 3: Street Spread Criteria

Issues / Considerations	Alignment A	Alignment B	Alignment C
Street Spread Criteria	Addresses spread along Lone Mountain between Buffalo and Conough	Addresses spread along Lone Mountain between Buffalo and Cimarron	Addresses spread along Lone Mountain between Buffalo and Cimarron
Unweighted Score	4	9	9

7.1.3 Local Drainage Issues

Removes Bubbler

It is in the best interest of the community to remove ineffective bubbler systems when feasible. The bubbler system at Lone Mountain Road and Cimarron drive has already received citizen complaints and is observed to cause frequent flooding.

Addresses Identified Ponding

Ponding and shallow flooding has been identified at several locations, including the intersections of Conough Lane and La Madre Way and Lone Mountain Road and Cimarron Road. The Project improvements would address these issues if the selected alignment provided a storm drain system at these intersections.

Future Expandability

The Project facility will be designed to convey the 100-year storm event and inlets will be provided as necessary to meet spread criteria within the Project limits. However, this does not address spread issues outside of the Project limits. The chosen alignment could provide a basis for future storm drain expansions to address these additional local drainage issues.

Table 7. 4: Local Drainage Issues

Issues / Considerations	Alignment A	Alignment B	Alignment C
Removes Bubbler	Does not remove bubbler	Removes bubbler	Removes bubbler
Addresses Ponding	Does not address ponding at La Madre and Conough or at Cimarron and Lone Mountain	Addresses ponding at La Madre and Conough and at Cimarron and Lone Mountain	Addresses ponding at Cimarron and Lone Mountain but not at La Madre and Conough
Future Expandability	Does not lend well to future systems in Lone Mountain to address spread in arterial roadway	Provides system in in Lone Mountain which could be extended to address spread in arterial roadway	Provides system in in Lone Mountain which could be extended to address spread in arterial roadway
Unweighted Score	4	9	7

7.1.4 Constructability

Topography

The topography of the Project watershed is a major controlling factor in the design of the proposed facility. In addition, the existing GOBU 0085 tie in facility has a fixed invert that is relatively shallow. All proposed systems are limited by this invert. Slopes throughout the Project watershed are gradual. In general the north to south slope is less than the west to east slope. This means that storm drains proposed in west to east running streets have potential for greater slope, while still maintaining minimum cover requirements.

Utility Conflicts

Utility conflicts are expected to be minimal. There are existing water, cable, gas, sewer, telephone, and power lines within each of the roadways for the possible alignments. There is an existing 8-inch water line with 18-inch steel casing, at the intersection of Buffalo Drive and Lone Mountain Road that will need to be crossed when heading up Lone Mountain Road.

There are two (2) water lines at the intersection of Conough Lane and Lone Mountain Road that need to be crossed by the proposed facility. The 8-inch water line will need to be crossed when continuing west on Lone Mountain Road, and the 16-inch water line will need to be crossed when heading north on Conough Lane. There is also an 8-inch water line and 8-inch sewer line that continues north on the east side of Conough Lane

There is also a proposed sewer line in Lone Mountain Road that is expected to be constructed very deep. City has requested that any storm drain within Lone Mountain Road be designed to leave a corridor of at least 15 feet for the future construction of this sewer line. Storm drain laterals will be checked for vertical clearance when crossing any of the existing utilities.

Buffalo Drive has gas, water, and sanitary sewer lines in it that limits the proposed facility to be placed between the sewer and gas line. The proposed facility would need to cross an 8-inch sewer line and multiple gas laterals.

The intersection of Buffalo Drive and Lone Mountain Road has a 10-inch, 12-inch, and 42-inch water line located in it as well as an 8-inch sewer line that may cause conflict when improving the bubbler system with storm drain inlets and laterals.

Table 7. 5: Constructability

Issues / Considerations	Alignment A	Alignment B	Alignment C
Topography	Buffalo has the least slope, limiting available main storm drain slope to 0.40%.	Lone Mountain has greater slope between Buffalo and Conough, providing depth to allow greater slope for storm drain up Conough. Storm drain slopes range from 0.30% to 1.06%	Lone Mountain flattens west of Conough. Between this and the length of this alignment, the slope available is greatly restricted. Storm drain slopes range from 0.60% to 0.92%
Utility Conflicts	Minimal utility conflicts are expected	Conflicts with water lines are possible at Lone Mountain and Conough	Conflicts with water lines are possible at Lone Mountain
Unweighted Score	4	7	6

7.1.5 Maintenance

Sediment

The rural nature of the Project watershed and undeveloped lots provide a source for higher sediment displacement during a storm event. Concentrated flow is conveyed in unlined roadside ditches, further contributing to sediment loading. Surface runoff with higher sediment carrying capacity is expected in the west to east direction, where slopes are steeper and flow velocities would be higher. The longer duration that surface runoff is conveyed within a roadside ditch prior to capture, the greater potential for sediment load to be generated. Providing inlets higher up in the watershed to capture relatively clean concentrated flow earlier on helps to mitigate sediment displacement, thereby reducing future maintenance costs.

Facility Length

Longer facilities will require greater maintenance.

Table 7. 6: Maintenance

Issues / Considerations	Alignment A	Alignment B	Alignment C
Sediment	Allows all flow from Project watershed to travel as concentrated flow through roadside ditches to the very downstream end of the watershed before capture. All inlets in ditch. High chance for sediment loading.	Captures runoff at Cimarron and Washburn and at Cimarron and Lone Mountain, reducing flow travel time in unlined ditches. Fewer inlets located in ditches.	Captures runoff at Cimarron and Washburn and at Cimarron and Lone Mountain, reducing flow travel time in unlined ditches. Fewer inlets located in ditches.
Facility Length	Approx 1 mile	Approx 1.5 miles	Approx 1.75 miles
Unweighted Score	3	5	5

7.1.6 Right of Way

Right of Way Ownership

During progress meetings, the City stated that the jurisdictional ownership would not affect the decision on selecting an alignment. This criterion is not a factor.

Easements

Easements are not expected to be required for any of the alignments. This criterion is not expected to be a factor.

Table 7. 7: Right of Way

Issues / Considerations	Alignment A	Alignment B	Alignment C
Right of Way Ownership	Not a factor	Not a factor	Not a factor
Easements	Not expected to be a factor	Not expected to be a factor	Not expected to be a factor
Unweighted Score	1	1	1

7.1.7 Cost

Relative alignment costs are presented below. Higher values represent lower cost.

Table 7. 8: Cost

Issues / Considerations	Alignment A	Alignment B	Alignment C
Capitol Cost	\$2,675,000	\$3,741,000	\$3,357,000
Cost Uncertainty and Contingencies	Low	Medium	Medium
Unweighted Score	8	4	5

7.2 Weighting Factors

During progress meetings it was established that cost is an important factor but not the ultimate deciding factor on selecting an alignment. The overall performance of the system takes precedence over all other factors. Each of the

criterion and their relative importance were discussed. The following table summarizes the weighting factors for each criterion.

Table 7. 9: Weighting Factors

No.	Criterion	Weight
1	Hydraulics	9
2	Street Spread Criteria	8
3	Local Drainage Issues	5
4	Constructability	7
5	Maintenance	4
6	Right of Way	1
7	Cost	6

7.3 Alignment Selection

The unweighted score for each criterion is multiplied by the weighting factor. The sum of the weighted scores provides a total score for each alignment. Alignment B scores the highest, and is recommended as the preferred alternative.

Table 7. 10: Alignment Selection

No.	Criterion	Alignment A	Alignment B	Alignment C
1	Hydraulics	54	81	63
2	Street Spread Criteria	32	72	72
3	Local Drainage Issues	20	45	35
4	Constructability	28	49	42
5	Maintenance	12	20	20
6	Right of Way	1	1	1
7	Cost	48	24	30
-	Total Alignment Score	195	292	263
-	Alignment Rank	3	1	2

8.0 RECOMENDATION

Based on the alternative analysis performed in this report, it is recommended that Alignment B be selected for design and construction. Alignment B is the most efficient storm drain system, aligned with the existing flow pattern, maximizing the available capacity of the existing tie in facility, and providing storm drain slopes that reduce facility sizes and improve hydraulics. Alignment B also provides the most beneficial use to the community, addressing local drainage issues and providing for future expansion. This alignment will require an MPA, which should be performed prior to the 90% design submittal.

9.0 REFERENCES

[CCRFCD, 1999]. *Hydrologic Criteria and Drainage Design Manual*.
Prepared by Montgomery Watson, for: Clark County Regional Flood Control District, 1999.

[MPU, 2008]. *Las Vegas Valley Flood Control Master Plan Update*,
Prepared by: PBS&J in association with Louis Berger Group and Parsons Brinckerhoff, September 2008.

[HEC, 1997]. *HEC-1 Flood Hydrograph Package Version 4.1*,
U.S. Army Corps of Engineers, Hydrologic Engineering Center, January 1997.

FlowMaster 2008 Bentley Systems, Inc. Haestad Methods Solution Center.

Drainage Study For The Road Improvements for Buffalo Drive Between Cheyenne Avenue and Lone Mountain Road 90 Percent Submittal
Prepared by: G.C. Wallace, Inc., January 1999, for City of Las Vegas

HTE# 01-16754, *Technical Drainage Study for MSM 86-01 4-Lot Minor Subdivision, Southeast Corner of Conough Lane and Rosada Way*, Prepared by: The Sear-Brown Group, May 23, 2001, for Phillip E. Cortney

HTE# 01-31616, *Technical Drainage Study for PM 90-99, Southeast Corner of La Madre Way and Janell Drive*, Prepared by: EMS Engineering, August 18, 1999, for Willie Earl Spann Scott

HTE# 02-9764, *Technical Drainage Study for Wellspring Ministries, Lone Mountain Road and Janell Drive*, Prepared by: AZTEC Engineering, March 26, 2002, for George Stover

HTE# 02-37398, *Technical Drainage Study for MSM 86-01 4-Lot Subdivision, Conough and Rosada Intersection, Parcel Number 125-33-707-001*, Prepared by: Redrock Engineering, October 30, 2002, for William D Childs

HTE# 05-37441, *Hydrology Study for MSM 04-0073*, Prepared by: Baughman & Turner, Inc., October 26, 2004, for Gary Perron

HTE# 06-52938, *Hydrology Study for Lone Mountain/Miller 2 Lot Division*, Prepared by: KJE Consulting Engineers, Inc., December 11, 2006, for Michael Ignatowicz and Cheryl Frischknecht

HTE# 93-1217, *Technical Drainage Study for Rosada and Conough Parcel Map PM 213-92*, Prepared by: FES Consulting Engineers, Inc., January 15, 1993, for James R. Zurschmiede

**PARSONS
BRINCKERHOFF**

HTE# 93-19979, *Hydrology Study for Angel Estates*, Prepared by: C.S.A. Engineers, October 21, 1993, for Richard Dufor

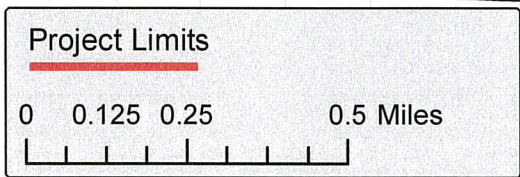
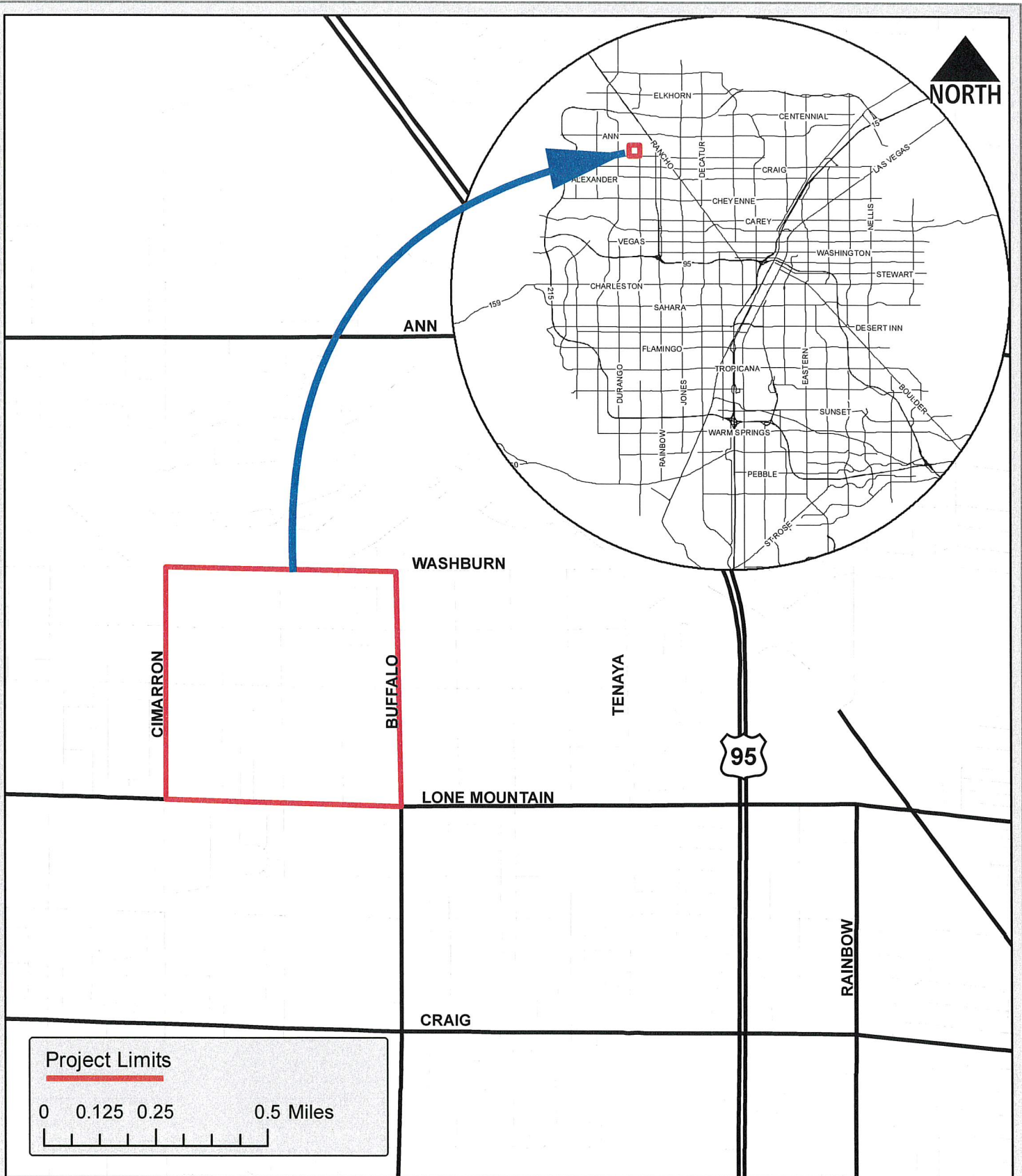
HTE# 94-21839, *Drainage Study for Cimarron Estates*, Prepared by: Baughman & Turner, Inc., December 23, 1994, for Jon Venteau

HTE# 97-26411, *Technical Drainage Study for PM 227-97 Lone Mountain/Conough Lane*, Prepared by: PBS&J, Inc., September 18, 1997, for Larkin-Gifford Developments, LLC

HTE# 98-22970, *Technical Drainage Study for Eagle Dancer*, Prepared by: Alpha Engineering, Inc., August 10, 1998, for Guy Bennallack

Appendix A - Figures & Maps

- A.1 - Vicinity Map
- A.2 - Alternative Alignments Map
- A.3 - 2013 MPU Hydrologic Map
- A.4 - 2013 MPU Facilities Map
- A.4A - 2013 MPU Facility Inventory
- A.5 - FEMA FIRM Panels
- A.6 - McCarran Airport Rainfall Area - HCDDM Figure 513
- A.7 - 10-year Depth-Duration-Frequency - Values - HCDDM Figure 503
- A.7A - 100-year Depth-Duration-Frequency - Values - HCDDM Figure 506
- A.8 - Depth-Duration-Frequency-Values - HCDDM Table 505
- A.9 - Six Hour Storm Distributions (SDN3) - HCDDM Table 503
- A.10 - Six Hour Depth - Area Reduction Factors - HCDDM Table 502



Vicinity Map

Appendix A.1





GOWAN NORTH
BUFFALO BRANCH
LONE MNT. TO WASHBURN



Legend

Alignment A
Main
Lateral

Alignment B
Main
Lateral

Alignment C
Main
Lateral

Existing Facilities

CLV Existing Facilities

City Ownership

10 ft Contour

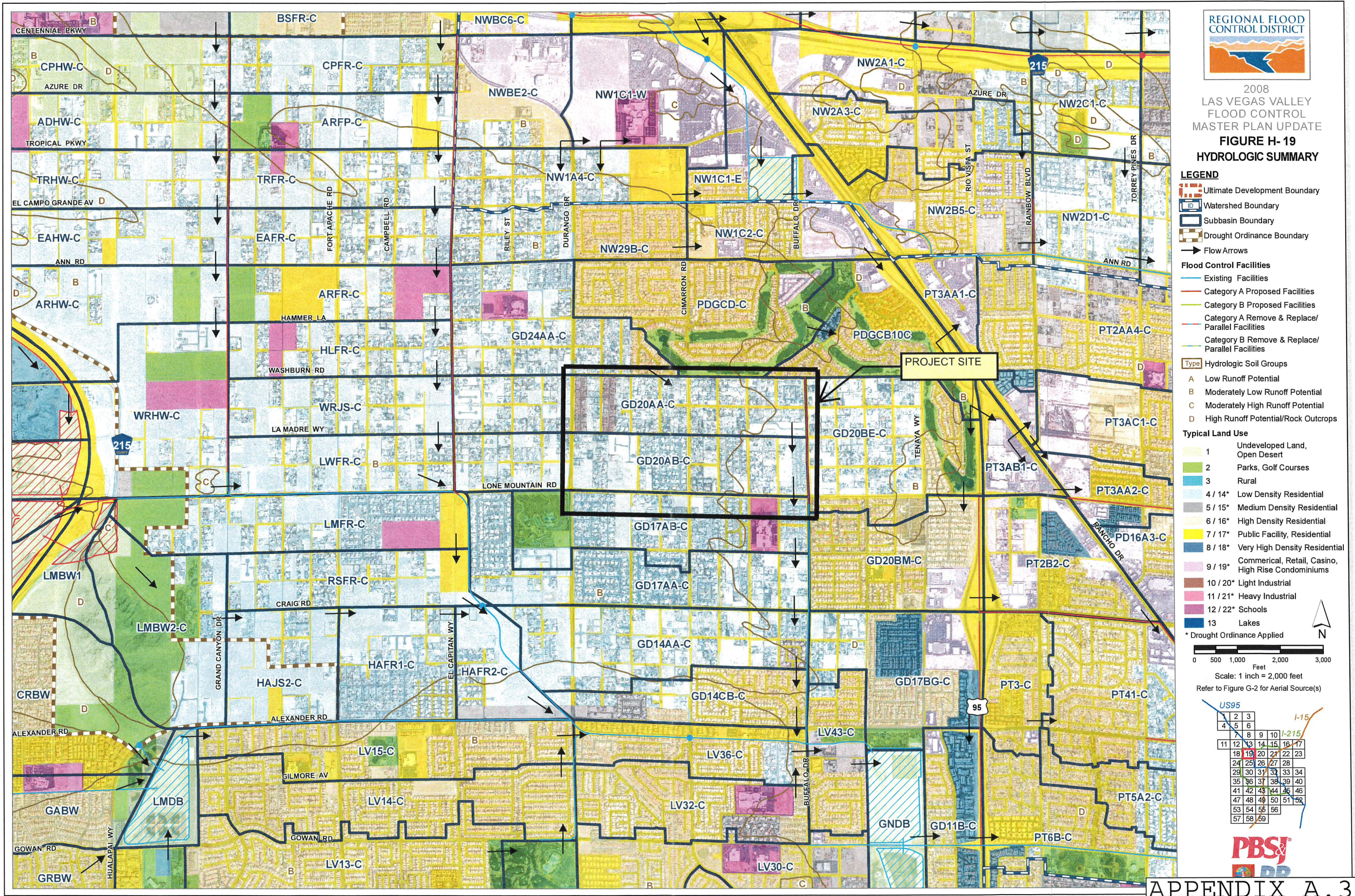
APPENDIX A.2
ALTERNATIVE
ALIGNMENTS MAP

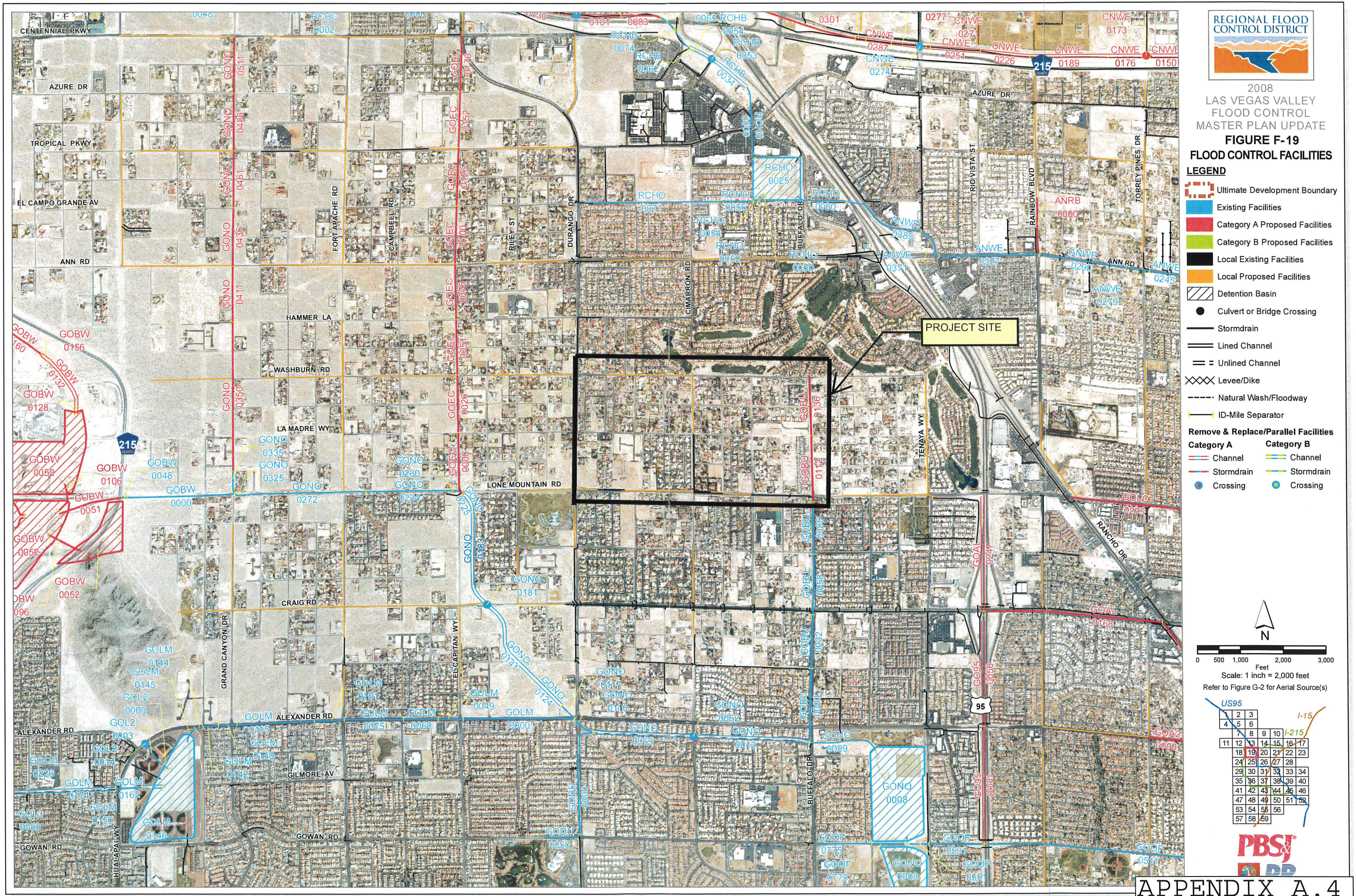


0 100 200 400 Feet

Scale: 1 inch = 200 feet

**PARSONS
BRINCKERHOFF**



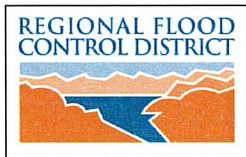


ID / River Mile	Status	Facility Description	Length (ft.)	Flow (cfs)	HEC-1 Node	HEC-1 Model	Tributary Area (sq.mi.)	Channel Slope (%) **
ANRB 0000	P1	ANN ROAD CHANNEL WEST - RAINBOW 10' X 7' RCB	1320	721	CNW2B5-C	WEST3	0.99	0.40
ANWE 0245	E	ANN ROAD CHANNEL WEST 10' X 9' RCB	1721	993	CNW2D1-C	WEST3	6.84	0.80
0279	E	10' X 9' RCB	553	743	2CNW2B5C	WEST3	6.37	0.80
0290	E	8' X 8' RCB	2050	743	2CNW2B5C	WEST3	6.37	0.70
0327	E	6' X 6' RCB	2360	161	RCHOOT	WEST3	5.38	0.87
0371	E	6' X 6' RCB	760	161	RCHOOT	WEST3	5.38	0.34
0385	E	54" RCP	1950	161	RCHOOT	WEST3	5.38	1.17
CNWE 0150	P2	CENTENNIAL PKWY CHANNEL WEST Conc Chnl 42"W 10'D 0:1 SS	720	4233	CNW3B3-C	WEST3	5.64	0.40
0173	P2	42' X 10' RCBC @ Torrey Pines	190	4233	CNW3B3-C	WEST3	5.64	0.40
0176	P2	Conc Chnl 32"W 12'D 0:1 SS	795	4233	CNW3B3-C	WEST3	5.64	0.40
0189	P2	Conc Chnl 32"W 10'D 0:1 SS	1845	4067	CNW2D4-C	WEST3	5.15	0.54
0226	P2	Conc Chnl 12"W 12'D 2:1 SS	1165	4067	CNW2D4-C	WEST3	5.15	1.00
0251	P2	Conc Chnl 12"W 12'D 2:1 SS	1135	3951	CNW2D3-C	WEST3	4.65	0.59
0271	P2	Conc Chnl 32"W 10'D 0:1 SS	185	3951	CNW2D3-C	WEST3	4.65	0.59
0274	E	32' X 10' RCBC @ Tenaya	130	3951	CNW2D3-C	WEST3	4.65	0.45
0277	P2	Conc Chnl 13"W 10'D 2:1 SS	590	3951	CNW2D3-C	WEST3	4.65	0.45
0287	P2	Conc Chnl 13"W 10'D 2:1 SS	605	3593	CNW2B2-C	WEST3	3.84	1.19
0301	P2	Conc Chnl 32"W 10'D 0:1 SS	235	3593	CNW2B2-C	WEST3	3.84	1.19
0304	P2	32' X 10' RCB	6510	3593	CNW2B2-C	WEST3	3.84	1.75
G095 0000	P1	GOWAN OUTFALL - U.S. 95 CHANNEL Conc Chnl 12"W 4'D 2:1 SS	2640	299	GD17BG-C	ALLGOW3	0.36	0.30
0050	P1	Conc Chnl 12"W 4'D 2:1 SS	2450	299	GD17BG-C	ALLGOW3	0.36	0.30
GOA2 0000	P1	GOWAN OUTFALL - ALEXANDER BRANCH 8' X 5' RCB	2281	523	CPT41-C	ALLGOW3	0.61	0.90
GOAL 0111	P1	GOWAN OUTFALL - ALEXANDER ROAD FACILITIES 10' X 8' RCB	3000	880	CPT2B2	ALLGOW3	2.28	0.83
0168	P1	10' X 8' RCB	4200	880	CPT2B2	ALLGOW3	2.28	0.50
0247	P1	Conc Chnl 12"W 5.5'D 2:1 SS	2640	757	CGD20BMC	ALLGOW3	1.98	0.30
GOBU 0000	E	GOWAN NORTH - BUFFALO BRANCH 2: 12' X 6' RCB	1705	961	CGD14CBC	ALLGOW3	2.53	0.20
0032	E	2: 12' X 5' RCB	1248	850	CGD14AAC	ALLGOW3	2.30	0.25
0058	E	2: 11' X 4' RCB	1398	745	CGD17AAC	ALLGOW3	1.90	0.25
0085	E	11' X 5' RCB	1266	614	CGD17ABC	ALLGOW3	1.52	0.25
0112	P1	8' X 6' RCB	1535	484	CGD20ABC	ALLGOW3	1.15	0.54
0136	P1	7' X 6' RCB	1400	344	CGD20AAC	ALLGOW3	0.76	0.36
GOBW 0000	E	GOWAN BELTWAY WEST 48" RCP	2527	116	LMBWDB	ALLGOW4	10.68	4.37
0048	E	72" RCP	131	116	LMBWDB	ALLGOW4	10.68	2.21
0051	P2	72" RCP Outlet	1508	116	LMBWDB	ALLGOW4	10.68	0.30
0052	P2	589 ac-ft Lone Mountain-Beltway Detention Basin		5140	CLMBW1	GW3SC	3.50	
0082	P2	51,400 cfs PMF Spillway		51400	CLMBW1	GW3SC	3.50	
0096	P1	8' X 8' RCB Connector Pipe Under Beltway	839	5140	CLMBW1	GW3SC	3.50	0.30
0097	P2	54" RCP	394	525	UVB1-2	ALLGOW3	0.34	8.09
0106	P2	8' X 8' RCB Connector Pipe Under Lone Mountain	697	5140	CLMBW1	GW3SC	3.50	0.30
0128	P2	Conc Chnl 20"W 10'D 0:1 SS	190	3429	CWRBW1	ALLGOW3	6.06	25.00
0132	P2	Conc Chnl 14"W 10'D 0:1 SS	1286	2869	CHLBW1-C	GW3SC	1.84	5.00
0156	P2	Conc Chnl 16"W 10'D 0:1 SS	221	2869	CHLBW1-C	GW3SC	1.84	1.05
0160	P2	16' X 8' RCB	1230	2869	CHLBW1-C	GW3SC	1.84	1.05
GOBX 0000	P2	GOWAN BOX CANYON 66" RCP	794	753	LWBW1	ALLGOW3	0.48	9.45
GODU 0000	E	GOWAN NORTH - DURANGO BRANCH 12' X 6' RCB	2629	1150	CLV14-C	ALLGOW3	1.40	0.91
0050	E	9' X 6' RCB	865	835	CLV20-C	ALLGOW3	0.97	1.50
GOEC 0000	P1	GOWAN NORTH - EL CAPITAN BRANCH 10' X 7' RCB	1445	1233	CLWFR-C	ALLGOW3	2.20	1.36
0026	P1	10' X 8' RCB	1320	1162	CWRJS-C	ALLGOW3	1.95	0.91
0051	P1	10' X 7' RCB	1320	1027	CHLFR-C	ALLGOW3	1.69	1.06
0076	P1	10' X 6' RCB	1320	894	CARFR-C	ALLGOW3	1.45	1.06
GOEC 0100	P1	GOWAN NORTH - EL CAPITAN BRANCH 10' X 6' RCB	1320	745	CEAFR-C	ALLGOW3	1.21	0.76
0126	P1	10' X 7' RCB	1320	635	CTRFR-C	ALLGOW3	0.96	0.38
0152	P1	7' X 6' RCB	1320	485	CARFP-C	ALLGOW3	0.70	0.77
0176	P1	78" RCP	1320	363	CCPFR-C	ALLGOW3	0.46	1.15
GOL2 0000	E	GOWAN LONE MOUNTAIN SYSTEM-BRANCH 2 5' X 4' RCB	150	461	CRBW	ALLGOW3	0.44	14.60
0003	E	66" RCP	607	461	CRBW	ALLGOW3	0.44	1.97
0014	E	84" RCPC @ Alexander	125	461	CRBW	ALLGOW3	0.44	4.00
GOLM 0000	E	GOWAN LONE MOUNTAIN SYSTEM 78" RCP	2590	345	CLV15-C	ALLGOW4	11.88	1.80
0049	E	6' X 5' RCB	585	345	CLV15-C	ALLGOW4	11.88	1.87
0060	E	66" RCP	817	345	CLV15-C	ALLGOW4	11.88	2.40
0075	E	60" RCP	1385	345	CLV15-C	ALLGOW4	11.88	2.55
0101	E	54" RCP	701	190	LMTNDB	ALLGOW4	11.52	1.74
0115	E	48" RCP	1799	190	LMTNDB	ALLGOW4	11.52	3.08
0140	E	42" RCP	439	190	LMTNDB	ALLGOW4	11.52	1.60
0142	E	48" RCP	348	190	LMTNDB	ALLGOW4	11.52	2.14
0144	E	66" RCP	196	190	LMTNDB	ALLGOW4	11.52	5.44
0145	E	66" RCP Outlet	378	190	LMTNDB	ALLGOW4	11.52	0.90
0146	E	888 ac-ft Lone Mountain Detention Basin		7252	LMTNIN	GW3SC	6.13	
0147	E	36,000 cfs PMF Spillway		36000	LMTNIN	GW3SC	6.13	
0150	E	Drop Structure	481	6323	CGABW	GW3SC	5.12	
0162	E	28' X 8' RCBC @ Hualapai	625	6323	CGABW	GW3SC	5.12	1.86
0174	E	Conc Chnl 28"W 8'D 0:1 SS	2715	6173	CCLMT5	GW3SC	4.92	3.20
GOLO 0275	P1	GOWAN OUTFALL - LONE MTN. ROAD BRANCH 8' X 6' RCB	3000	590	CPT3AA2	ALLGOW3	1.16	0.77
GONO 0000	E	GOWAN NORTH SYSTEM 8' X 8' RCB Outlet	184	558	GWNNDB	ALLGOW5	68.49	0.51
0001	E	8' X 8' RCB Outlet	156	558	GWNNDB	ALLGOW5	68.49	0.63
0006	E	30,780 cfs PMF Spillway		30780	GWNNDB	ALLGOW5	68.49	
0008	E	921 ac-ft Gowan North Detention Basin		4937	CCLV43-C*	GW4SC	11.93	
0009	E	3: 13' X 8' RCB	1662	4937	CCLV43-C	GW4SC	11.93	0.62
0012	E	Conc Chnl 30"W 8'-9.5'D 0:1 SS	2665	4117	CCLV36-C	GW4SC	8.54	1.18
0062	E	Bridge 30"W 8.5'D @ Cimarron	80	3844	CCLV15-C	GW4SC	8.03	0.30
0063	E	Conc Chnl 30"W 8.5'-10'D 0:1 SS	2302	3844	CCLV15-C	GW4SC	8.03	1.00
0110	E	2: 12' X 8' RCAC @ Alexander	547	3352	CCRSFR-C*	GW3SC	6.10	1.00
0117	E	2: 12' X 8' RCAP	424	3352	CCRSFR-C*	GW3SC	6.10	1.10
0124	E	Conc Chnl 24"W 9'D 0:1 SS	887	3352	CCRSFR-C*	GW3SC	6.10	1.36
0141	E	Conc Chnl 24"W 9'-10.5'D 0:1 SS	2064	3352	CCRSFR-C	GW3SC	6.10	0.59
0181	E	Bridge 30"W 7'D @ Craig	142	2846	CRSFR-C	GW3SC	5.20	0.65
0183	E	Conc Chnl 22"W 8'-10.6'D 0:1 SS	2193	2846	CRSFR-C	GW3SC	5.20	0.72
0225	E	Conc Chnl Width Varies Depth Varies 0:1 SS	508	2605	CCLWFR-C	GW3SC	4.54	1.05
0230	E	13' X 5' RCB	256	1486	CCWRHW-C	GW3SC	2.34	2.78
0234	E	12' X 6' RCB	2010	1486	CCWRHW-C	GW3SC	2.34	1.67
0272	E	10' X 6' RCB	2797	1486	CCWRHW-C	GW3SC	2.34	3.15
0325	E	15' X 7' RCB	291	1486	CCWRHW-C	GW3SC	2.34	1.79
0335	E	15' X 7' RCB	529	1486	CWRHW-C	ALLGOW3	2.34	1.79
0350	P1	10' X 9' RCB	3473	1486	CWRHW-C	ALLGOW3	2.34	0.88
0411	P1	10' X 9' RCB	1320	1404	CARHW-C	ALLGOW3	1.89	0.76
0436	P1	10' X 7' RCB	1320	1173	CEAHW-C	ALLGOW3	1.53	1.14
0461	P1	10' X 9' RCB	1320	959	CTRHW-C	ALLGOW3	1.22	0.38
0486	P1	8' X 7' RCB	1320	747	CADHW-C	ALLGOW3	0.90	0.76
0511	P1	7' X 6' RCB	1320	546	CCPHW-C	ALLGOW3	0.60	1.14
GOOF 0511	E	GOWAN OUTFALL FACILITIES 8' X 5' RCB	8390	699	CPT6B-C	GW3SC	1.08	0.50
0531	E	8' X 5' RCB	1300	558	GWNNDB	ALLGOW5	68.49	0.50
0551	E	72" RCP	524	558	GWNNDB	ALLGOW5	68.49	0.62
0773	E	60" RCP	803	286	LV30-C	ALLGOW3	0.42	1.40
0775	E	60" RCP	1300	286	LV30-C	ALLGOW3	0.42	1.00
RCHB 0000	E	RANCHO ROAD SYSTEM - BELTWAY 2: 12' X 8.5' RCAP	1700	2631	CNW1C-W	WEST3	4.68	0.63
0034	E	Conc Chnl 21"W 8'D 0:1 SS	1000	2631	CNW1C-W	WEST3	4.68	1.19
0053	E	2: 12' X 8' RCBC @ South Ramp Connector	85	2304	CDW1C1	WEST3	4.31	1.40
0054	E	Conc Chnl 21"W 8'D 0:1 SS	432	2304	CDW1C1	WEST3	4.31	1.51
0062	E	Transition Structure	130	2304	CDW1C1	WEST3	4.31	1.51
0065	E	24' X 7' RCB	480	2304	CDW1C1	WEST3	4.31	0.30
0074	E	24' X 6' RCB	50	2226	CNWBC6-C	WEST3	4.17	0.30
0075	E	20' X 6' RCBC @ Beltway	428	2226	CNWBC6-C	WEST3	4.17	2.81
0083	P2	20' X 6' RCB	950	2226	CNWBC6-C	WEST3	4.17	2.49
0101	P2	Conc Chnl 20"W 7'D 0:1 SS	980	2226	CNWBC6-C	WEST3	4.17	2.38
0120	E	20' X 6' RCBC @ Grand Montecito	120	2226	CNWBC6-C	WEST3	4.17	1.00
0122	P2	Conc Chnl 16'-20"W 6'D 0:1 SS	350	2226	CNWBC6-C	WEST3	4.17	1.84
0130	P2	Conc Chnl 16"W 6'D 0:1 SS	1012	2226	CNWBC6-C	WEST3	4.17	2.67
RCHO 0000	E	RANCHO ROAD SYSTEM 60" RCP with 36" Orifice Plate	1183	161	RCHODB	WEST3	5.38	0.74
0025	E	321 ac-ft Rancho Road Detention Basin		3115	RCHOIN	WEST3	5.38	
0027	E	18,000 cfs PMF Spillway		18000	RCHOIN	WEST3	5.38	
0050	E	Energy Dissipator	90	402	CNW1A4-C	WEST3	0.51	
0052	E	Conc Chnl 10"W 10'D 0:1 SS	115	402	CNW1A4-C	WEST3	0.51	11.43
0054	E	10' X 5' RCB	128	402	CNW1A4-C	WEST3	0.51	0.50
0056	E	10' X 5' RCB	815	402	CNW1A4-C	WEST3	0.51	0.47
0071	E	72" RCP	3140	402	CNW1A4-C	WEST3	0.51	1.80

* The HEC-1 node shown identifies the controlling concentration point for the associated facility and is located upstream of this facility due to decreasing peak flow with increasing tributary area caused by storm distribution transitions, depth area reduction factors, or attenuation of flow from routing.

** As-built or design slopes were used when available. All other slopes are based on existing topography. The user should verify the facility slope listed prior to performing any facility specific analysis.

* For parallel facilities, the existing facility flow equals its normal depth capacity, and the proposed parallel facility flow equals the remaining flow (i.e., HEC-1 Node flow = existing facility normal depth capacity + proposed parallel facility flow).

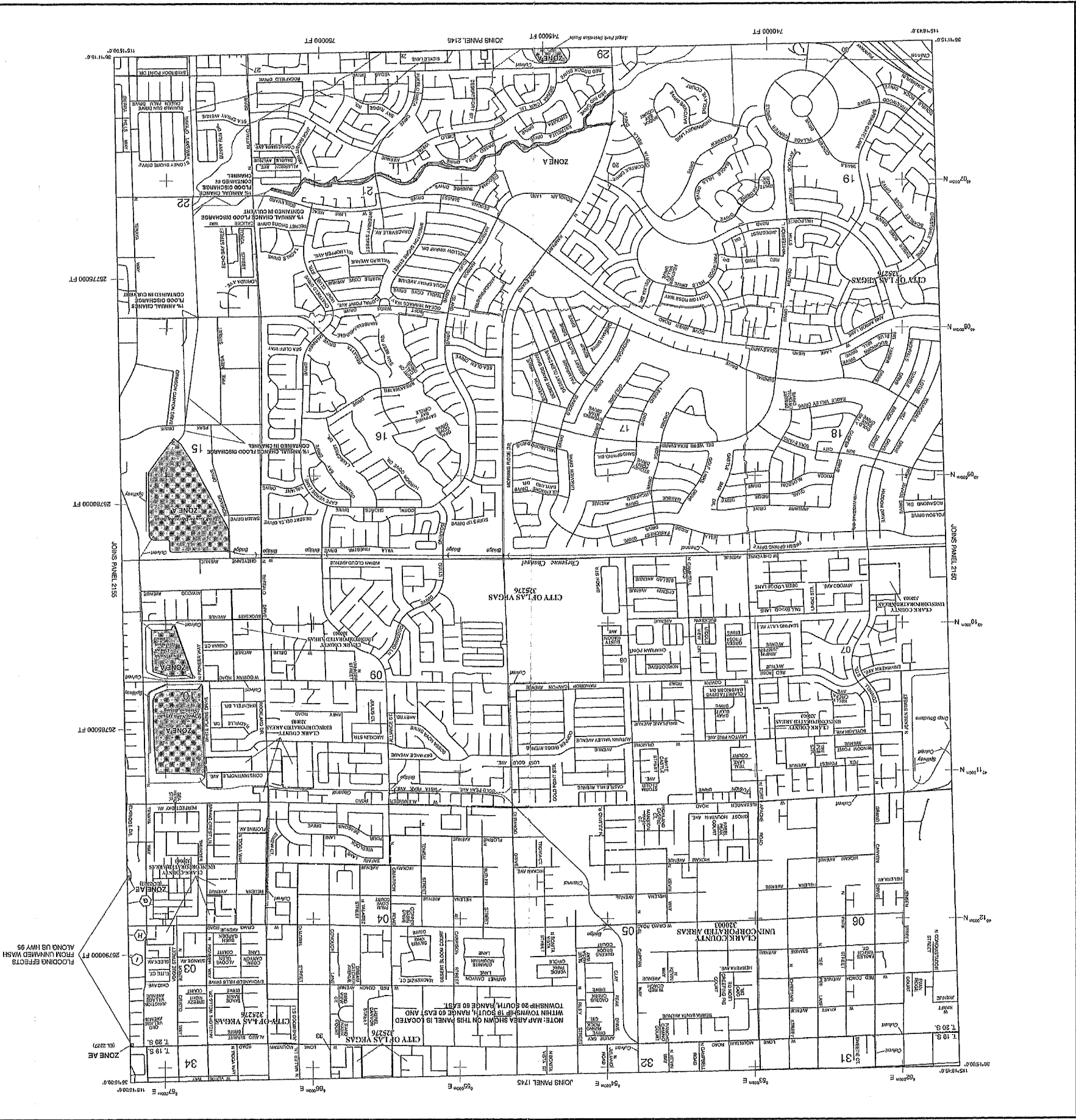


2008 LAS VEGAS VALLEY
FLOOD CONTROL
MASTER PLAN UPDATE

FACILITY INVENTORY
FIGURE F - 19

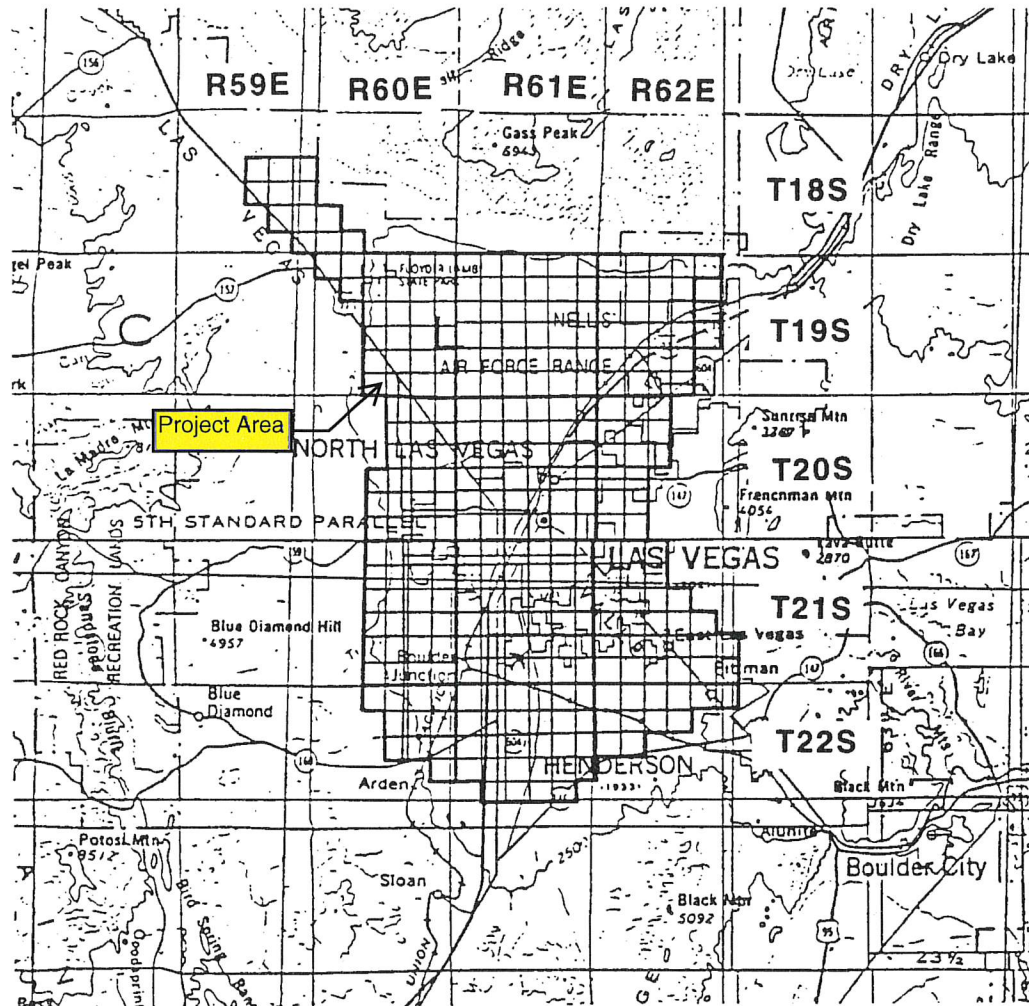
LEGEND	ID (Facility Identifier)	AABB	Existing Facility.....	E			Construction Features	
	Parent Stream Name		Proposed or Modified Facility.....	P	Bottom Width.....	W	Cast in Place Concrete Pipe.....	CIPCP
	Stream Name		Contingency Level		Depth.....	D	Corrugated Metal Arch Pipe Culvert.....	CMAP
	River Mile		Category B.....	P0	Side Slope, H:V.....	SS	Reinforced Concrete Box Culvert.....	RCBC
	Distance Above Confluence with Parent Stream (Miles)		Master Plan.....	P1			Reinforced Concrete Pipe.....	RCP
	Miles in Hundredths		Preliminary Design.....	P2			Reinforced Concrete Pipe Culvert.....	RCPC
			Design.....	P3			Storm Sewer Pipe.....	SSP



[illegible]

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

McCARRAN AIRPORT RAINFALL AREA



TOWNSHIP	RANGE	SECTIONS	TOWNSHIP	RANGE	SECTIONS
18 South	59 East	13-15,22-26,36	20 South	62 East	4-9,16-20,29-32
18 South	60 East	30-32	21 South	60 East	1-4,9-16,21-28,33-36
19 South	60 East	1-6,8-16,21-28,33-36	21 South	61 East	ALL SECTIONS
19 South	61 East	ALL SECTIONS	21 South	62 East	4-9,15-23, 25-36
19 South	62 East	2-11,14-23,27-34	22 South	60 East	1-4,10-15,24
20 South	60 East	1-3,10-15,21-28,33-36	22 South	61 East	1-24,26-29
20 South	61 East	ALL SECTIONS	22 South	62 East	1-10,17-18

Notes:

1. Refer to Table 505 and Figure 516 Depth-Duration- Frequency values in the McCarran Airport Rainfall Area.
2. Refer to Table 506 and Figure 517 for Time-Intensity-Frequency values on the McCarran Airport Rainfall Area.

Revision	Date

RAINFALL DEPTH-DURATION-FREQUENCY
10-YEAR, 6-HOUR
(DEPTHS IN TENTHS OF INCHES)



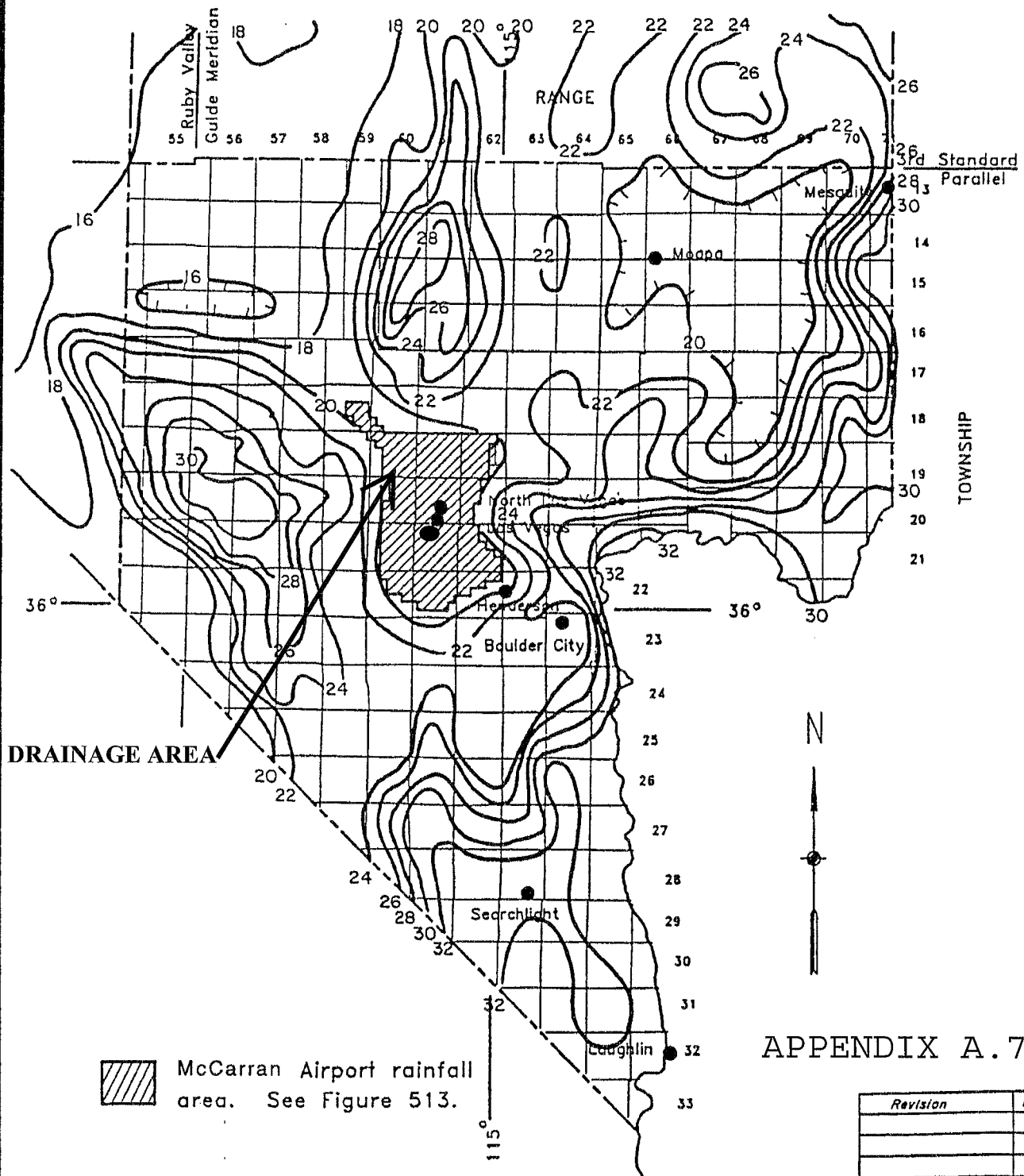
WRC
ENGINEERING

NOAA ATLAS 2, VOLUME VII NEVADA, 1973

FIGURE 503

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

RAINFALL DEPTH-DURATION-FREQUENCY 100-YEAR, 6-HOUR (DEPTHS IN TENTHS OF INCHES)



HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

DEPTH-DURATION-FREQUENCY VALUES FOR McCARRAN AIRPORT RAINFALL AREA (IN INCHES)

TIME	RECURRENCE INTERVAL					
	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
5 min.	0.15	0.27	0.35	0.46	0.54	0.63
10 min.	0.25	0.44	0.57	0.74	0.89	1.02
15 min.	0.33	0.57	0.74	0.97	1.15	1.32
30 min.	0.44	0.78	1.01	1.31	1.55	1.79
1 hour	0.52	0.89	1.15	1.50	1.78	2.06
2 hour	0.59	1.01	1.30	1.70	2.01	2.30
3 hour	0.64	1.08	1.39	1.82	2.15	2.48
6 hour	0.72	1.22	1.58	2.05	2.41	2.77
24 hour (TR-55)	1.20	1.60	1.80	2.40	2.70	2.96

- NOTE: 1. Refer to Figure 513 for a description and drawing of the area included in the McCarran Airport Rainfall Area.
2. The 24 hour values presented above are for use with TR-55 only.
3. Table 501 adjustments not required.

APPENDIX A.8

Revision	Date

WRC
ENGINEERING

REFERENCE:

USACE, Los Angeles District, 1988

TABLE 505

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

SIX-HOUR STORM DISTRIBUTIONS

Percent of Total Storm Depth				Percent of Total Storm Depth			
Storm Time (In Minutes)	SDN3	SDN4	SDN5	Storm Time (In Minutes)	SDN3	SDN4	SDN5
0	0.0	0.0	0.0	185	32.2	37.6	43.0
5	2.0	2.0	2.0	190	35.2	41.5	47.7
10	5.7	5.8	5.9	195	40.9	46.2	51.4
15	7.0	7.5	8.0	200	49.9	53.0	56.1
20	8.7	9.9	11.0	205	59.0	61.0	63.0
25	10.8	12.6	14.4	210	71.0	71.0	71.0
30	12.4	13.7	15.0	215	74.4	73.2	72.0
35	13.0	14.5	16.0	220	78.1	75.6	73.1
40	13.0	14.9	16.8	225	81.2	78.2	75.2
45	13.0	15.1	17.1	230	81.9	79.9	77.9
50	13.0	15.5	18.0	235	83.5	81.3	79.0
55	13.0	15.6	18.2	240	85.1	82.3	79.5
60	13.0	15.9	18.7	245	85.6	83.0	80.4
65	13.3	16.2	19.0	250	86.0	83.5	81.0
70	14.0	16.9	19.7	255	86.8	84.4	82.0
75	14.2	17.2	20.2	260	87.6	85.1	82.6
80	14.8	17.9	21.0	265	88.8	86.4	84.0
85	15.8	18.9	22.0	270	91.0	88.5	85.9
90	17.2	20.1	23.0	275	92.6	90.8	88.9
95	18.1	21.1	24.1	280	93.7	92.4	91.0
100	19.0	22.0	25.0	285	95.0	94.4	93.8
105	19.7	22.8	25.9	290	97.0	96.8	96.6
110	19.9	23.2	26.5	295	97.6	97.3	97.0
115	20.0	24.0	28.0	300	98.2	97.8	97.4
120	20.1	24.6	29.0	305	98.5	98.2	97.9
125	20.4	25.2	30.0	310	98.7	98.4	98.1
130	21.4	26.0	30.5	315	98.9	98.6	98.3
135	22.9	26.9	30.9	320	99.0	98.8	98.5
140	24.1	27.6	31.0	325	99.3	99.1	98.9
145	24.9	28.3	31.7	330	99.3	99.2	99.0
150	25.1	28.6	32.1	335	99.4	99.3	99.2
155	25.6	29.2	32.7	340	99.5	99.4	99.3
160	27.0	30.2	33.3	345	99.8	99.7	99.6
165	27.8	31.2	34.6	350	99.8	99.8	99.7
170	28.1	32.1	36.1	355	99.9	99.9	99.9
175	28.3	33.2	38.1	360	100.0	100.0	100.0
180	29.5	35.2	40.8				

- Notes: 1. For drainage areas less than 8 square miles in size, use SDN 3.
 2. For drainage areas greater than or equal to 8 square miles and less than 12 square miles in size, use SDN 4.
 3. For drainage areas greater than or equal to 12 square miles, use SDN 5.
 4. A graphical representation of these values is presented on **Figure 515**.

Revision	Date

REFERENCE:

APPENDIX A.9

TABLE 503

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

SIX HOUR DEPTH-AREA REDUCTION FACTORS

<u>Drainage Area (Square Miles)</u>	<u>Six-Hour Depth-Area Reduction Factor</u>
0.0	1.00
0.5	0.98
1.0	0.97
2.0	0.93
4.0	0.91
6.0	0.90
8.0	0.88
10.0	0.86
20.0	0.79
30.0	0.74
50.0	0.68
100.0	0.60
150.0	0.55
200.0	0.51
300.0	0.46
400.0	0.42
500.0	0.39

- NOTES: 1. A graphical representation of these factors is presented in Figure 514.
2. Consult with the local entity and/or the CCRFCD for guidance in using the Depth-Area Reduction Factors for drainage areas greater than 200 square miles.

APPENDIX A.10

<i>Revision</i>	<i>Date</i>

**WRC
ENGINEERING**

REFERENCE:

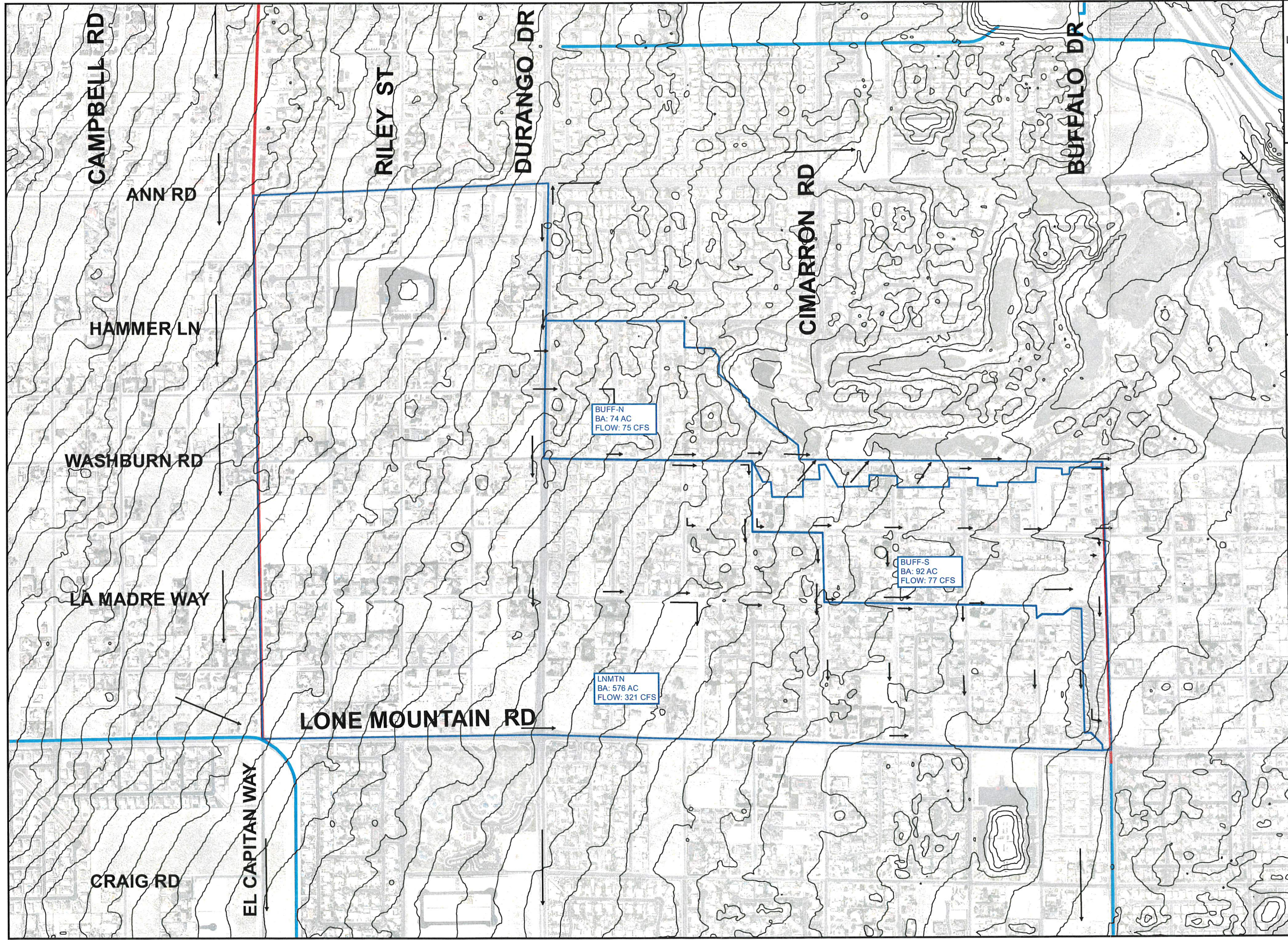
USACE, Los Angeles District, 1988

TABLE 502



Appendix B - Hydrology

- B.1 - Overall Drainage Basin Map
- B.2 - HEC-1 Output
- B.3 - Dimensional Simplification of Manning's Equation
- B.4 - Flow Split Table
- B.5 - Flow Split Map
- B.6 - Alignment A - Facility and Flow Map
- B.7 - Alignment B - Facility and Flow Map
- B.8 - Alignment C - Facility and Flow Map



GOWAN NORTH
BUFFALO BRANCH
LONE MNT. TO WASHBURN



Legend

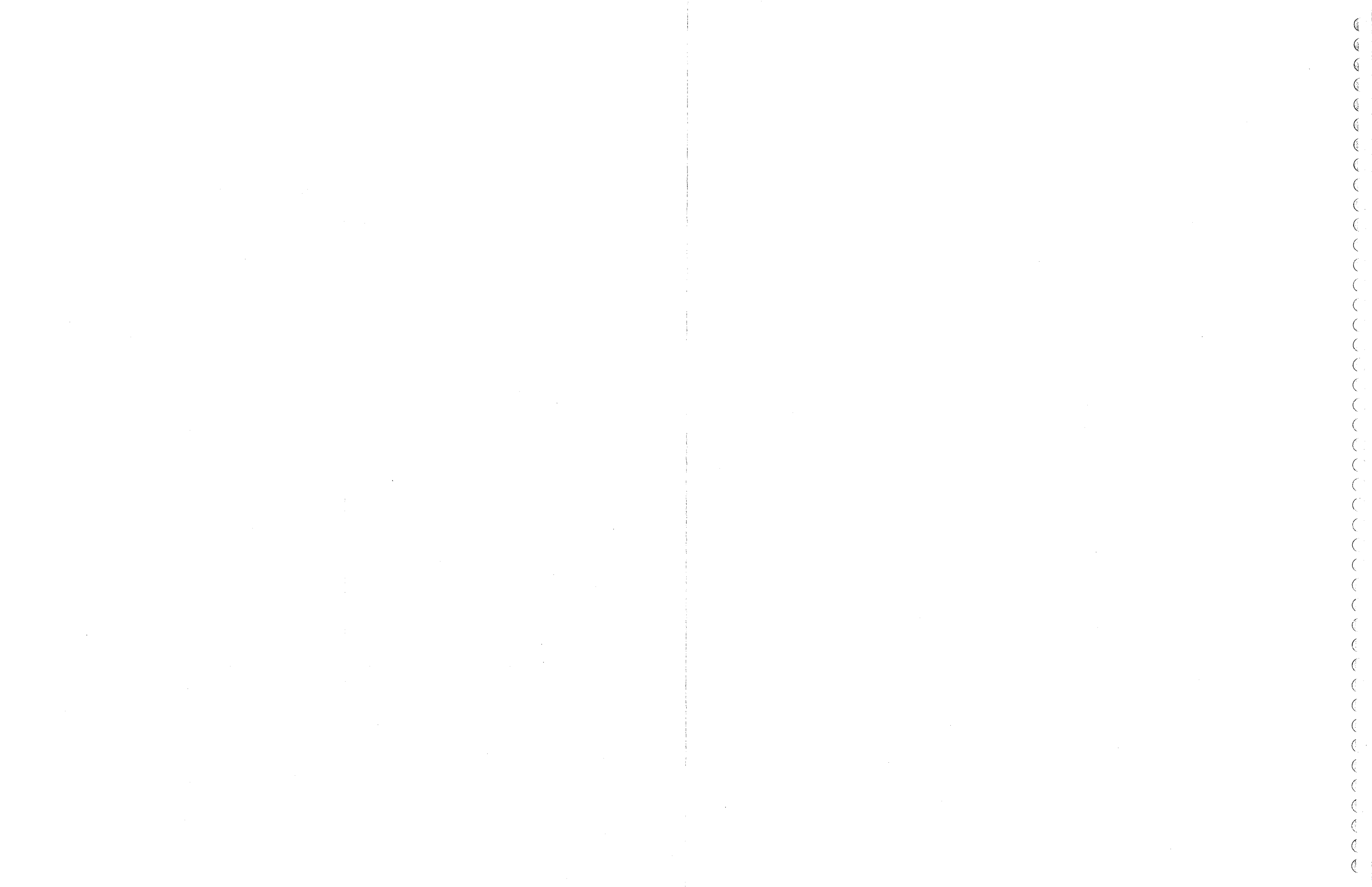
- Drainage Basin
- Drainage Pattern Arrows
- 5 ft Contours
- Existing MPU Facilities
- Proposed MPU Facilities

APPENDIX B.1
REVISED MAJOR BASIN
DRAINAGE MAP



Scale: 1 inch = 400 feet





```

1*****
*****
*
*
* FLOOD HYDROGRAPH PACKAGE (HEC-1)
* U.S. ARMY CORPS OF ENGINEERS
* JAN 1997
* HYDROLOGIC ENGINEERING CENTER
* VERSION 4.1
* 609 SECOND STREET
*
* DAVIS, CALIFORNIA 95616
* RUN DATE 10NOV14 TIME 14:59:46
* (916) 756-1104
*
*****
*****

```

```

X      X  XXXXXXXX  XXXXX      X
X      X  X        X      X      XX
X      X  X        X      X      X
XXXXXXX XXXX      X      XXXXX  X
X      X  X        X      X      X
X      X  X        X      X      X
X      X  XXXXXXXX  XXXXX      XXX

```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.

THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION

NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,

DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION

KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1
PAGE 1

HEC-1 INPUT

LINE
ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

*DIAGRAM

*** FREE ***

1	ID	GOWAN NORTH BUFFALO BRANCH - LONE MOUNTAIN TO WASHBURN
2	ID	15% ALTERNATIVE ANALYSIS STUDY
3	ID	11/13/2014
4	ID	
5	ID	BASED ON THE FOLLOWING MODEL:
6	ID	CLARK COUNTY REGIONAL FLOOD CONTROL DISTRICT 2008 MASTER PLAN


```

UPDATE
7      ID      GOWAN WATERSHED (ALL)
8      ID      RECOMMENDED DRAINAGE SYSTEM WITH ULTIMATE DEVELOPMENT
9      ID      INPUT FILE = ALLGOW3.DAT
10     ID      INPUT FILE DATE = MAY 5, 2008
11     ID      DESIGN STORM = 100-YEAR 6-HR STORM
12     ID      STORM DISTRIBUTION = SDN #3
13     ID
14     ID      JR CARDS CONTAIN DARFS BASED ON THE FOLLOWING VALUES:
15     ID
16     ID      AREA      DARF
17     ID      SQ. MI.
18     ID      0-0.5    0.99
19     ID      0.5-1    0.975
20     ID      1-2      0.95
21     ID      2-3      0.925
22     ID      3-4      0.915
23     ID      4-5      0.908
24     ID      5-6      0.903
25     ID      6-7      0.895
26     ID      7-8      0.885
27     ID
28     ID      JR CARD RATIOS REPRESENT DEPTH-AREA REDUCTION FACTORS (DARF'S)
29     ID
30     ID      100-YEAR, 6-HOUR STORM, SDN3
31     ID
32     IT      5        0        0        650
33     IO      5        0        0
34     IN      5        0        0
35     JR      PREC     0.99    0.975    0.95    0.925    0.915    0.908    0.903
0.895    0.885
*
36     KK      BUFF-N
37     BA      0.115
38     PB      2.81
39     PC      0        0.02    0.057    0.07    0.087    0.108    0.124    0.13
0.13    0.13
40     PC      0.13    0.13    0.13    0.133    0.14    0.142    0.148    0.158
0.172    0.181
41     PC      0.19    0.197    0.199    0.2    0.201    0.204    0.214    0.229
0.241    0.249
42     PC      0.251    0.256    0.27    0.278    0.281    0.283    0.295    0.322
0.352    0.409
43     PC      0.499    0.59    0.71    0.744    0.781    0.812    0.819    0.835
0.851    0.856
44     PC      0.86    0.868    0.876    0.888    0.91    0.926    0.937    0.95
0.97    0.976
45     PC      0.982    0.985    0.987    0.989    0.99    0.993    0.993    0.994
0.995    0.998
46     PC      0.998    0.999    1
47     LS      0        77.3
48     UD      0.250
*
```

1
PAGE 2

HEC-1 INPUT

LINE
ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

49 KK BUFF-S

50	BA	0.143	
51	PB	2.79	
52	LS	0	78.0
53	UD	0.400	
	*		
54	KK	LNMTN	
55	BA	0.900	
56	PB	2.79	
57	LS	0	78.0
58	UD	0.750	
	*		
59	ZZ		

1

SCHEMATIC DIAGRAM OF STREAM NETWORK

INPUT
LINE (V) ROUTING (--->) DIVERSION OR PUMP FLOW

NO. (.) CONNECTOR (<---) RETURN OF DIVERTED OR PUMPED FLOW

36 BUFF-N

49 . BUFF-S

54 . LNMTN

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

1*****

* *

* *

* FLOOD HYDROGRAPH PACKAGE (HEC-1) *

* U.S. ARMY CORPS OF ENGINEERS *

* JAN 1997 *

* HYDROLOGIC ENGINEERING CENTER *

* VERSION 4.1 *

* 609 SECOND STREET *

* *

* DAVIS, CALIFORNIA 95616 *

* RUN DATE 10NOV14 TIME 14:59:46 *

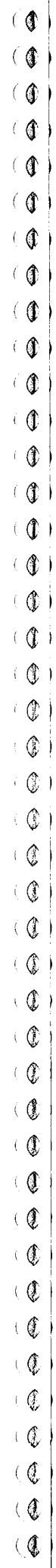
* (916) 756-1104 *

* *

* *

GOWAN NORTH BUFFALO BRANCH - LONE MOUNTAIN TO WASHBURN
15% ALTERNATIVE ANALYSIS STUDY
11/13/2014

BASED ON THE FOLLOWING MODEL:
CLARK COUNTY REGIONAL FLOOD CONTROL DISTRICT 2008 MASTER PLAN UPDATE
GOWAN WATERSHED (ALL)
RECOMMENDED DRAINAGE SYSTEM WITH ULTIMATE DEVELOPMENT
INPUT FILE = ALLGOW3.DAT
INPUT FILE DATE = MAY 5, 2008



APPENDIX B.3

METHOD - DIMENSIONAL SIMPLIFICATION OF MANNING'S EQUATION

Given Manning Equation

$$Q_T = \frac{1.49}{n} AR^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where:

Q_T = Total Flow

n = Manning's n

A = flow area (sq-ft)

R = hydraulic radius (ft)

S = slope (ft/ft)

Assume Manning's n value is consistent between streets

$$Q_T \propto AR^{\frac{2}{3}} S^{\frac{1}{2}}$$

Given:

$$R = \frac{A}{P}$$

Where:

A = flow area (sq-ft)

P = wetted perimeter (ft)

Then:

$$Q_T \propto A \left(\frac{A}{P} \right)^{\frac{2}{3}} S^{\frac{1}{2}}$$

$$Q_T \propto \frac{A^{\frac{5}{3}}}{P^{\frac{2}{3}}} S^{\frac{1}{2}}$$

Area is W times depth y, Perimeter is W plus depth 2y

$$Q_T \propto \frac{(W \times y)^{\frac{5}{3}}}{(W + 2y)^{\frac{2}{3}}} S^{\frac{1}{2}}$$

Eliminate 2y in denominator because y is small with respect to W

$$Q_T \propto \frac{(W \times y)^{\frac{5}{3}}}{(W)^{\frac{2}{3}}} S^{\frac{1}{2}}$$

$$Q_T \propto \frac{W^{\frac{5}{3}} y^{\frac{5}{3}}}{W^{\frac{2}{3}}} S^{\frac{1}{2}}$$

$$Q_T \propto W y^{\frac{5}{3}} S^{\frac{1}{2}}$$

Eliminate y in equation because the relative difference in y between two streets is small as compared to the difference in W and S

$$Q_T \propto W S^{\frac{1}{2}}$$

By conservation of mass and energy:

$$Q_T = Q_S + Q_E$$

Or

$$Q_E = Q_T - Q_S$$

Where:

Q_S = Flow draining to south street

Q_E = Flow draining to east street

And:

$$\frac{Q_S}{Q_E} = \frac{W_S S_S^{1/2}}{W_E S_E^{1/2}}$$

Where:

W_S = Width of south street

S_S = Slope of south street

W_E = Width of east street

S_E = Slope of east street

Assume:

$$X = \frac{W_S S_S^{1/2}}{W_E S_E^{1/2}}$$

Substitute X for the ratio

$$\frac{Q_S}{Q_E} = X$$

Substitute for Q_E

$$\frac{Q_S}{(Q_T - Q_S)} = X$$

$$Q_S = (X)(Q_T - Q_S)$$

$$Q_S = Q_T(X) - Q_S(X)$$

$$Q_S + Q_S(X) = Q_T(X)$$

$$Q_S[1 + (X)] = Q_T(X)$$

$$Q_S = \frac{Q_T(X)}{[1 + (X)]}$$

With ratio X replaced back in:

$$Q_S = \frac{Q_T \left(\frac{W_S S_S^{1/2}}{W_E S_E^{1/2}} \right)}{\left[1 + \left(\frac{W_S S_S^{1/2}}{W_E S_E^{1/2}} \right) \right]}$$

B.4 Flow Split Table

Intersection	Intersection Geometry										Total Q After Split			
	Sub-Basin Flow (cfs)	Contribution from US Flow Split (cfs)	Flow Including US splits (cfs)	Half Street Capacity (cfs)	Remainder for Split (cfs)	South Street		East Street		Qs/Qe Ratio (-)	Split Flow		Total S (cfs)	Total E (cfs)
						Width (ft)	Slope (ft/ft)	Width (ft)	Slope (ft/ft)		Heads S (cfs)	Heads E (cfs)		
Durango & Hammer	53.1	0.0	53.1	54.0	0.0	40	0.004	25	0.020	0.716	0.0	0.0	53.1	0.0
Durango & Fisher	20.1	53.1	73.2	-	73.2	40	0.000	25	0.020	0.000	0.0	73.2	0.0	73.2
Durango & Washburn	28.6	0.0	28.6	38.0	0.0	40	0.015	25	0.023	1.279	0.0	0.0	28.6	0.0
Washburn & Tomsik	42.7	73.2	118.9	42.0	76.9	22	0.019	35	0.010	0.880	36.0	40.9	36.0	82.9
Tomsik & Rosada	7.7	36.0	43.7	21.9	21.8	30	0.007	30	0.027	0.502	7.3	14.5	29.2	14.5
Cimarron & La Madre	32.7	29.2	61.9	286.0	0.0	40	0.016	40	0.020	0.894	0.0	0.0	61.9	0.0
Conough & La Madre	17.8	0.0	17.8	-	17.8	40	0.006	35	0.010	0.899	8.4	9.4	8.4	9.4
Buffalo & La Madre	17.8	9.4	27.2	94.0	0.0	45	0.008	30	0.005	1.897	0.0	0.0	27.2	0.0

Note: See Appendix B.3 for the derivation of the Qs/Qe Ratio

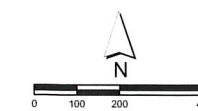
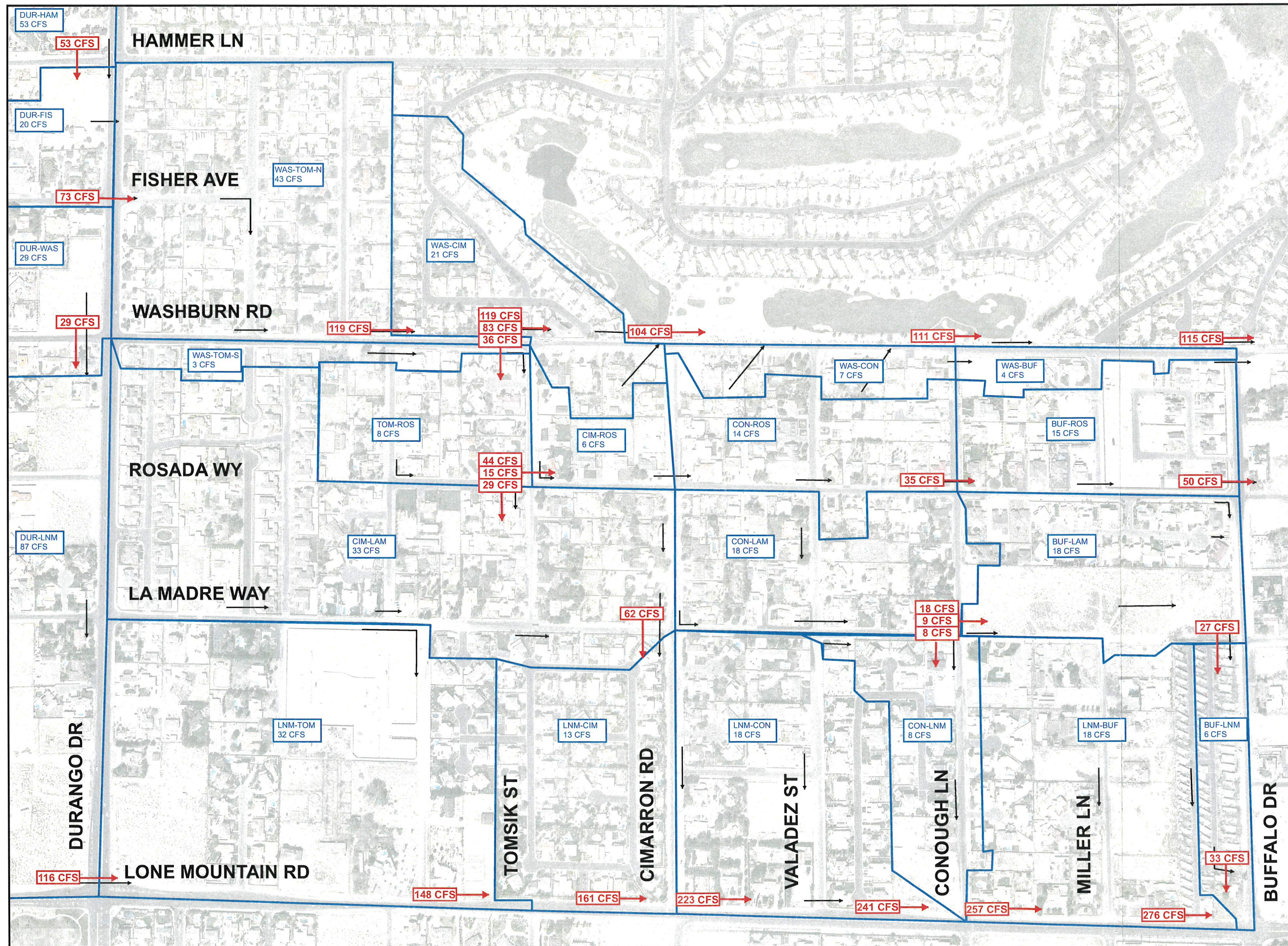
GOWAN NORTH
BUFFALO BRANCH
LONE MNT. TO WASHBURN



Legend

- Flow Direction
- Drainage Pattern
- Sub-Basins
- 100-yr Flow

APPENDIX B.5
FLOW SPLIT MAP



Scale: 1 inch = 200 feet

PARSONS
BRINCKERHOFF

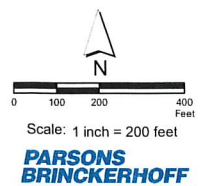
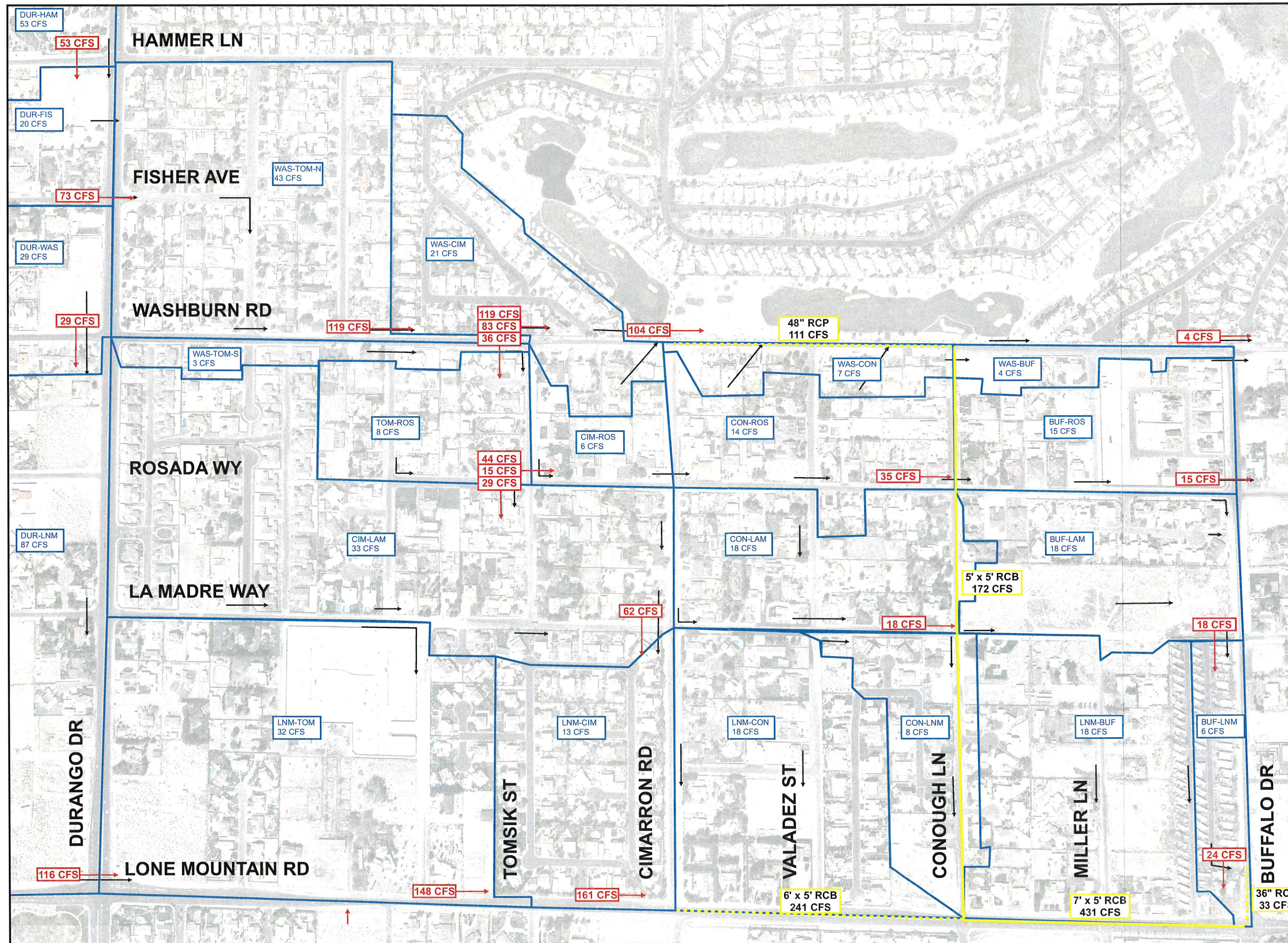




Legend

- Proposed Storm Drain
 - MPU Facility
 - Lateral
- Street Flow Arrows
- Drainage Pattern Arrows
- Subbasins

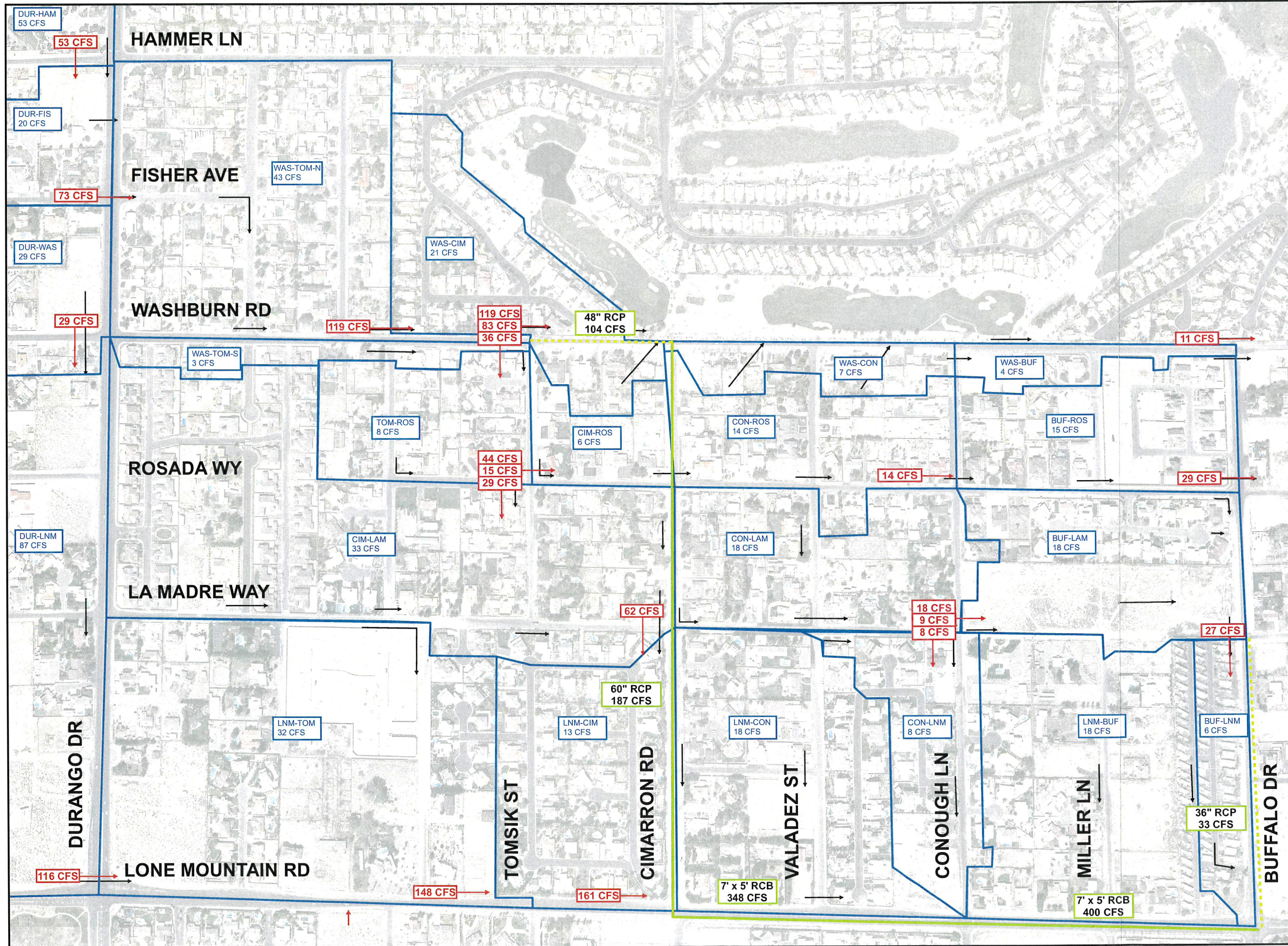
APPENDIX B.7
ALIGNMENT B
FACILITY AND FLOW MAP





- Legend**
- Proposed Storm Drain
 - MPU Facility
 - Lateral
 - Street Flow Arrows
 - Drainage Pattern Arrows
 - Subbasins

APPENDIX B.8
ALIGNMENT C
FACILITY AND FLOW MAP



Appendix C - Hydraulics

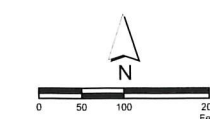
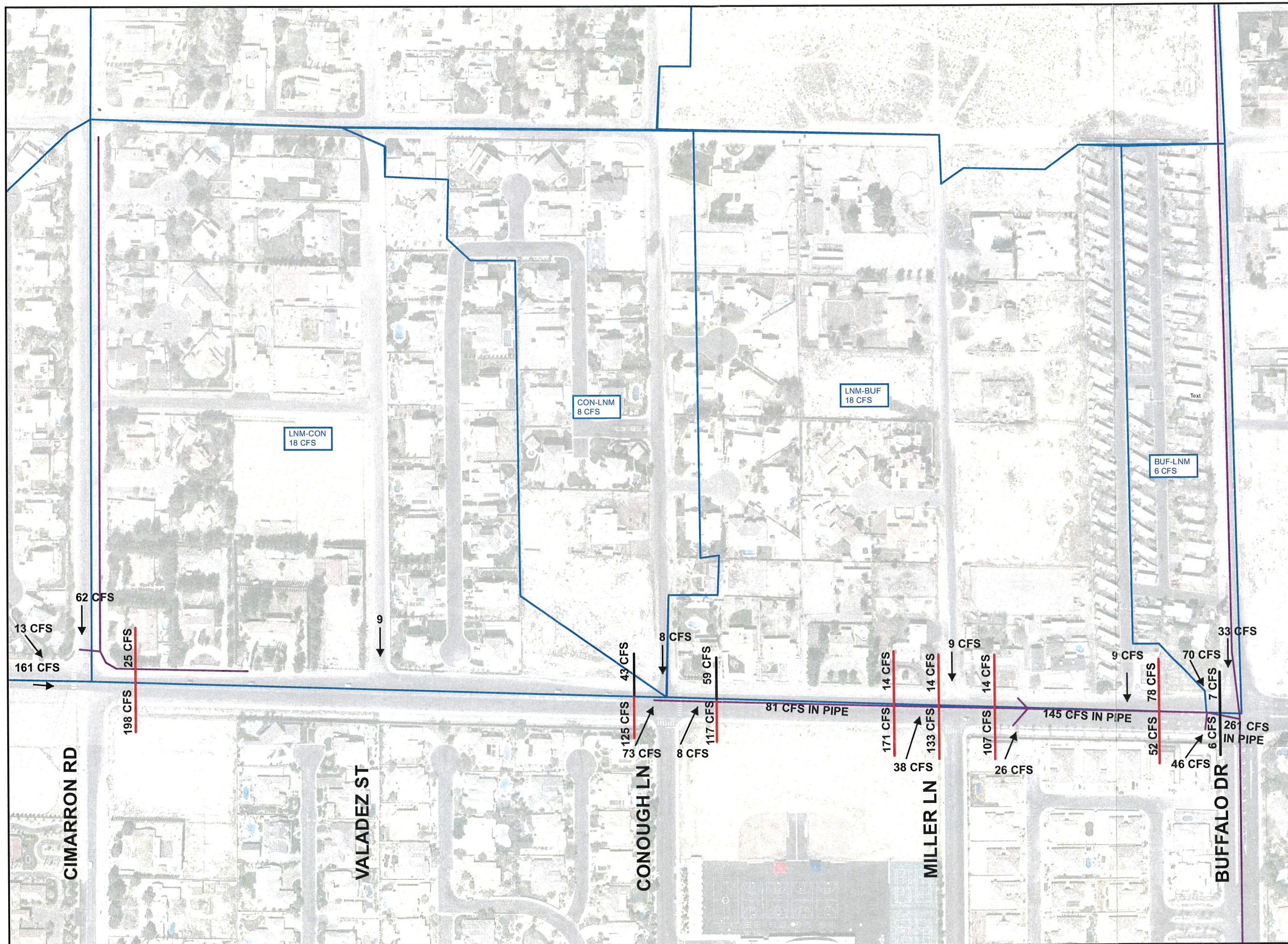
- C.1 - Dry Lane in Lone Mountain Road Figure



Legend

- Storm Drain
- Subbasin
- Flow Direction
- Cross Section
- Section Does Not Meet Criteria

APPENDIX C.1
DRY LANE IN
LONE MOUNTAIN ROAD

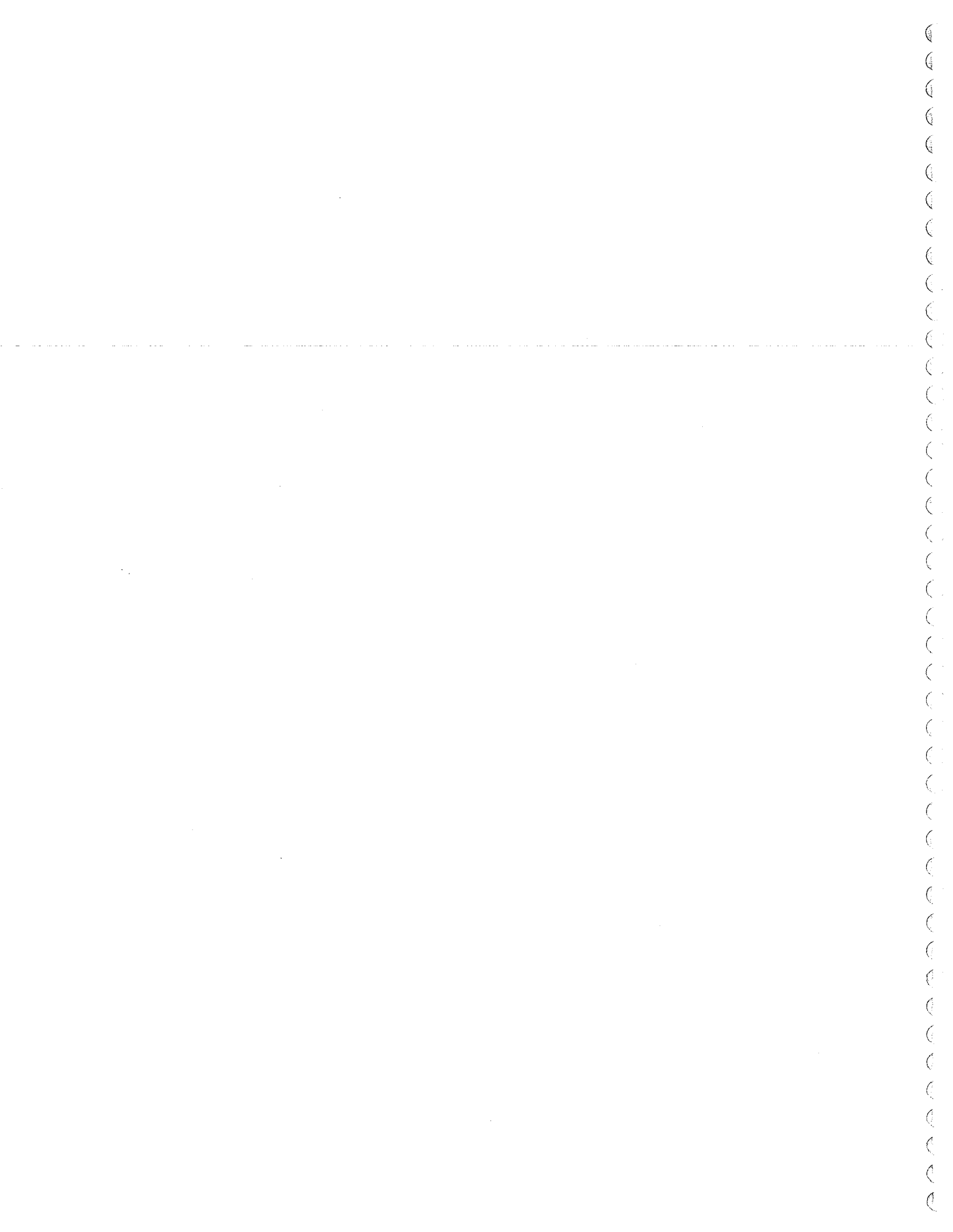


Scale: 1 inch = 100 feet

PARSONS
BRINCKERHOFF

Appendix D - Reference

- D.1 - As-Builts
- D.2 - Meeting Minutes
- D.3 - Citizen Complaint for Bubbler System



Project: Gowan North Buffalo Branch – Lone Mountain to Washburn
Purpose: Kickoff Meeting
Date: Wednesday August 20, 2014
Time: 2:00 PM
Location: City of Las Vegas
DSC 9th Floor Granite Conference Room
Attendance: Mike Sturdivant, City of Las Vegas
Jeremy Leavitt, City of Las Vegas
Tim Parks, City of Las Vegas
Bill Snyder, City of Las Vegas (ROW)
Oh-Sang Kwon, City of Las Vegas
Sherri McMahon, City of Las Vegas (Environmental)
Mike Kinney, City of Las Vegas (Survey)
Todd Myers, Regional Flood Control District
James Marrs, PB
Nicholas Appuglise, PB
Jessica Schick, PB
Eric Hsu, PB

DISCUSSION ITEMS

This kickoff meeting was held to introduce PB's design team to City of Las Vegas (CLV) staff involved on the project. The meeting also was held to give a project overview, a status update for what has been completed at this time, what is expected to be completed for the 15% alternative analysis submittal, to go over the projected schedule for future submittal deadlines, and to discuss any questions any attendees may have regarding the project.

Three 24" x 36" exhibits were presented at the meeting which showed the project area. One exhibit showed the existing and proposed Las Vegas Valley Flood Control Master Plan Update (MPU) facilities and their respective basins. Another exhibit showed the topography of the area based on survey and aerial footage received by PB's sub-consultant. The third exhibit showed which areas within the project study limits are within CLV and which are in Clark County, along with the three conceptual alignments for the alternative analysis.

Hydrology

The GC Wallace Drainage Study, which will be referenced for the Buffalo Drive Design, was completed in 1999. In 2008 the MPU updated land use values throughout the valley. The current 2014 MPU land uses will be utilized for this design, which means the HEC-1 analysis and hydrology design from the GC

Gowan North Buffalo Branch – Lone Mountain to Washburn

Wallace study will need to be updated accordingly. This update creates higher peak flow to be collected by the Buffalo Drive storm drain as well as the Gowan Detention Basin south of the project area.

Jessica asked Todd if Regional Flood Control CLV and County boundaries would be a factor in the selection of the alignment of the proposed storm drain facility. Todd said this is not a major factor in selecting the storm drain alignment.

Jessica mentioned having storm drain laterals on Conough Lane and/or Cimarron Road would allow for better protection of the houses along those corridors.

Todd mentioned that Buffalo Drive will not be upgraded with curb and gutter unless major residential development is completed. The County will not likely fund a “complete streets” design of Buffalo Drive.

Jessica mentioned that the project area has a very flat north to south slope and the east to west slope is steeper, as seen on the aerial survey exhibit. Placing the storm drain on Buffalo Drive, the north-south MPU alignment, may result in design issues meeting minimum cover requirements and/or may require a larger facility. Alternatives to the MPU alignment are being considered that will utilize the steeper east-west slope within the project area and potentially provide more protection to properties to the west of Buffalo Drive. Jessica also mentioned that a larger facility may create issues at the connection to the existing MPU facility in the intersection of Buffalo Drive and Lone Mountain Road. It may be favorable to choose a storm drain alignment that does not use Buffalo Drive. These are some of the considerations that will go into selecting the alignment.

The MPU facility on Buffalo Drive, including all portions south of Lone Mountain Road that drain to the Gowan Detention Basin, are sized based on ultimate conditions of the area. There is a proposed MPU facility on El Capitan Way that will collect offsite flow and transfer it south, away from the Buffalo Drive storm drain facility. It was asked if the Buffalo Drive facility is expected to have the capacity to carry the interim condition flows, where the El Capitan MPU facility is not in place. Todd said that the Buffalo Drive facility should have the capacity to carry the ultimate conditions flows, not the interim condition flows. The Buffalo Drive system should be analyzed for the impacts to it during interim condition, however, and if there is the possibility to place extra inlets within the project alignment to maximize the flow intake into the system, that should be considered.

Utility

Tim mentioned there may be the need to have a city/county special improvement district (SID) being placed on the properties in the area due to improvements made in the area being paid for by the city/county. This will be something discussed at a later date.

Tim said there is a proposed sewer line that is planned to be placed on Lone Mountain Road, west of Buffalo Drive, which is not planned to be constructed until after the construction of the Buffalo Drive storm drain. PB will consider the sewer line's proposed location, size, and depth in the alternative

analysis of storm drain alignment alternatives on Lone Mountain Road. There was discussion that one of the benefits of placing the storm drain alignment along Lone Mountain Road is that both the proposed sanitary sewer line and storm drain line could be trenched simultaneously to save on construction costs. However, the timing of these projects is not likely to coincide.

Inlets

Todd and Mike said the NDOT Type 2B inlet is the preferred inlet to be used in a rural setting, as it has an opening small enough to keep from being a hazard to a person walking nearby, yet collects enough storm water to be efficient. Jeremy said the type 2A inlet is hazardous to pedestrians. Other inlets types are open for discussion.

Todd mentioned it would be more efficient to place proposed inlets at existing curb and gutter locations, if the design warrants. This would minimize inlets from being placed in graded swales, which pose a threat to pedestrians and equestrians in the area.

Oh-Sang mentioned that there are area inlet drains on Rainbow Boulevard, between Grand Teton Drive and Elkhorn Road, which are proving to be ineffective due to dirt and debris clogging them during storm events. It was mentioned that PB will make a site visit to inspect these inlets to analyze possibly how to better utilize this type of inlets for the Buffalo Drive project or how possibly selecting different inlets to use on this project would be beneficial.

Storm Drain

Currently there is an 8' x 3' reinforced concrete box (RCB) at the intersection of Buffalo Drive and Lone Mountain Road that connects to the existing 11' x 5' RCB in Buffalo Drive. The 8' x 3' RCB will most likely need to be resized to accommodate the Buffalo Drive storm drain MPU facility. This RCB is believed to have been made this size due to a utility conflict present when it was constructed, as well as there being minimum vertical clearance between the RCB and finish grade.

Jessica mentioned a Master Plan Amendment (MPA) would be needed if an alignment other than Buffalo Drive is selected in the alternative analysis report. Preparation of the MPA would be covered in additional services.

Todd mentioned the best way to determine the best alternative alignment is to have a group meeting between CLV and PB and to go over PB's findings and recommendations of the alternatives to make a qualitative decision. Tim added that CLV has created a matrix on a previous project on where specific items and factors were rated on a 1 to 10 scale, which was an effective tool in deciding alternative designs. Tim said he would send Mike a copy of the matrix.

Todd mentioned he would like to see PB's suggestion on a best alternative and that if that alternative is more costly than the others, it still will be considered because the main goal of this project is to collect

as much storm water as efficiently as possible. He said a quantity analysis will not factor in heavily on deciding the best alternative. The goal is to provide the most effective and efficient design.

Right of Way

Jessica mentioned that some homeowners in the area have made improvements in public right-of-way (ROW), including paved driveways with small culverts underneath, to allow storm water to flow past their property, mail boxes and other aesthetic improvements. She asked how this would affect hydrology design and ROW concerns. Oh-Sang said that if any property is disturbed during construction CLV will replace in kind. Todd added that for hydrology analysis if any property improvements affect the flow of water in the street, that will be reviewed as needed.

At this point in time, additional ROW or easements are not anticipated.

Miscellaneous

Todd mentioned that the County does not allow rip rap within ROW.

Additional survey and geotechnical data will be obtained from PB's sub consultants once a preferred alignment is selected.

PB's survey sub consultant will need to submit electronic copies of their survey to City of Las Vegas for them to include in their database.

Groundwater is not expected on this project, but if there is, a National Pollution Discharge Elimination System (NPDES) permit may be required.

Action Items

Tim Parks is to be contacted regarding electronic files for sanitary sewer lines that will be sent to PB to include with utility information. He will also provide PB with the approximate size, depth, and horizontal location of the proposed sewer line going in on Lone Mountain Road, west of Buffalo Drive.

A meeting with CLV is planned for September 17 to have an open discussion regarding the alternative analysis and which design alternative will be selected for moving forward with the design.

Next Meeting

2:00 PM Wednesday September 17, 2014

At City of Las Vegas

Project: Gowan North Buffalo Branch – Lone Mountain to Washburn
Purpose: Alternative Analysis Progress Meeting
Date: Wednesday September 17, 2014
Time: 2:00 PM
Location: City of Las Vegas
DSC 9th Floor Gravel Conference Room
Attendance: Mike Sturdivant, City of Las Vegas
Tim Parks, City of Las Vegas
Oh-Sang Kwon, City of Las Vegas
Peter Jackson, City of Las Vegas
James Marrs, PB
Nicholas Appuglise, PB
Jessica Schick, PB

DISCUSSION ITEMS

This meeting was held to discuss the alternative analysis on the Gowan North Buffalo Branch that will be presented in a report for the 15% alternative analysis submittal. The main focus was to discuss the existing drainage patterns, the alternative designs, and to take general questions about the information presented.

Five 24" x 36" exhibits were presented at the meeting which showed the project area. One exhibit showed the Las Vegas Valley Flood Control Master Plan Update (MPU) facilities and their respective MPU basins. The second exhibit showed the topography of the area based on survey and aerial footage received by PB's sub-consultant, as well as showing the drainage basins being revised based on PB study of the contours and street layout in the area. The third exhibit showed the first alternative of having the proposed storm drain facility being located on Buffalo Drive as the MPU suggests. The fourth exhibit showed the second alternative of having the proposed storm drain facility being located along Lone Mountain Road and Cimarron Road. The fifth exhibit showed the third alternative of having the proposed storm drain facility being located along Lone Mountain Road and Conough Lane.

Hydrology

Jessica discussed why the MPU drainage basins have been modified based on PB's preliminary analysis of the area contributing to the proposed storm drain facility. Due to existing valley gutters being present in certain intersections, as well as looking more closely at contours and roadway layout in the area, most the flow goes to Lone Mountain Road and not to Buffalo Drive as the MPU suggests. There was discussion on how the flow on Washburn Road will continue east past Buffalo Drive if not collected at Buffalo Drive and this flow should be considered as to its impact to future and existing systems.

Peter stated that past experience with the larger storm events causes flow to overtop at the Washburn Road and Durango Drive intersection, and continue east past Durango Drive, while leaving sediment on the west side of Durango Drive. Mike noted that in ultimate condition there will be an MPU facility along Durango Drive, between Lone Mountain Road and Ann Road, which will reduce the amount of flow reaching this intersection. As a part of Alternatives Analysis Report, PB will analyze flow volumes and paths based on the MPU basin areas (ultimate condition).

Jessica mentioned flow split calculations will need to be done at certain intersections to accurately analyze how much flow goes east or south. Oh-Sang stated that for the Alternative Analysis Report that half-street capacity calculations will suffice in determining flow splits at intersections. He also stated if a drainage basin needs to be split into smaller basins, rather than updating the HEC-1 models, it would be acceptable to use a ratio of the basin's Q to determine flows at the intersections.

Jessica stated that at this point in the analysis, locating the MPU facility on Lone Mountain Road would be the best alternative. It would allow for inlets to be placed in existing curb and gutter sections and at a frequency to allow for by-pass flow collection. She mentioned that the system should be extended to the Washburn Road and Cimarron Road intersection to collect flows coming from the neighborhood to the northwest. This Lone Mountain Road-Cimarron Road system would allow for flows to be collected sooner, which keeps higher flows from accumulating at other locations in the project site, allows less sediment to transfer, reduces flow velocity, and protects more homes to the east.

Jessica said the GC Wallace Drainage Study for the Improvements for Buffalo Drive showed that more flow was directed to Lone Mountain Road than Buffalo Drive, which is dissimilar to what the MPU basin map suggest. This further supports the alternative of having a facility on Lone Mountain Road.

Peter stated having a facility on Conough Lane would allow for a higher Q value to be collected in the proposed design as opposed to having one on Cimarron Road. Analysis of the Conough Lane alignment is included as one of the alternatives to be analyzed.

Oh-Sang stated a Master Plan Amendment (MPA) will be required if the proposed MPU facility is not on Buffalo Drive as the 2008 MPU shows, and this will need to be supported with hydraulic calculations and data. This will need to be submitted prior to the 90% submittal for approval.

Hydraulics

Nick presented two exhibits showing the profiles of the Lone Mountain Road, Cimarron Road, Conough Lane, and Buffalo Drive proposed storm drain systems. These exhibits showed the amount of cover, slope, size, and maximum flow each system could ideally convey. Nick mentioned the limiting factor on these systems was connecting to the existing storm drain invert at the Buffalo Drive and Lone Mountain Road intersection, as well as the existing slope of the roadways, which limits the slope of the proposed storm drains.

Gowan North Buffalo Branch – Lone Mountain to Washburn

Peter stated as-builts of the existing storm drain system along Lone Mountain Road between Buffalo Drive and Cimarron Road should be requested from the City of Las Vegas or Clark County. This will allow consideration of what system is currently in the road and its impact to the proposed design.

Jessica mentioned the bubbler system located at the north side of the Cimarron Road and Lone Mountain Road intersection. Peter said this system could potentially be removed if the proposed storm drain was placed on Lone Mountain Road up to Cimarron Road. This would allow for a more desirable system than the bubbler.

Peter stated that the main purpose of the storm drain system is to maximize the total collection of flow, to meet the MPU's requirements.

Peter stated the existing corridors will most likely remain rural with side ditches if currently present and will not likely be improved by the County. This means that their capacity will be less than that those with curb, gutter and sidewalk.

Jessica mentioned one of the benefits to the Cimarron Road alignment are the existing curb and gutter.

Peter mentioned that anywhere a proposed facility is put into place, the dry-lane criteria from the Clark County Regional Flood Control District Hydrologic Criteria and Drainage Design Manual needs to be met.

Utility

Tim stated that there is a proposed sanitary sewer line to be placed on Lone Mountain Road at a future date past the expected construction of this project. He said that this must be a consideration in the alternative analysis. A 10 foot wide section, clear of utilities and storm drain improvements in the roadway will be sufficient for construction of the sewer line.

Report

Peter said the Alternative Analysis Report should present the storm drain alternative alignments, designation of which portions are considered MPU facility and which are considered laterals off the MPU facility, and their associated cost. The report should provide a matrix showing each alternative, how much flow is collected, how much is bypassed, the flow split calculations where necessary, and any other data regarding the alternative so as to allow the City of Las Vegas to accurately determine which alternative is best. The best alternative for the MPU system may include facilities on Buffalo Drive and Lone Mountain Road, with laterals at multiple locations.

Peter and Oh-Sang agree inlet efficiency calculations will not be required for the Alternative Analysis Report, but flow splits, using half street capacity calculations, and hydraulics will be completed as appropriate.

Next Meeting

2:00 PM Wednesday October 8, 2014
At City of Las Vegas

Submittal for the 15% Alternative Analysis Report scheduled for October 20.

Project: Gowan North Buffalo Branch – Lone Mountain to Washburn
Purpose: Progress Meeting: Alternative Analysis
Date: Tuesday October 21, 2014
Time: 3:30 PM
Location: City of Las Vegas
DSC 9th Floor Gravel Conference Room
Attendance: Mike Sturdivant, City of Las Vegas
Oh-Sang Kwon, City of Las Vegas
Peter Jackson, City of Las Vegas
Todd Myers, Regional Flood Control District
James Marrs, PB
Nicholas Appuglise, PB
Jessica Schick, PB

DISCUSSION ITEMS

This meeting was held to discuss the alternative analysis for the Gowan North Buffalo Branch MPU facility that will be presented in a report for the 15% alternative analysis submittal. The main focus was to discuss the preferred alternative of the three alternatives that are to be presented in the report.

Jessica provided an update of the flow patterns within the project watershed. An updated basin exhibit was presented showing subbasins and flow splits. It is essential to collect flow on Washburn Road, which currently continues east on Washburn Road, across Buffalo Drive and out of the MPU watershed boundary.

Jessica discussed how there is flow from outside of the MPU watershed boundary that contributes to the project watershed via a 4' x 2' reinforced concrete box (RCB) located at the southwest corner of Durango Drive and Lone Mountain Road. This RCB collects water from Mountain Crest Park. The as-built obtained shows 48 cfs being collected by the 4' x 2' RCB for the 100-year event. This flow will be considered when designing the proposed storm drain facility.

Jessica presented the city with a handout of photos that were taken in the field during a recent storm event. These photos illustrate some of the flooding concerns within the project limits. The main areas of concern and issues discussed are:

- There is a bubbler system located on the north side of Lone Mountain Road at the intersection of Lone Mountain Road and Cimarron Road, which causes major flooding at the intersection. A citizen's complaint was submitted to RFCD pertaining flooding in this area.

Gowan North Buffalo Branch – Lone Mountain to Washburn

- The street capacity on Lone Mountain Road is limited on the north side of the street, causing dry lane criteria to be of concern. Most of the water in larger storm events weirs over to the south side of street.
- Ponding at the intersection of La Madre Way and Conough Lane is a recurring problem during minor storm events. A storm drain facility on Conough Lane would alleviate flooding at this intersection and could be extended north to collect flows on Washburn Road.
- Dry lane is of potential concern on Lone Mountain Road between Cimarron Road and Durango Drive. It was mentioned that if the proposed MPU facility is placed on Lone Mountain Road, it could be extended in the future to capture flow between Cimarron Road and Durango Drive to meet dry lane criteria. This would also provide for connectivity of the existing and future storm drain facilities within Lone Mountain Road and Durango Drive.

Jessica also presented a summary of the existing drainage facilities within the project limits. There are two key items. First, the existing MPU facility on Buffalo Road, south of Lone Mountain Road has the capacity to convey the 470 cfs generated within the project watershed. Second, the existing drop inlets on Lone Mountain Road just west of Buffalo Road are sized to collect most of the 100-year flows on Lone Mountain Road. However, they do not address the dry lane criteria on Lone Mountain Road west of the inlets or the flooding issues along Lone Mountain Road or Conough Lane.

Jessica presented a handout containing preliminary construction cost estimates for the three alternatives under consideration. She also stated that these estimates were only for the MPU facility trunkline and the cost does not include other factors contributing to project costs such as inlets, lateral systems, transition structures, removals, utility relocation, etc. Oh Sang stated that the cost estimates would need to be prepared using the Regional construction cost estimating tool for the Master Plan Amendment.

After the presentation and discussion of the existing flow patterns and other factors within the basin limits, alternatives under consideration were briefly discussed and the Conough Lane alignment was recommended to be the alternative selected to move forward to design. The Conough Lane alignment begins at Buffalo Drive and extends west on Lone Mountain Road to Conough Lane. At Conough Lane the alignment turn north and continues on to Washburn Road. Quarter mile lateral extensions would be placed on Lone Mountain Road from Conough Lane to Cimarron Road, and on Washburn Road from Conough Lane up to Cimarron Road or as needed. All meeting attendees concurred with the recommendation in that it addressed the issues present in the watershed and would collect flows equal to the capacity of the existing downstream MPU facility.

Todd noted that a Master Plan Amendment or Master Plan Change would be needed for the Conough Lane alternative.

James said it would be beneficial to send out a geotechnical crew to the field to begin the soil study after this meeting, so that PB could have the data back to include in the 30% design submittal. Mike

agreed that this was acceptable with the high confidence level of the selection of the proposed MPU alignment, based on the discussion at this meeting.

Todd said the MPU storm drain facility could be designed based on the flows calculated within HEC-1 for the large scale drainage basins. These large scale basins have longer lag times and the flows closely match what is found in the 2013 MPU. These large scale basins can be broken down to evaluate the drainage pattern by using an area ratio. Todd suggested that the only need to subdivide the basins into smaller sizes and run hydrology calculations with shorter time of concentrations would be for sizing drop inlets. This would allow for a more conservative design, accounting for capture of higher peak flow rates at inlets.

Follow-Up

Oh-Sang will send PB a cost estimator tool to estimate the cost of the proposed facility.

The 15% Alternative Analysis Report will be submitted to City of Las Vegas within the next 2 to 3 weeks.



Schick, Jessica

From: Hsu, Eric SC.
Sent: Monday, October 20, 2014 9:27 AM
To: Schick, Jessica; Appuglise, Nicholas
Subject: FW: RFCD - Citizen Contact Tracking System

From: Oh-Sang Kwon [mailto:okwon@LasVegasNevada.GOV]
Sent: Monday, October 20, 2014 9:05 AM
To: Michael Sturdivant; Todd L. Myers; Peter Jackson
Cc: Marrs, James A.; Hsu, Eric SC.
Subject: FW: RFCD - Citizen Contact Tracking System

Mike,

Received complaint from a citizen. Maybe we could address this with the Buffalo Storm Drain Project.

Thanks,

Oh-Sang Kwon, P.E.
City of Las Vegas
Engineering Project Manager
Flood Control Section
333 N. Rancho Drive
Las Vegas, NV 89106

Phone: (702) 229-1815
Cell: (702) 379-9491
Fax: (702) 382-8551
TTY: (702) 386-9108

From: Kelsey Hand [mailto:KHand@regionalflood.org]
Sent: Friday, October 17, 2014 8:19 AM
To: Jerry Walker; Peter Jackson; Oh-Sang Kwon
Subject: RFCD - Citizen Contact Tracking System

This e-mail is being sent from the Regional Flood Control District's Citizen Contact Tracking System. This system is used by RFCD staff to record flood- or stormwater-related incidents that occur in Clark County. You are being sent this information because you may be able to provide assistance for this incident, information about which is outlined below:

Date/Time Reported: 10/15/14 15:51

Problem: Clogged storm drain

Location: At or near CIMARRON and LA MADRE (Lat: 36.25179, Long: -115.26974)

Comment: HOA: Aviana Association, clogged drain, will there be cleaning or a new drain installed. Waters continually back up to the properties. Contact: Kim Sand @ 702.880.4632

If you are not the correct person to assist with this issue please pass this along to the appropriate person or department. If you have any questions about this system or the incident mentioned above, please contact us at 702-685-0000 or via return e-mail.

Thank you for your kind assistance.

RFCD Citizen Contact Tracking System

Appendix E - CD

- E.1 - Half Street Capacity for Flow Splits
- E.2 - Normal Depth Calculations in Existing Lone Mountain Road
- E.3 - Flowmaster Output for Alternative Alignments